Visions for Sustainable Energy Transformations:

Integrating Power and Politics in the Mediterranean Region

by

Sharlissa Moore

A Dissertation Presented in Partial Fulfillment
of the Requirements for the Degree
Doctor of Philosophy

Approved April 2015 by the
Graduate Supervisory Committee:

Edward Hackett, Chair
Ben Minteer
Jameson Wetmore
Mary Jane Parmentier

ARIZONA STATE UNIVERSITY

May 2015

ABSTRACT

This dissertation examines the nexus of three trends in electricity systems transformations underway worldwide—the scale-up of renewable energy, regionalization, and liberalization. Interdependent electricity systems are being envisioned that require partnership and integration across power disparities. This research explores how actors in the Mediterranean region envisioned a massive scale-up of renewable energy within a single electricity system and market across Europe, North Africa, and the Middle East. It asks: How are regional sociotechnical systems envisioned? What are the anticipated consequences of a system for a region with broad disparities and deep sociopolitical differences? What can be learned about energy justice by examining this vision at multiple scales? A sociotechnical systems framework is used to analyze energy transformations, interweaving the technical aspects with politics, societal effects, and political development issues. This research utilized mixed qualitative methods to analyze Mediterranean electricity transformations at multiple scales, including fieldwork in Morocco and Germany, document analysis, and event ethnography. Each scale—from a global history of concentrating solar power technologies to a small village in Morocco—provides a different lens on the sociotechnical system and its implications for justice. This study updates Thomas Hughes' *Networks of Power*, the canonical history of the sociotechnical development of electricity systems, by adding new aspects to sociotechnical electricity systems theory. First, a visioning process now plays a crucial role in guiding innovation and has a lasting influence on the justice outcomes.

Second, rather than simply providing people with heat and light, electrical power systems in the 21st century are called upon to address complex integrated solutions. Furthermore, building a sustainable energy system is now a retrofitting agenda, as system builders must graft new infrastructure on top of old systems. Third, the spatial and temporal aspects of sociotechnical energy systems should be amended to account for constructed geography and temporal complexity. Fourth, transnational electricity systems pose new challenges for politics and political development. Finally, this dissertation presents a normative framework for conceptualizing and evaluating energy justice. Multi-scalar, systems-level justice requires collating diverse ideas about energy justice, expanding upon them based on the empirical material, and evaluating them with this framework.

ACKNOWLEDGEMENTS

A research project that crosses continents is invariably indebted to a network of supportive people, all instrumental in making my rather outlandish dream to conduct fieldwork on a regional sociotechnical vision a reality. I am deeply grateful for Ed Hackett's patience and support and for having faith in me that I would be successful. Ed was extremely generous with his time, providing countless hours of advice and feedback that shaped the intellectual contributions of this dissertation. I aspire both to his standards of scholarship and his principled mentorship. Mary Jane Parmentier has been a significant source of support and facilitated my participation in study abroad programs that supplemented my fieldwork and improved my teaching. Ben Minteer's class on Environmental Ethics, and later his participation on my committee, were of great inspiration to me in developing the normative parts of this dissertation. Jamey Wetmore's detailed feedback on drafts from my second year project onwards and his knowledge of sociotechnical systems have been invaluable to me. Clark Miller's leadership of the HSD program and his investment in me as a scholar were also instrumental in my success.

I am indebted to fellow students Monamie Bhadra and Chad Monfreda who have given me feedback and support throughout the program. My thanks go also to Brenda Trinidad for her ongoing support. Brenda crossed the Strait of Gibraltar to join me on my first trip to Morocco, which included a winding bus trip through the Atlas Mountains and sitting through a 2.5-hour interview in French. Thanks to fellow students Carlo Altamirano Allende, Jen Fuller, Shannon Lidberg, Jason O'Leary, Cyndy Schwartz, and CSPO visiting scholars Raffael Himmelsbach and Sarah Davies, for their comradery.

My extensive travel was dependent upon the fantastic administrative staff at ASU including Bonnie Lawless, who processed multiple complicated travel forms, and Andra Williams, Lori Hidinger, and Karin Ellison for guiding me through the administrative steps necessary for success in the first cohort of an interdisciplinary PhD program.

I am grateful to the ASU Study Abroad Office for supporting me in three trips to Morocco and Spain. I am humbled by the student cohorts from these trips, many of whom were leaving the country for the first time and embraced Morocco with compassion, excitement, and an eagerness to learn. I learned much from seeing Morocco through their eyes. My thanks go out in particular to Parker Helble and Mary Munoz Encinas, who were student workers on the energy justice portion of this project and intrepid voyagers on the 2014 trip. I am grateful to my friends at International Studies Abroad (ISA) in Meknes, Morocco, including Dani Ostad. Shukran bizef to Iman Essamati from ISA for valuing my research when I was discouraged and to her family for welcoming me into their home and sharing the best meals I have had in my life.

I owe a deep debt of gratitude to the El Hilali family in Morocco for their hospitality, which that ensured I did not sleep on the streets during my fieldwork. Meriem El Hilali was instrumental in helping me to develop ongoing collaborations between experts in Morocco and the United States, and I am proud to have collaborated with the MENA Policy Hub, which she heads. Youssef El Hilali's help was essential in navigating daily life and language in Morocco. I am grateful to Mehdi Ounjema, for his insights and help with interviews and translation. Without Mehdi I would likely have become irreparably lost navigating the city of Rabat. Many government employees, researchers, businesspeople showed me great hospitality, welcoming into their offices for hours at a time, always with Moroccan mint tea. I also want to thank the Egyptians I met during my travels for welcoming to their country during a precarious time. Thanks to Angeline Cione for her support and for exploring Cairo with me in the midst of a revolution.

I am fortunate to have forged a serendipitous research collaboration with Boris Schinke of Germanwatch. This collaboration was instrumental in the development of Chapter 7 of this dissertation. My thanks go to Boris and the other collaborators in the Social CSP report, including our tireless Moroccan research assistants and translators: Fatima Ahouli, Souaad Ouzahim, Ghizlane Atik, Mohamed Ait El Haj, and Zakariya Ait El Bouhali. I am deeply grateful to the new NGO The Human Touch, for welcoming me, along with a group of American students, back to Ouarzazate with heartfelt hospitality.

I would like to thank Georgeta Vidican from the German Development Institute and Jonathan Walters for generously sharing their contacts.

I am very grateful to the NSF for my Doctoral Dissertation Improvement Grant # DNS0307 and to the Quantum Energy and Sustainable Solar Technologies Center at ASU (QESST) and the Consortium for Science, Policy and Outcomes for financial support.

Thanks to my parents for supporting me throughout the lengthy course of my PhD and to my grandmother who empowered me to take advantage of opportunities she did not have as a woman several generations ago. Last, but certainly not least, none of this would have been possible without Aubrey Wigner's support, for which I am deeply grateful.

TABLE OF CONTENTS

CHAPTER Page

CHAPTER Page

CHAPTER Page

LIST OF TABLES

LIST OF FIGURES

Figure Page

Figure Page

Figure Page

LIST OF ACRONYMS

ADEREE: Agence Nationale pour le Développement des Energies Renouvelables et de l'Efficacité Energétique

CAISO: California Independent System Operator

CSP: Concentrating Solar Power

CNRST: Centre National Pour Le Recherche Scientifique et Technique

Dii: Desertec Industrial Initiative/ Desert Power Industry Initiative

DSO: Distribution Systems Operator

EMP: Euro-Mediterranean Partnership

ESMAP: Energy Sector Management Assistance Program (World Bank)

EU: European Union

BMZ: German Development Agency

BMU: German Environmental Agency

BMWi: Germany Ministry of Economy and Technology

EU-MENA: Europe Middle East North Africa

ENSTO-E: European Network of Transmission Systems Operators for Electricity

FDI: Foreign direct investment

FIT: Feed-in-tariff

GIZ: German Development Agency

GW: Gigawatt

HVDC: High Voltage Direct Current transmission

DLR: German Aerospace Center

ISCCS: Integrated Solar-Combined Cycle System

MAD: Moroccan Dirham

MASEN: Moroccan Agency for Solar Energy

Mascir: Moroccan Foundation for Advanced Science, Innovation and Research

MCINet : *Ministère de l'Industrie, du Commerce, de l'Investissement et de l'Economie Numérique* (Ministry of Industry, Commerce, and the Digital Economy)

Med-EMIP: Euro-Mediterranean Energy Market Integration Project

Med-TSO: Mediterranean Transmission Systems Operator

MEMEE : *Ministère de l'Energie, des Mines, de l'Eau* et de *l'Environnement* (Ministry of Energy, Mines, Water, and Environment)

MENA: Middle East North Africa

MOU: Memorandum of Understanding

MSP: Mediterranean Solar Plan or Moroccan Solar Plan

MW: Megawatt

ONEE: *Office National de l'Electricité et de L'eau Potable* (National Office of Electricity and Potable Water)

IRESEN: Institut de Recherche en énergie solaire et énergies nouvelles (Institute for Research on Solar Energy and New Energy Technologies)

Kwh : kilowatt-hour

PSA: Plataforma Solar de Almeria (Solar Research Platform of Almeria)

PURPA: Public Utilities Regulatory Policy Act

PV: Solar Photovoltaics

PX: Power Exchange

QF: Qualifying facility

RCREEE: Regional Center for Renewable Energy and Energy Efficiency

R&D: Research and Development

RWE: *Rheinisch-Westfälisches Elektrizitätswerk AG*

SAP: Structural Adjustment Program

SAMIR: *Société Anonyme Marocaine de l'industrie du Raffinage* (Anonymous Moroccan Business for the Refining Industry)

SATA: Systems Analysis and Technology Assessment

SCOT: Social Construction of Technology

SIE: Société d'investissement énergétique (Energy Investment Business)

SMADER : *La Société Marocaine de Développement des Energies Renouvelables* (Moroccan Society for the Development of Renewable Energy)

SNIP: *Société Nationale des Produits Pétroliers* (National Business of Petroleum Products)

STEP: *Station de transfert d'énergie par pompage* (pumped storage)

STS: Science and Technology Studies

TREC: Trans-Mediterranean Renewable Energy Cooperation

TSO: Transmission Systems Operator

CHAPTER 1

VISIONS FOR ENERGY TRANSFORMATIONS: INTEGRATING POWER AND POLITICS ACROSS A REGIONAL SYSTEM

Burnt Norton

Time present and time past

Are both perhaps present in time future

And time future contained in time past.

If all time is eternally present

All time is unredeemable.

What might have been is an abstraction

Remaining a perpetual possibility

Only in a world of speculation.

What might have been and what has been

Point to one end, which is always present.

Footfalls echo in the memory

Down the passage which we did not take

Towards the door we never opened

Into the rose-garden. My words echo

Thus, in your mind.

But to what purpose

Disturbing the dust on a bowl of rose-leaves

I do not know.

-- *T.S. Eliot, the Four Quartets*

Just after sunset, I am sitting outdoors at a café on the Friedrichstraße in Berlin waiting for my dinner. As I look around me, I see all of the trappings of modernity on this commercial, cosmopolitan street. Nearby there is an H&M, Starbucks, Hugo Boss, and the Westin Grand. I hear bustling traffic and crowds of people speaking various languages, and the U-Bahnhof electric train rumbles below. As the sun sets, signs and streetlights begin to illuminate this modern "Great White Way," a term that described the first world's electrified streets. I imagine how much the Friedrichstraße has changed throughout its storied history. The new Kaiser Wilhelm Memorial Church is a half-mile from here, standing amidst the ruins of the original 1890 church that was mostly destroyed in intense bombing during World War II. As recently as 1989, the Berlin Wall divided the street separating East from West Berlin, and the past of the Wall is present in the brick line that still bisects the city. Checkpoint Charlie was active just down the street. As my thoughts return from the Berlin of the past to the present, I begin thinking of my recent interview with a consultant who is part of a group of investors from a consortium called Desertec, seeking to build a Mediterranean-wide electricity grid that would one day export solar energy from the Sahara Desert to Europe. As I look around at the lights forming the constellations of the city, I find myself wondering what this would all look like if the Desertec vision were to come to pass. In fact, what would it look like if the entire Mediterranean were powered with Saharan desert power?

While it is dark now here in Berlin, the late day sun is still shining on the site of a solar power plant under construction in rural Morocco. Some imagine that the electrons generated at that site could be transmitted underneath the Mediterranean and across Europe to light the streetlights in front of me on the Friedrichstraße. It occurs to me that very little would look different here, yet much would change as a behemoth, complex system would have to be constructed to make Berlin's Great White Way come to life at night with renewable energy from the desert sun rather than coal. I imagine a sea of mirrors glimmering amongst the empty sand dunes of the Sahara Desert, making the desert blossom with green electrons. Such a dream has been dreamt for a century and a half but that passage we did not take.

Six months later, I wandered through the village of Tasslemante, Morocco in the High Atlas Mountains of Morocco. My colleague remarked that this is an idyllic place. The mountain air smelled fresh, and there was not a cloud in the sky. Children played in the street and rarely saw cars. Palm trees glistened in the oasis, and the village was nearly silent. There were ruins of a Kasbah in the middle of the village, a testimony to the 3,000-year history of the Berber dynasties in this area. Despite this peaceful scene, these are not empty sand dunes—Ouarzazate, a city of almost 70,000 people, is only about ten miles away, and the broader Province of Ouarzazate is home to a fast-growing population of almost 300,000.

I saw an old woman in a pink traditional *djellaba* (robe) pulling brackish water up from a rudimentary well. Clean drinking water is a long walk from here. I climbed up the berm on the side of the village and saw the beginnings of construction on the world's largest solar energy facility just a stone's throw away. I wondered, what would people here think if the electricity from the nearby power plant were to be exported to power the Friedrichstraße? What would the outcomes be for social justice if the power system were globalized to bring together these disparate places—the commercial present of East Berlin with its storied past and the future of a small village at the door of the Sahara that lacks clean drinking water?[1]

Figure 1. Village of Tasslemante, Morocco, Photo by Author.

The Challenge of Designing Sustainable Energy Systems

Electrical grids are “critical infrastructure” in the industrialized world, driving economies supporting much of contemporary life (Farrell, Zerriffi, & Dowlatabadi, 2004). Electricity powers the production of goods like iPads and building materials, the operation of the Internet, the provision of water, and the production and transportation of food. Developing countries lack sufficient access to energy and lack sufficient capital to

[1] This scene follows the structure of the T.S. Eliot poem above.

build the energy infrastructure needed for a burgeoning population and escalating energy demand. They are also disproportionately exposed to global energy production's negative consequences, including climate change and human displacement. Worldwide, interdependent electricity systems are being envisioned that require partnership, integration, and negotiation among developed and developing countries. This research explores how actors separated by broad power and wealth disparities and heterogeneous energy needs envision regional sociotechnical systems and the technologies embedded within them. The visioning process, which is further defined below, plays a crucial role in guiding innovation and has a lasting influence on systems' shape as well as societal and justice outcomes.

The sustainability challenge related to designing a new energy system is a systems-level challenge. Renewable energy systems are not built from scratch but must be grafted onto obdurate existing infrastructure, as well as onto a sociopolitical landscape with disparate energy policies and goals. It is commonly assumed that renewable energy has not become a significant part of the energy mix because it is too expensive. I illustrate that the challenge is more formidable than this. The factors are not just economic, rather stakeholders must retrofit an existing system in a complex political and cultural landscape with a stakeholder network that has evolving goals. Even the most powerful companies in the world are struggling to transform energy systems to incorporate renewable energy. Although it is commonly assumed that renewable energy will *de facto* obviate the social, political, and justice problems oil causes and therefore be intrinsically sustainable, this study illustrates that this is not the case.

The most ambitious vision worldwide for a sustainable electricity system is unfolding in the Mediterranean region. The idea is to build dozens of large-scale solar and wind power plants in the Sahara desert and export part of the electricity to Europe. The initial vision was for a regional system that would supply North Africa, Europe, and the Middle East with sustainable and affordable power. It would entail building around 40 large-scale solar and wind power plants mostly in North Africa, interconnecting the somewhat fragmented transmission infrastructure of 38 Mediterranean countries, and linking North Africa to the European Union (EU) through undersea transmission cables. The organization most known for promoting this vision, the Desertec Industrial Initiative (Dii), is a limited liability corporation and a conglomerate of companies that at its peak reached 56 shareholder and partner companies. Dii's organizational structure and network rivals the novelty and complexity of its vision, not to mention the numerous other actors promoting similar visions in the Mediterranean.

The Mediterranean is a strategic site for research in regional and in transnational sociotechnical systems due to its unique regional development history. Recently, the EU provided a variety of incentives for integration, including allowing member states to meet renewable energy mandates with imported electricity from non-member states through Article 9. The Desertec vision is thus situated in a broader political and institutional context of regional energy integration. The EU's roots in regional energy integration trace back to the 1950s with the European Coal and Steel Community. The European Coal and Steel Community was not merely an economic liberalization project, it was a political initiative and fulcrum for spurring European integration and trust (Spierenburg

& Poidevin, 1994). It also sought to ensure that Germany was kept in check both economically and politically (ibid).

Morocco is also a strategic site for research, as it would be a crucial node in this imagined system. It is committed both to regional renewable energy integration and to developing 2 GW of domestic solar power by 2020, plus an additional 4 GW of wind and hydropower. Construction is already underway on the Noor solar power facility in the Atlas Mountains of Morocco, which, when complete, likely will be the largest concentrating solar power plant on the globe. Noor provides a case study relating to solar power's effects on local villages in the MENA region and how power plant siting would affect the energy justice dynamics of the regional system.

I used multi-scalar analysis over four years to understand the vision for an integrated Mediterranean electricity system from different perspectives. My objectives in this dissertation were analytic and normative: 1) to understand how a network of actors constructed and negotiated a vision for a regional energy system and 2) to evaluate the justice implications of electricity systems using a framework grounded in the justice and sociotechnical systems literatures and refined by this empirical study.

Desertec Vision Synopsis

After the Chernobyl nuclear accident in 1986, physicist Dr. Gerhard Knies dreamt of safer large-scale sources of energy. He made a back-of-the-envelope calculation that the world's sunbelt received far more than enough solar energy to power the world with energy from deserts. Knies noted that deserts have lots of space and sunlight stating, "within six hours deserts receive more energy from the sun than humankind consumes within a year." Because 90% of the world lives within 1,800 miles of a desert, and since HVDC can transmit electricity with losses of 3% over 1,000 kilometers, he calculated that the world could be powered from renewable energy from deserts.

Knies founded the MENA-REG conferences that convened engineers and politicians in Ghana, Amman, Cairo, and Damascus to discuss renewable energy development in deserts. A conference participant said, "Yeah and so this was very creative, very, very good. Also the guys from North Africa and the Middle East joining the project were very interesting guys from universities there, and it was a really fantastic cooperation."[2] During the second conference, the Trans-Mediterranean Renewable Energy Cooperation (TREC) organization was established. MENA-REG was later commandeered by the Germany Ministry of the Environment and lost its north-south collaboration goal, so the TREC founders broke off and changed the name of their vision to Desertec. TREC continued to promote the Desertec vision with the support of the Jordanian Prince Hassan, the head of the Club of Rome.[3]

At least three designs for a Mediterranean power system developed under the umbrella of the Desertec vision. Prior to an international renewable energy development conference in Germany in 2006, the German Federal Ministry of the Environment was searching for an ambitious project to showcase Germany's commitment to renewable energy. They funded the German Aerospace Center, DLR, to conduct three feasibility studies on TREC's Desertec vision to present at the conference. These studies fleshed out

[2] This quote is based upon interviews conducted for this study with those involved in the formulation of the Desertec vision.
[3] The Club of Rome is a think tank and network of intellectuals interested in addressing environmental and social problems.

what I call Design I, which will be further described in Chapter 5. One year later, the Desertec White Book was published, with an introduction by Prince Hassan and contributions from other Middle-East-North-Africa (MENA) region authors about how their countries could benefit from the vision. This illustrated support from the Southern Mediterranean for the vision. The White Book was then presented in Berlin to an overcapacity audience of 400 people in an evening presentation that ran four hours longer than expected, illustrating the growing interest in the vision. In 2008, the Desertec vision became the flagship initiative for the Union for the Mediterranean under the name Mediterranean Solar Plan.[4] Therefore, the Desertec vision had gained significant traction outside of the TREC network and was even adopted by the Union for the Mediterranean, the political authority responsible for Mediterranean integration.

In January 2009, the TREC institutionalized its vision by incorporating the Desertec Foundation, which is a nonprofit organization seeking to export the Desertec vision to other regions of the globe. TREC also helped to form the Desertec Industrial Initiative (Dii) as a private limited liability corporation. Dii was founded with 12 shareholder companies, including Siemens, Munich Re, and Deutsche Bank, to accelerate progress on the Desertec vision in the Mediterranean region. There were no North African companies initially involved. It was launched on July 13, 2009 in Munich, Germany in the largest press conference in Munich Re's history (Heckel, 2011). The

[4] The Union for the Mediterranean (UfM) was launched in July 2008 with the Paris Summit, led by the French. The development of the Union and its French leadership were controversial, especially with tension from Germany related to French control of the Union. It also struggled because of the controversial inclusion of Israel in the UfM. They searched for a non-political topic to guide the Union, and solar power was selected. The Mediterranean Solar Plan (MSP) sought to develop 20 GW of renewable energy and to harmonize the energy efficiency measures in the member states of the UfM. However, the plan is stalled because the involved parties did not reach a consensus on the roadmap in late 2014. While related to the Desertec vision, the Mediterranean Solar Plan is out of the scope of this study.

Desert Power 2050 studies published by Dii in 2012 outline what I call Design 2 in Chapter 5. A third design for the system later arose from the shareholder companies to fund virtual exports, meaning to finance renewable energy projects in North Africa through a surcharge on European electricity bills without building a regional power grid.

Visions of sociotechnical systems

In today's knowledge societies, large-scale sociotechnical systems' evolution is often guided by a distinct and systematic visioning phase (Borup, Brown, Konrad, & Van Lente, 2006). The visioning phase encompasses formal policy processes, such as developing roadmaps and steering a course for the future through legislation. These formal processes often include conducting studies to prove that the vision is feasible. The visioning phase also includes informal processes, for example, conversations and decisions made behind the closed doors of corporate conference rooms and government offices. It extends from the back-of-the-envelope calculations Knies made for the Desertec vision through to a concrete design up until construction begins. The visioning phase plays a crucial role in proffering, jettisoning, and cementing aspects of the system's design. Decisions made in the visioning phase steer innovation and have lasting influence on the system's shape. Visions are powerful and have effects in the real world even if nothing material is built.

It is important to better understand, and even improve, the visioning phase, as energy system builders grapple with long time horizons and uncertainty. An investment cycle in the power sector is between 25 and 50 years long, depending upon who one asks, as it encompasses planning, permitting, constructing, operating, and decommissioning.

Poorly planned dreams for electricity systems could later turn into nightmares. For example, the complex power market and transmission systems operator put in place in California in the 1990s liberalization push attempted to implement a new management scheme over a complex system, which led to rolling blackouts.[5] Better planning in the visioning phase could help system builders to anticipate future problems and avoid building technological juggernauts. As critical infrastructure, the Desertec system, if it were built, would be too big to fail. Therefore, the pressure to maintain it at all costs, even if it perpetuates the energy justice failures of the current system, would be great.

Visions are also important because they help to anticipate what technologies might play a role in destabilizing the current, obdurate electricity system. Geels added to the conception of sociotechnical systems the multi-level theory of sociotechnical regime change. He defines niches as incubators in which radical innovations could carve out a place in the system. Niches can break through the socio-technical regime up to the landscape level (Geels, 2004) but breaking through is difficult (Verbong & Geels, 2007). A niche could also be viewed as the future spaces or future moments that social groups then occupy in order to control the future (Brown, Rappert, and Webster, 2000). How are these windows of opportunity imagined, what problems do they create in the system, and how are these problems addressed?[6] The answer to these questions could lead to a more nuanced understanding of why it has been seemingly impossible to integrate renewable energy to significant scale into the 'energy mix.'

[5] See Chapter 5.
[6] See Chapter 5.

Visions also play an important role in innovation (Selin, 2006) by setting expectations for the technology and its future benefit. These expectations are "performative," because they attract and coordinate actors who influence or align themselves with the vision (Borup et al., 2006). Embedded in these imaginations are powerful ideographs (popular but empty terms), such as technological progress, which legitimate expectations for future social benefits from the envisioned technology or technological system (Van Lente, 2000). These expectations for social benefits become requirements after they are used to recruit supporters to a shared vision (Van Lente & Rip, 1998). What happens to this network of supporters when a vision must conform to the realities of construction delays, siting processes, and disruptive events, which could result in certain expectations not being met?[7] What forces are needed to accelerate a fantasy for a new electricity system from the dreaming, to the visioning, to the design, and finally to the construction phase?

Within the vision, expectations shape the depictions and assumptions of what society might look like in the future. However, in the visioning phase societal outcomes are often poorly thought through and unrealistic. Narratives of futures reflect ideologies, just as interpretations of the past do (Brown, Rappert, & Webster, 2000) Means of representing the future are often utopian, offering win-win promises greater than what can be achieved in reality (ibid). Geels & Smit (2000) argue that imagined futures for an emerging technology are biased by the cultural framings of the current period. They also argue that future representations of technology often reflect static conceptions of society and social practices.

[7] See Chapter 5.

Selin (2008) stated that visions are "speculative framings and expectations that accompany and fortify a new technological field" so as to "colonize the future." Expanding upon Selin's definition, this study develops a more concrete model of what a vision for a sociotechnical system is, as well as its anticipated societal outcomes. The components comprising a vision are scattered throughout the literature.

Table 1 collates these components, outlining a model of a vision, including the compositional factors of the technological system and its spatial distribution, as well as its representation of the future and promises for societal benefit. I call the actors shaping this vision the system imaginers. The vision is also shaped by the macro-level socio-political context and major disrupting factors, which scenario planners call wildcards. (Hughes terms these drivers the "system's environment.")

Chapter 5 expands and improves upon this model that was developed from the literature through further empirical study. It seeks to improve understanding of the processes necessary to move from a dream, to a vision, to a design, to a constructed power system in the desert. This is not necessarily a linear process, and the vision can move backwards across these phases. For example, technologies construed as elegant and sustainable in the design phase are reimagined and problematized when they are situated in particular sociocultural and geographic contexts, sometimes shifting the system design back to the visioning phase. The updated model will aid in understanding how the vision is constructed and negotiated over time and what processes affect whether it will come to be built in the future or deferred.

Table 1.

Model of a Vision Developed from the Literature

VISION	EXAMPLES….				
Technology & spatial distribution	Size (e.g. # of plants, transmission lines, # of sq mi)	Siting (power plants & transmission lines)	Technologies (e.g. PV, CSP, HVDC)	Cost estimates	Power distribution (North vs. South)
Depiction of & promises for the future	Promised effect on climate change/ environment	Assumptions about the future	Depiction of regional energy needs	Promised economic impact	Promised effect on development
DRIVERS	**EXAMPLES …**				
System imaginers/ Builders	Companies involved (e.g. date joined, sector, size)	Mergers, MOUs (e.g. Dii and MedGrid)	Staffing (Dii & Desertec Foundation)	Participating governments	Funders
Sociopolitical context	Regional political process on energy (e.g. Euro-Med Partnership, Union for the Med)	EU electricity policy developments	National renewable energy developments	Public opinion	Financial/ debt crisis
Wildcards	Arab Spring	Bankruptcy of major partner company	Radical policy shift toward distributed energy generation. Price of PV	Radical & disruptive technological innovation in energy sector	Fukushima (Japanese nuclear accident)

Research Questions

The research questions relate to generalizable questions of how sociotechnical systems are envisioned and designed, how they cross scales in a globalized world, and their enduring implications for justice. This research asks: How are regional sociotechnical systems envisioned? What forces and processes shape aspects of the design? How do design elements achieve closure, and what does it take to reopen a closed design feature? What are the anticipated consequences of a system for a region with broad power and wealth disparities, heterogeneous energy needs, and deep cultural differences? By examining this vision at multiple scales, what can be learned about energy justice and equity?

Electrical Power Systems in Brief

The Desertec vision case study illustrates that changes in energy systems extend beyond changes in individual technologies to a system-level. Even minor changes in the technological mix quickly scale up to challenges in systems governance and management. In order to appreciate these challenges, an overview of the current electrical power system is necessary in order to understand the significance of these systems-level challenges. Electrical power systems, which are for the most part currently centralized in configuration, consist of generation, transformation, transmission, and distribution (see *Figure **2***). First, electricity is generated mainly in large-scale power plants often sited in remote areas. Then, the voltage is ramped up for efficient transmission along transmission lines to cities. Once the power reaches cities, the voltage is ramped down for safe distribution along power lines to consumers. Utility companies then sell electricity to consumers.

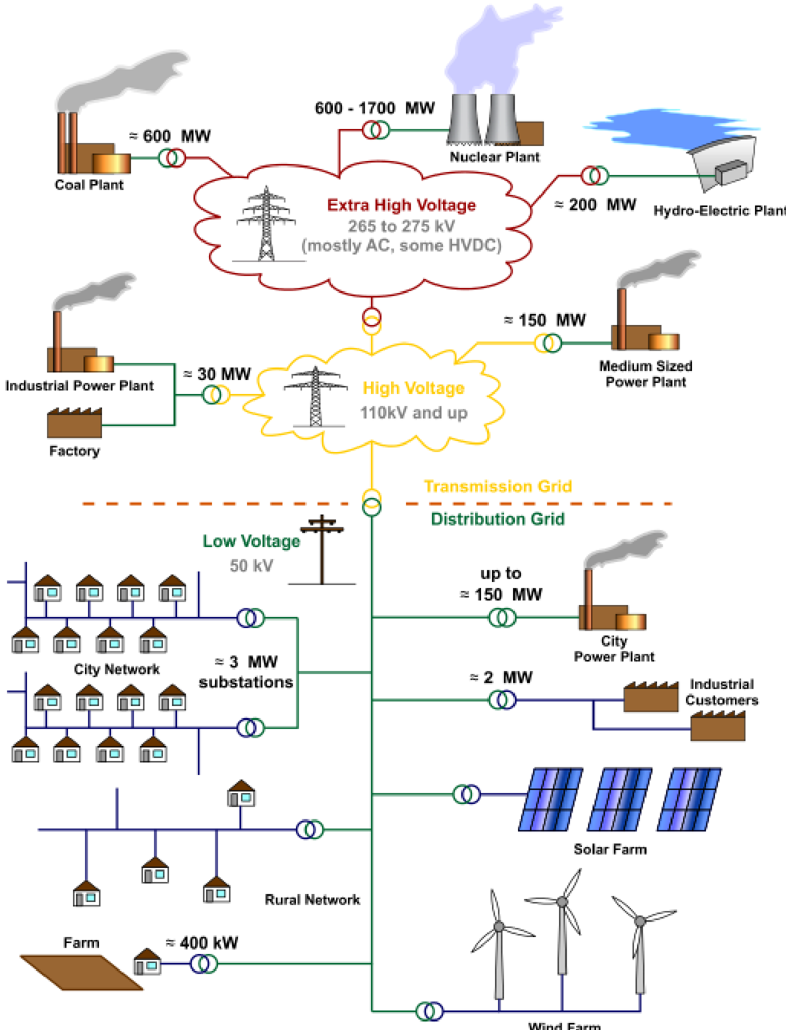


Figure 2. The Grid. From Wikipedia commons by MBizon.[8]

Electricity demand, also called the load, follows a curve throughout the day called the load curve. Peak hours of usage vary across regions based on the type of industry, services, and household usage in the area, as well as the weather. Load shedding occurs when supply cannot meet demand, typically during these peaks, and blackouts or brownouts occur. Curtailment occurs when supply exceeds demand and electricity is wasted.

[8] http://en.wikipedia.org/wiki/Electrical_grid#/media/File:Electricity_Grid_Schematic_English.svg

Different types of generation facilities are used to supply electricity at different points on the load curve. Baseload power plants, typically nuclear and coal-fired plants, run continuously and are difficult, costly, and inefficient to shut down and restart (see the baseload demand in *Figure **3***). Baseload power plants are also important for ensuring the system operates at a constant voltage. “Peaker plants,” typically natural gas plants, meet peak demand. Electricity is more expensive to generate during peak hours because peaker plants are generally old and inefficient. Power plants that can be easily controlled — turned on and off or ramped up and down— to provide electricity on demand are called “dispatchable” power sources. While there is no direct market for dispatchable power per se, it is valued indirectly for its role in ensuring the reliability of electrical power systems.

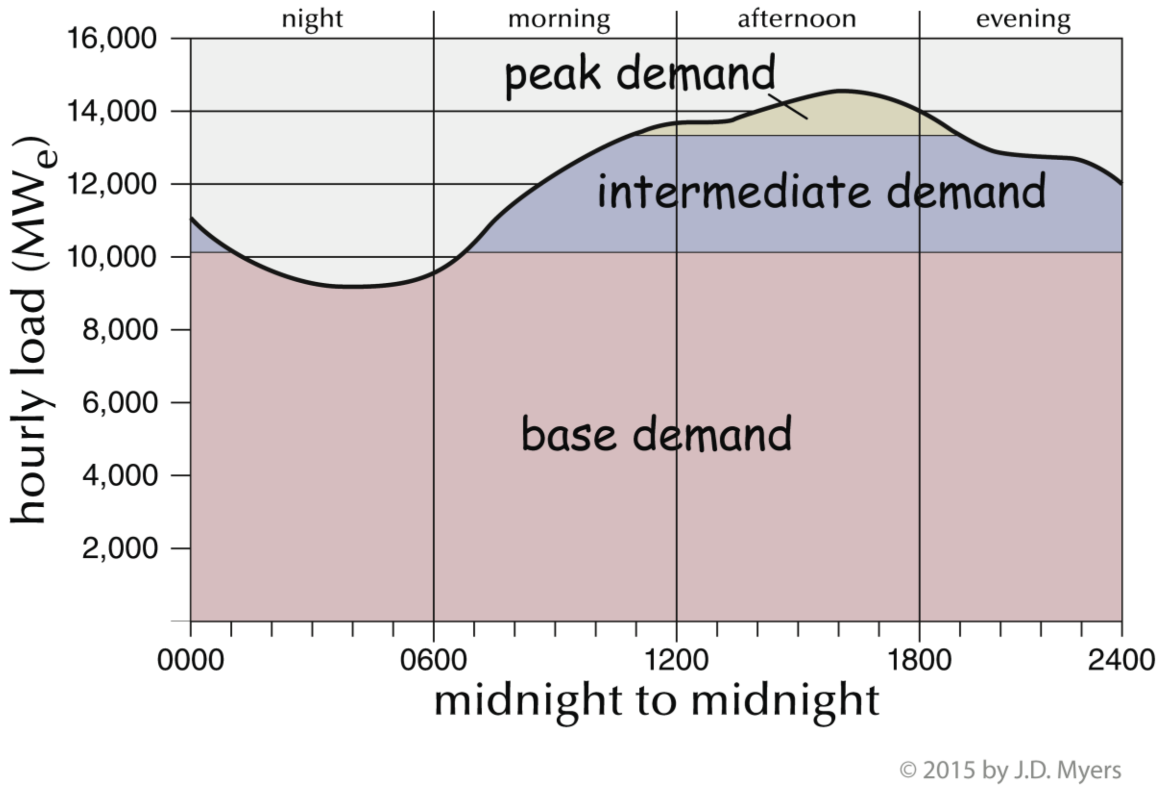


Figure 3. How the Load is Met During Different Times of Day, Source J.D. Myers, Used with permission.[9]

The Desertec vision illustrates how system builders are trying to integrate renewable energy into this system while maintaining its overall centralized configuration. This study discusses three main renewable energy technologies included in the Desertec vision—wind, solar photovoltaics (PV), and concentrating solar power (CSP, or solar thermal), with the greatest focus placed on CSP. Solar PV uses sunlight (photons) to generate electricity; the solar cells convert solar radiation directly to electricity through photons exciting electrons. Sometimes PV panels are sited en masse in the desert. PV can also be placed on rooftops for point-of-use generation. An electrical power system in which PV panels or other small-scale energy technologies provide point-of-use power for

[9] http://www.gg.uwyo.edu/content/laboratory/coal/economics/electricity_intro/demand/peak.asp?callNumber=23165&SubcallNumber=0&color=873F8A&unit=

homes or businesses is called a distributed generation system. In contrast, the Desertec vision imagines that these PV panels would be sited in large desert installations in a centralized system.

Unlike PV, CSP uses the heat from the sun to generate electricity rather than light. A CSP tower plant consists of a field of heliostats, or towers with garage-door-sized mirrors affixed on them, which concentrate sunlight on a central power tower receiver, heating air or water to drive a steam turbine to generate electricity. This generating system is very similar to that of a conventional power plant, although the heat comes from the sun rather than from fossil fuel combustion.

This study also addresses wind energy. Wind turbines use the kinetic energy from wind to turn the turbine's blades around a rotor. This kinetic energy drives a turbine to produce electricity. Wind energy became cheaper than CSP over the course of the Desertec vision.

By scaling up large-scale renewable energy technologies in deserts, the Desertec vision seeks to reach nearly a 90% renewable energy future while maintaining the overall system configuration described above. A key challenge facing renewable energy is how to scale it up while maintaining the reliability of the system and its overall centralized configuration. In the power sector, intermittent renewable energy is generally viewed as a challenge to system reliability. Unlike coal, which provides reliable power on demand, the sun does not always shine, nor does the wind always blow. Renewable energy is dependent upon the whimsy of the sun and wind throughout the day, and upon the seasons. Even flocculent, passing cloud cover disrupts the supply of power from large-scale PV plants. In contrast, CSP provides the system benefit of dispatchability. It can be coupled with thermal storage to generate electricity up to 20 hours per day—even at night— and it can be coupled with natural gas backup to even out the fluctuations during start up and passing clouds. CSP is more nimble than baseload power plants because it can be easily shut off by simply moving the mirrors to the stow position. By building dispatchable renewable energy technologies and integrating the transmission grid across a region, electricity companies involved in the Desertec vision hope to build a reliable, centralized system with very little fossil fuels.

Reliability is a highly valued systems trait in centralized electricity systems which renewable energy complicates. In my research on electricity systems in the U.S. West, I found that utility companies viewed themselves as selling the service of reliability, rather than the product of electrons (Miller & Moore, 2011). A lack of reliability has a high price on a country's economy; for example, Munich Re estimated that blackouts cost the U.S. economy $100 billion per year despite the fact that U.S. electricity infrastructure is typically very reliable (Munich RE, 2015).[10] A reliable power system is often seen as a precursor to growing a robust industrial sector in a country. Most regulatory bodies in Western countries require 10-25% reserve generation capacity in the system, which is generating capacity that is typically not used but can be quickly brought online if a spike in demand or an unexpected loss of supply were to occur. This ensures demand can be met and that system reliability will be maintained if unexpected increases in demand or failures occur.

Generally, it is possible to integrate up to 20% renewable energy generation capacity into the system without affecting reliability or radically reshaping it. Above 20%,

[10] Munich Re is a reinsurance company, including insurance provided to the power sector.

energy might not be available from intermittent renewable energy when it is needed. Therefore a transformation in the system would be required, such as building significant storage technologies or integrating the power system at significant east-west and/or north-south scale to compensate for seasonal variations and variations in demand throughout the day. For example, peak hours of usage in the afternoon in Germany would be balanced out by peak hours of usage in the evening in Morocco. The system would be integrated across such a large area that generation capacity would be available somewhere within the region to meet demand elsewhere in the region.

Expanding Sociotechnical Systems Analysis through Energy Transformations Analysis

Key to understanding changes in energy systems and their significance to society is conceiving of electrical power systems not as technological systems but as sociotechnical systems. Sociotechnical systems analysis combines analysis of the hardware of the system— power plants, transmission lines, transformers—with an analysis of the human, social, and institutional aspects of power systems—regulatory institutions, engineers, political frameworks, activist groups, villagers, and financiers. This is essential both to understanding how electrical power systems work and to evaluating their sociopolitical stakes. It also illustrates that energy systems—and the visions for the energy systems of tomorrow—are shaped by complex sociopolitical landscapes that cannot be ignored if new systems designs are to be made a reality.

Sociotechnical systems theory provides a meso-scale analytical framework for understanding how electrical power systems are shaped by political, social, and financial institutions (See, for example, Glaser, 2009; Hughes, 1983; Nye, 1990; Rose, 1995; Tobey, 1996). Much of what is known about how sociotechnical electrical power systems evolve has been developed through historical case studies, particularly Hughes' seminal work on how electrical power systems formed in the late 1800s and early 1900s in the United States, Germany, and England. These case studies offer a rich starting point for understanding how sociotechnical systems are shaped and evolve. However, I will argue that some of the assumptions made in Hughes' work about the set-up of these sociotechnical systems no longer hold true.

Hughes argued that electrical power systems are better characterized as sociotechnical systems, rather than technical systems, as they are shaped by social factors including economics, politics and political institutions, and geography. Therefore, technological standards—like the frequency of the transmission network—are often established for political or social reasons, not technical reasons. Hughes viewed systems as groupings of interacting parts arranged in a network configuration, which in the power sector have historically been centrally controlled and arranged hierarchically (Hughes, 1983). These systems develop within exercises of power to reflect the interests, values, and politics of powerful social groups. The system exerts an influence on its environment (e.g., on communities, landscapes, politics) and is also shaped by its environment (e.g., by geography, major events, policies) (ibid). Hughes' comparison among three countries illustrates that the electricity system is a "cultural artifact" influenced by the technological style of each individual country. For example, Thomas Edison's U.S.

system could not be transferred to Britain, where the political movement for municipal socialism shaped the electrification of the country.

In the first phase of sociotechnical systems development, inventor-entrepreneurs—or system builders—like Thomas Edison, possessed both the technical acumen to develop new technologies and the business and networking prowess to grow a system into which these technologies were integrated. In the second phase, the technology was transferred from one region of a country to other. In the third phase, the system grew and was influenced by the surrounding geography and country-specific technological style. In the fourth phase, the system achieved substantial momentum with mass, velocity, and direction. In the final phase, holding companies emerged to manage monopolies and consulting engineers gained prominence as problem solvers.

Once systems have achieved momentum, also termed path dependence or technological lock-in, they are remarkably difficult to change (Arthur, 1994; Hughes, 1994). It would most likely require a major event such as a world war to transform such systems, although I argue later that electrical power systems are continuously in transition at the microscale. For example, World War I was powerful enough to influence the momentum of the electrical power system. For example, Germany and the United States built monolithic power plants for war, such as the Muscle Shoals hydroelectricity power plant to provide the electricity needed for fertilizers and explosives (ibid). War also increased the interconnection and centralization of power systems to improve their efficiency (ibid). Actors can also make changes to the system within particular constraints through radical inventions (ibid). In some cases such inventions could transform the system, although this largely remains to be proven in the power sector since the centralized system arrangement has remained in place for over a century. Radical inventions typically emerge after a “reverse salient” is identified, which is a part of the system that is marching behind or out of sync (ibid). The people Hughes called “system builders” work to invent solutions to these reverse salients. If a solution cannot be found, the system must shift to a certain extent in order to grow.

This study will extend Hughes’ work in several ways. Most significantly, it will look in greater depth at the visioning phase for sociotechnical systems, which is typically not fully recorded in historical case studies but plays an important role in innovation and in shaping the electrical power systems of the future. It will also look at how sociotechnical systems are shaped across nation-state lines—on a transnational instead of cross-comparative basis. Additionally, it will extend Hughes’ view of the spatial and temporal factors that shape the system. Finally, as the goals for electrical power systems are expanding from powering cities to empowering sustainable development, I explore the energy justice aspects of energy transformations.

I also argue that the founding principles of the electrical power systems from 1880 are different today and that sociotechnical systems theory needs to be revised to account for them. The development of electrical power systems in the 21st century is a different challenge from what Hughes (1983) studied. Building a sustainable energy system includes a refurbishing and retrofitting agenda, as system builders cannot start from scratch but must graft new infrastructure on top of old systems. The most popular type of future energy technology assessment examines the simple substitution of a conventional technology like coal with a technology like solar power (Byrne et al., 2006). The Desertec case study illustrates that a new type of energy assessment is needed at the system-level because energy transformations relate to the integration of technology into systems. For example, if wind energy were used instead of CSP, this would reconfigure the overall shape of the system. In Hughes' case, this existing infrastructure did not yet exist.

The challenges at stake are not merely about electricity as they were in 1880 but also about water, poverty, food, and development. Rather than analyzing one technology versus another, energy policy for the 21st century must understand these broader, integrated system challenges. The problems the system builders seek to solve are not only technical but are social problems with major political challenges. A case study that explores future visions for electricity systems illustrates the values and goals underpinning competing dreams for energy futures and their anticipated outcomes.

Transnational Energy Transformations. This dissertation explores the social, political, cultural, and technological shaping of global energy transitions to better understand how sociotechnical systems are shaped. Energy systems are continually in transition to a certain extent, as power plants are decommissioned and fuel sources shift, the geographies of energy are rearranged, and fuel sources are depleted. Laird (2013) argued that the term "energy transition" has been used so narrowly to describe the technical aspects of substitutions in fuels and technologies that it masks the important social and political stakes of energy transitions. Scholars need either a new word or a complete reevaluation of how scholars and system builders conceive of energy transitions (ibid). This is not merely a matter of semantics but a call for scholars to design methodological frameworks sufficient to the task of understanding the social and political underpinnings of energy transitions. This dissertation uses multi-scalar analysis to focus on major disjunctures in energy systems that could destabilize their shape and result in extensive social, policy, and regulatory changes. I take Miller, Iles, & Jones' (2013) lead in referring to energy transitions as “energy transformations” to highlight the extent of these system-level changes.

Studying energy transformations in their early—visioning— stage, which is often not available in the historical record, illustrates the constitution of current energy systems. Moreover, it makes visible the sociopolitical conflicts surrounding changes to the modern infrastructure of societies that is often only visible when it fails (Davies & Selin, 2012; Edwards, 2004)— for example, the power poles that blend into the urban landscape, the energy generation that is out of sight, and the gas stations people are accustomed to seeing at every major intersection. While I agree with Starosielski (2012) that these infrastructures are, in fact, visible to certain populations and that this visibility is negotiated, it is also the case that these infrastructures are largely latent and invisible to the majority of people who benefit from them and overlooked by technological designers. Qualitative methods can be used from the perspective of an infrastructural outsider to observe changes in these often-invisible infrastructures.

The path of energy transformations across the globe is still uncertain, allowing for a window into their reorganization. Energy transformations relate fundamentally to scale e.g., centralized versus decentralized, point-of-use vs. remote, domestic versus regional. Below I describe the four possible scenarios (posed as questions in italics below) for the overall systems configuration of the future of electrical power systems I identified throughout the course of this research, which differ greatly from the context in which the power systems of the 1880s formed. In each case, the scale of the envisioned problem relates closely to how actors frame the scale of the problem. For example, the appropriate technology movement of the 1970s focused on individual-level solutions to environmental problems. The Club of Rome focused on planetary-scale problems and developed a solution related to massive transmission integration for efficiency and flexibility.

Scenario 1. Will future energy systems blend distributed and centralized generation, which is appropriately scaled to industrial and household needs, as recommended by Amory Lovins? In the 1970s, Lovins envisioned the "soft path," which, although often misunderstood as promoting green energy, related instead to the scale of energy generation. He called for technologies that are appropriately scaled to match their use; household demand could be most efficiently met with distributed PV panels, whereas a factory would be best supplied with centralized, large-scale sources of power (Lovins, 1977). In this vision, the most flexible sources of energy are those that are appropriately scaled.

Scenario 2. Will the power systems of the future be mostly distributed, with point-of-use generation and efficient storage? This option would construct a completely distributed, small-scale, point-of-use electricity system as advocated by the appropriate technology movement, Schumacher's Buddhist economics, and certain environmental groups worldwide. This would result in the most radical transformation in the power sector and would require a breakthrough in storage technologies likely coupled with a fall from power of the current energy system builders. In this vision, small-scale energy technologies are framed as the most flexible.

Scenario 3. Will centralized grids sprawl across four or five major regions of the globe to balance out intermittent renewable energy through massive systems integration? (This dissertation uses the term "regional" to refer to the Mediterranean region, not regions within a country.) The *Limits to Growth* report by the Club of Rome framed environmental problems at a planetary scale, arguing that the earth's population was fast outstripping its carrying capacity, which would lead to environmental demise (Meadows, Randers, & Meadows, 1972). Desertec, as originally promoted by the Club of Rome, envisions that the most flexible and agile solution for a growing planet is an energy system that is regional in scale. Environmental sustainability is framed as the integration of power systems to enhance efficiency and enable the use of less polluting energy generation, up to 90% renewable energy generation (Euro-Mediterranean Energy Market Integration Project, 2010). In this vision, the most flexible power system is an integrated one.

Scenario 4. Finally, will energy systems remain in generally the same configuration as today, powered by new and extreme sources of fossil fuels? The business-as-usual alternative would require more extreme methods of fuel extraction but not a systems-level transformation. Extreme methods of extracting fossil fuels, like fracking and ultra-deepwater drilling, along with new sources of fossil fuels like shale gas, will preclude an electricity transformation but at great cost to society and the environment. In this case, reliability and maintaining the traditional fossil fuel sector would be prioritized over environmental protection. Business-as-usual appears to be a more likely scenario in the United States than Europe.

Three major trends underway in power systems across the globe will affect which of the end scenarios described above might be reached in the future. Desertec provides a case study at the nexus of these three trends. The envisioned system transformations, and the trends observed during my empirical work, help to illustrate why system builders would consider the extreme measure of sourcing electricity generation from a different continent.

First there is an ongoing shift toward the *liberalization, or deregulation, of power markets*. Market liberalization breaks up longstanding vertically integrated monopolies in the power sector and reduces state control over the power sector. In states or countries with a vertically integrated monopoly in the power sector, utility companies control generation, transmission, and distribution. In states or countries with a liberalized market, separate companies control generation, transmission, and distribution. Most power markets are neither fully liberalized nor fully monopolized.

In Europe, liberalization has been changing the power sector since the 1960s (Verbong & Geels, 2007). In the 1980s, politicians and regulators across the globe questioned whether vertically integrated utility monopolies were the best arrangement for the sector (Hirsh, 1999; Dubash, 2005). This led to a global deregulation trend that was aggressively pursued by multilateral development banks and thereby shaped the power sectors of at least 70 countries (Dubash and Williams 2006), including Morocco. In many cases, the World Bank and International Monetary Fund (IMF) mandated deregulation as a prerequisite to receiving energy loans (Dubash, 2003; Dubash 2005). They expected that developing countries could become electrified without the strong state support and regulated monopolies essential to U.S. electrification (ibid). The Washington Consensus was disrupted by black-outs in California, Argentina, and elsewhere and by exposing the depth of the Enron Corporation's global malefactions in the energy sector (Dubash & Singh, 2005). However, many countries' electrical power systems are still in disarray following deregulation reforms made in the 1990s.

In the early 2000s, the World Bank acknowledged that the needs of each country's electrical power system are unique (Byrne & Mun, 2003). They shifted from a deregulation model to a Private-Public Partnerships model (Dubash & Williams 2006), which balances state and private control and is used today in the Moroccan renewable energy sector, for example. Despite this caution, there is still a general trend toward liberalization of power markets around the world. The liberalization trend will affect whether regional power systems can be built, as liberalized systems make it easier to sell electricity across nation-state lines. It will also affect how much distributed energy is built into the system, as liberalization generally allows small-scale generators of electricity to access markets.

The second trend is grafting *renewable energy technologies* onto existing systems. This could result in the most significant energy transformation. Today, the global recognition of the contribution of the world's energy system to climate change is bolstering actors' and institutions' attempts to shift toward renewable energy. UN Secretary-General Ban Ki-moon named 2012 the International Year of Sustainable Energy for All, which was recently expanded into the Decade of Sustainable Energy for All. Recently, Spain and Germany have integrated over 20% renewable energy capacity into their electricity systems to meet European targets. Changes up to 20% are framed as picking "low hanging fruit," or making the easiest adjustments to the system. Once renewable energy generation exceeds 20% of generating capacity, major systems transformations are no longer optional. Spain and Germany's system configurations have not dramatically shifted but are at a breaking point. Electricity storage or hydrogen would be possible technical solutions for balancing out intermittent renewable energy, but they are not well developed. This is because since the 1900s, baseload power plants have been "load-seeking turbines," and system builders have always constructed additional demand through promoting new uses of electricity, rather than designing storage technologies (Nye, 1990; Rose, 1995). Despite this historical lack of focus on storage, it is possible, although not probable, that a radical system transformation could occur from centralized power systems to distributed (decentralized) energy generation with storage. Another option would be to mix distributed and centralized electricity, although this would likely maintain a high level of fossil fuel generation in the system to balance out renewable energy's intermittency. A third option would be to integrate power systems across a region to balance out renewable energy's intermittency while allowing for 80% or higher renewable energy generating capacity.

The third, and most recent trend, relates to *electrical power systems crossing nation-state borders*. An expert from the major power technologies manufacturer ABB said "…the only solution for balancing seasonal mismatches of load and generation that we see with our knowledge of available technologies today is large, interconnected power systems."[11] Until recently, electricity generation and distribution has largely been based upon local markets, as opposed to oil, which is sold through global markets. More recent trends show that electricity systems have become increasingly *inter*dependent across the

[11] Based on an interview conducted for this study.

globe (Yergin, 2006). Choi & Caporaso (2002) argue that globalization is, in fact, largely the regionalization of trade and investment. Seen through this lens, system builders are imagining the eventual globalization of electricity markets. This has implications for north-south collaboration, the distribution of the benefits and drawbacks from energy systems, cooperation among diverse stakeholders, and energy geography. The impetus for integration is partly to address renewable energy's intermittency while maintaining the centralized systems configuration. Put differently, renewable energy, often see as a technology to promote energy independence, is in fact spurring greater energy interdependence.

While electricity has not yet become globalized, there are many examples of long-distance transmission projects and the early transnationalization of electrical power systems in which the electricity from a single generating station is exported across nation-state lines to meet the demands of another country's electricity system. On each continent, High Voltage Direct Current (HVDC) transmission lines are already transmitting electricity across thousands of kilometers. Below are some examples, although not a comprehensive list.

- **Asia.** Since 2010, a Chinese hydropower plant in Xiangjiaba has connected consumers 3,500 kilometers away in Shanghai via HVDC cables with a loss of 7%. The Greater Mekong Sub-region power market connects China, Laos, Thailand, Vietnam, and Cambodia. India and Nepal share electricity across borders.
- **Middle East**. In the Middle East, the Gulf Cooperation Council Interconnection Authority began trading electricity in 2010, linking Saudi Arabia, Kuwait,

Bahrain, Qatar, Oman, and the United Arab Emirates. Iran is selling electricity to its neighbors, including Syria, in order to skirt international sanctions that prevent it from exporting its oil (Mirsaeedi-Glossner, 2013).

- **Africa.** On the African continent, South Africa already uses advanced HVDC lines to connect its Cahora Bassa hydroelectric plant to Mozambique through the Southern African Power Pool.[12]
- **South America.** In South America, a 3,500-kilometer HVDC line is being built to connect the Itaipu dam in Brazil to load centers. Argentina exports power to Brazil through a 1,000 MW capacity line called the Garabi project**.** The Electrical Interconnection System (SIEPAC) project connects electricity across nation-state borders in Central America.
- **Europe.** In Europe, many electricity experts view the Nordic electricity market as the most successful integrated electricity market within the European Union.

Visions for more deeply integrated electricity systems, like the Desertec Industrial Initiative's vision for a supergrid and single electricity market in the Mediterranean region, would fully integrate electricity markets at a regional scale, which could lead to the globalization of electricity. This would link all three of the trends (liberalization, renewable energy, and transnationalization), because integrating intermittent renewable energy into the centralized system is the main impetus for regionalization and in order to construct this regional market the power sectors of each country would likely have to be liberalized. Dubash & Williams (2006) argue that the internationalization of electricity

[12] The Southern Africa Power Pool connects Angola, Botswana, Democratic Republic of the Congo, Lesotho, Mozambique, Malawi, Namibia, South Africa, Swaziland, Tanzania, Zambia, and Zimbabwe.

will pose many of the same sociopolitical considerations as the internationalization of oil. For example, they speculate that proposed interconnections across nation-state lines in Asia could result in an inequitable "electricity resource colony" relationship (ibid). Additionally, it could lead to oil-poor states to become rentier states, which are less accountable to their citizenry because they are not reliant on tax revenue (Ross, 2001).[13] Therefore, these rentier states are freer to make electricity policies based upon generating rents rather than increasing domestic access to energy. Mitchell (2011) turned this argument around by asserting that today's Western democracies are "carbon based" because unionized coalmine workers played a key role in developing regulations and institutions that spurred democratic reforms, supporting workers and mobilizing civil society. The core observation that is relevant to this study is that energy development and political development are closely intertwined. In this study, by political development, I am largely referring to the aspects of political development that relate to national and social cohesion and identity, as well as questions of a potential change in who participates in political decision-making following the Arab Spring[14] (e.g., new expert groups, youth, rural citizens). I found that a country's social contract or social pact for electricity, which is an informal agreement about what social benefits an electricity system promises to provide a country (Victor & Heller, 2006), is shaped by and shapes a country's political development. Power systems are also shaped by how nation-states frame what counts as a modern power system. I also found that unlike oil and gas

[13] A rentier state is "a state that derives a large fraction of its revenues from external rents," such as the sale of oil or the Suez Canal crossing (Ross, 2001).

[14] This is a controversial term with the problematic insinuation that the Arab World was frozen before the spring. Even the person who coined the term is skeptical about its usefulness. I use it in the dissertation because it is widely recognized.

pipelines, regional electricity integration requires concurrent and highly temporal integration of technological, social, political, and regulatory institutions, to an extent that oil markets do not. The scenarios and trends for the future of electrical power systems described above paint a much different picture from the context of Hughes' work in 1880.

Temporality. In addition to adding transnational analysis to sociotechnical systems theory, Hughes' attention to the temporality of these systems should be extended. Hughes began *Networks of Power* by calling on social scientists to pay more attention to temporality in their analysis by studying the past to interpret the present. In addition to understanding how sociotechnical systems evolved in the past, it is important to add to sociotechnical systems analysis a more complex understanding of the future as an ontological object and an examination of the upfront stages of innovation often not captured in historical documentation. Understanding projections of the future is essential for understanding energy transitions and transformations. Despite these important issues of planning across long timescales, the temporal aspects of energy transitions are often overlooked. To landscapes, Adam (1998) added the concept of "timescapes," stressing "the temporal features of living…its rhythmicities, timings and tempos, changes and contingencies." She theorized that through an Enlightenment shift from "natural time" to "clock time," humans have come to commodify, control, and colonize time. Energy systems are a key domain in which " [we] insert ourselves into the future" (Brown, Rappert, & Webster, 2000). Adam's concept of the "immaterial real" adds that even though the future does not yet exist, it gains a sort of ontological status by being constructed in the present (Adam, 2004). For instance, positioning the future as proximal or distant does work (Selin, 2008). Actors make representations of the future, which are "objectified on paper" (Brown, Rappert, & Webster, 2000). I found that there are methods by which system imaginers construct technological feasibility and maturity in an attempt to colonize the future through reframing the emergence of technology. Clashes over the construction of the future are the temporal versions of energy siting conflicts. Situating the future entails even more uncertainty than siting power plants.

Chapter 5 describes how Adam's conceptualization of timescapes should be added to Hughes' concept of momentum. Electricity markets are fundamentally temporal. Demand must match supply at each moment or the load is shed or curtailment occurs. Shifts in energy demand cannot occur quickly enough to account for these asynchronicities in power markets. If surplus electricity is generated in one country and cannot be exported, it will be curtailed and is as useless as surplus coffee beans that cannot be exported when global markets bottom out, for example. If intermittency is framed as the reverse salient in the system, then system imaginers see controlling time and the weather as the solution to this reverse salient. Temporal disjunctures stemming from the timescapes of renewable energy are one impetus for the transnationalization and potential globalization of electricity systems. Through massive systems integration, renewable energy's intermittency can be controlled.

In the past, electricity systems were crucial in constructing clock time, allowing people to work and play around the clock (Nye, 1990). Today, the Desertec vision illustrates a reconfiguration of electricity systems to match the natural time of wind and solar cycles. Without being integrated into a highly temporal system, renewable energy cannot produce electricity around the clock in the way that fossil fuels can. System imaginers are attempting to adjust the centralized system described above to account for these rhythmicities. These system-level temporal challenges are equally important to renewable energy's more often acknowledged economic challenges.

Transnational sociotechnical systems. Hughes wrote about the differences in technological style across three different countries. Today's world is more closely intertwined, although certainly not flat. Contemporary theories will need to address how transnational sociotechnical systems are developed. In addition to the cross-country comparison Hughes employed, contemporary case studies must address the internationalization, or even globalization, of electricity. One way of considering this shift to transnational electricity systems is through the lens of what Castells calls the "network society." The network society is characterized by the following traits: technology is not hardware but material culture (what [Bijker, 2010] calls technological culture), technology plays a crucial role in globalization, there is a growing ecological consciousness worldwide, and the importance of the nation-state is receding as multinational corporations and non-state actors gain power (Castells, 2000). Networks have eliminated centralized, hierarchical forms of organization, and infrastructure is characterized by the space of flows (ibid). These factors should be considered in contemporary theories on sociotechnical systems.

As the network society model would suggest, the perceived and actual changes in the role of the nation-state within the Mediterranean region have profoundly shaped the vision. Regional systems imaginers assumed regional markets could transgress nation-state borders. However, Morocco's national social pact for electricity, developed under a sovereign kingdom dating back to 1631, and its specific national-level electricity challenges, guide its domestic and regional plans for solar power.[15]

Also in accordance with the network society, I found that ecological consciousness is changing the temporal aspects of how actors imagine systems. This is partly due to an increased concern for sustainability and future generations. For example, Design 1 of the Desertec vision sought to build infrastructure that met integrated challenges, such as power plus water desalination; it considered the lifecycle assessment of the relevant technologies; and it aimed to mitigate carbon dioxide emissions at a large scale.

Access to infrastructure in the network society is uneven. Graham (2000) argued that one's level of power in society is closely coupled to those who have the best access—or any access— to high-reliability networks. Certain areas (e.g., neighborhoods, countries, communities) with preferential access to water, electricity, and communications infrastructure are "premium networked spaces" with more power in a globalized world (ibid). Premium-networked spaces "are the results of the *strategies* of coalitions of interests within the contested and highly complex geopolitical and governance context of their respective cities" (ibid, p. 186). The Desertec vision promises to extend premium-networked spaces to nearby developing countries to improve livelihoods. I found that many officials in Morocco saw themselves as being unjustly severed from premium-networked spaces due to European politics, although the justice outcomes of the networking process are highly dependent upon establishing a just process

[15] See Chapter 6.

for integrating regulatory and political frameworks. Chapter 8 addresses the procedural and other justice aspects of energy systems.

The central analytical question of the network society is how shared social meaning results from the networking of disparate spaces through an "instrumental, global logic" (Castells, 2000). Societies with similar infrastructures seem less foreign or exotic than those with different infrastructures (Edwards, 2000). In the Desertec case, is it possible to tie together such disparate spaces in a regional power grid? What inequities will result? Throughout the dissertation, I explore the issue of connecting people in remote desert landscapes to premium-networked spaces. This study found that an "instrumental, global logic" attempts to flatten sociopolitical differences both at the EU level, as well as the EU-MENA level, which was a major stumbling block to achieving the vision. Chapter 4 explores whether this integration discourse focuses on true collaboration and bridging political and socioeconomic divides, or seeks to promote unanimity in the region that keeps people separate but equal.

The interplay between technologies and systems. This dissertation examines the interplay between the framing of emerging technologies and the framing of systems. While the sociotechnical systems approach provides a mesoscale view of sociotechnical systems, the Social Construction of Technology (SCOT) approach provides for microscale analysis of how technological systems are socially shaped. SCOT illustrates that as fledgling technologies and technological processes emerge, stakeholder groups, including both users and technologists, form different framings of them through interpretive flexibility. Controversy develops around these competing framings, and through the mobilization of resources by the stakeholder groups technologies stabilize into a particular form (Bijker, 1995). “Closure” occurs when conflict is resolved and the artifact is declared to work, or when the technology’s problems are reframed as attributes (ibid).

Combining these approaches contributes to the understanding of systems-level challenges to better understand modernity and technology. It emphasizes that renewable energy technologies evolve within system contexts, and systems are shaped by the context of available technologies and the benefits or drawbacks they offer the system. This analysis provides more feedback between the SCOT technological framing approach, which is typically not studied in a systems-level context, and the sociotechnical systems approach, which often overlooks how microscale framings of technologies affect the shaping of the visions for a system. Chapter 5 analyzes the framings of ensembles of technologies within a systems context, considering what benefits they provide the overall system.

The politics of the technologies within the vision are then dependent upon the politics of the overall system. Langdon Winner argued that artifacts have politics, and infrastructure can legislate. He drew upon the example of the bridges in the New York City area that were designed to be too low to allow buses carrying people of color to reach wealthy beaches like Jones Beach (Winner, 1986). Furthermore, certain technologies, such as nuclear power, necessitate an authoritarian politics and governance by a “techno-scientific-industrial-military” elite (ibid). Winner says that technologies like solar PV are fundamentally democratic (ibid). If actors view technologies as mere tools—e.g., a hairdryer to dry hair—then they neglect to consider how these tools are embedded in systems composed of complex high technologies that restructure lives. He stated, "We continue to talk about technologies as if telephone and electric systems were analogous in their employment to a simple hand drill, as if an army were similar to an egg beater" (Winner, 1977, p. 202). This dissertation illustrates that technologies' politics are dependent upon the broader system in which they are embedded. I found that some of an energy technology's politics are flexible and others endure over time. The technology's politics were not as cemented in the visioning phase as I originally assumed they would be but are highly dependent upon procedural justice.[16]

Expanding the conceptualization of how geography shapes systems. Hughes observed that geographical factors shaped electrical power systems as they first developed. For example, the existence of large hydropower resources in California shaped the U.S. electrical power system by transforming nature into a resource and spurring the development of long-distance transmission systems to make up for "natural inadequacies" in other areas. This study builds upon Hughes' observation within a transnational context. Here too, the technological system is envisioned to enroll nature to account for spatial disjunctures in the distribution of energy wealth. But in the contemporary development of electrical power systems, the geographical scale is much greater, and I use a constructivist lens on the region's geography to illustrate how the actors' imagination and construction of geographical space through mapping and abstraction affect electricity system designs.

[16] See chapters 4 and 5.

Energy transformations reconfigure space, as power plants, transmission lines, pipelines, and other infrastructure are situated in specific places. These technologies and systems are shaped by their surrounding geography and shape or even dramatically re-landscape the geographies in which they are situated. Energy transformations change who sees energy systems and what they see. Energy siting conflicts have arisen over the new geographies of renewable energy, from conflicts about how wind turbines affect citizens' sense of place through disruption of viewsheds, noise, and avian death to large-scale solar power's effects on rare and endangered flora and fauna, to homeowner's associations placing restrictions on rooftop solar panels.[17] Much has been written about siting conflicts over renewable energy in Europe (Devine-Wright, 2011). This literature illustrates that citizens oppose renewable energy not just for instrumental reasons—reduced property value, noise, disruption of viewsheds—but for reasons relating to symbolic interactionism, such as the perception that the new technologies are "anachoristic" (Cresswell, 2004), or out of place within the landscape. Relatively land-intensive technologies like CSP (a 400 MW CSP plant requires about 4,000 acres of contiguous land) are contentious because they involve the loss of places that may be of material, cultural, spiritual, or visual importance to affected publics. Such effects would scale up to a system's level and reshape the region's geography, just as the geography influences the technological design. Chapter 7 examines the effects on local communities in Morocco of a CSP plant that is under construction as an example of the effects of siting renewable energy in North Africa.

[17] This is illegal in some states.

This study illustrates how these perceptions of landscapes, places, and even regions shape visions for sociotechnical systems. The relationship between new energy systems and human geography is complex and often contentious. In addition to siting concerns, this study addresses how regional electricity system designs reflect the constructions and representations of the region's geography. Energy justice has a spatial component, as some geographical features, and some populations, are invisible in these abstract representations, while others are prominent. If electricity systems become interconnected over greater distances, these issues of abstraction and scale will become more prominent in the calculus of energy justice. Chapter 4 examines the geographical shaping of the regional vision for an integrated electricity market. I found that the system is not just influenced by where the energy resources are as Hughes found, but also by how landscapes are envisioned, perceived, and mapped and the politics behind this process. The representations and framings of the region matter for energy justice, as they exclude particular populations and convey unity and separation within the region. Examining the spatial aspects of energy transformations make visible the political development issues at stake.

In fact, the spatial aspects of energy transitions illustrate a political development challenge in the West— that people want to live in premium-networked spaces but many want this infrastructure to remain invisible. As siting conflicts grow in the West, will electricity generation be pushed even further away from load centers into the developing world, and at what social consequence? Or, will electricity systems come closer to citizens, literally to their backyards? The head of the Desertec Foundation asked in an interview with me, "what is really the acceptance [sic] of these [transmission] lines? We have a discussion in Germany, a very intense discussion, of, yes, we need the lines, but not in my backyard."[18] The Desertec proposal, in part, responds to the attempt to address European resistance to power plant siting, which could be worrisome as the countries it looks to may have fewer democratic institutions and a less publically mobilized civil society than European countries. Through a transnational electricity system, the energy usage of one country would shape the landscapes of another. For example, Algeria's natural gas export industry has dramatically reshaped its landscape, mostly for European consumption (Ghosn, 2009). There are 16,000 kilometers of pipeline laid in Algeria and across the Mediterranean (ibid). Europe, in some sense, consumes much of Algeria's space. Chapter 5 illustrates that the Desertec vision was disrupted by transmission siting concerns in Spain, despite the attempt to site generation facilities on a different continent.

Multi-scalar analysis. Edwards (2004) argued that multi-scalar analysis should be used as a method of examining modern technological systems, because infrastructures look different on different scales of force, time, and social organization (Edwards, 2004). Each scale yields true but incomplete stories (ibid). The STS literature traditionally focuses on the microscale through the SCOT or actor-network approach, while the literature on modernity examines the macroscale. The SCOT approach is careful to attribute agency to individual actors in order to avoid technological determinism. While this is important it also risks missing broader systems-level and structural effects. The microscalar analysis of SCOT should be paired with meso-scale work on large technological systems as well as a macroscale understanding of political economy and

[18] Note that [sic] is used in interview quotes in this study to indicate a change in the grammar of the quote. Since many interviews were conducted in the interviewee's second (or even third or fourth) language, [sic] is used more often than usual in this study.

governments. Additionally, to examine the infrastructure of modernity, geophysical scales of force should be considered to account for the extensive effects of climate change (ibid). This dissertation explores the vision for a sociotechnical system across multiple scales, from the global history of CSP technology, through to a regional vision for an integrated sustainable energy system based partly on CSP in the Mediterranean region, to the national interpretation of CSP technology and visions for a Mediterranean energy system in Morocco, to the village level where the first CSP plants are being built. One theme of this dissertation is to explore the relationship between modernity and electrical power systems as the system imaginers conceive it.

A multi-scalar systems-level approach to energy justice. In addition to the analysis of sociotechnical systems, this dissertation also has a normative goal to evaluate the anticipated outcomes of building sociotechnical systems in a complex world. Energy justice in a globalized world is fundamentally multi-scalar. One area justice theory has not extensively explored is developing principles of justice for globalized energy systems that affect people differently at local, regional, national, and international scales. Energy technologies cross temporal scales throughout a technology's lifecycle. Complex energy supply chains interweave justice issues in disparate locations. For example, photovoltaic panels on rooftops in Arizona may be tied to rare earth metal mining in China where workers have insufficient protection from hazards. Germany's bustling commercial streets could be tied to energy generation in small villages in Morocco.

Decisions made in the energy sector today during the visioning stage will have significant effects on justice for decades to come. The massive investment needed ought to be guided by ethical principles early on, especially in order to build socially and environmentally sustainable energy systems. Systems-level justice calls us to collate the diverse ideas about energy justice, expand upon them based on reasoned principles, and re-evaluate them with a new framework. Chapter 8 presents an energy justice framework I developed from the justice literature and then applies and refines it using the empirical information from the Desertec case study. This chapter illustrates how sociotechnical complexity relates to the energy justice challenge. It adds to the framework issues identified in the dissertation relating to moving from the outmoded concept of energy sovereignty to capacity building and freedom from coercion, energy security and human security, trade-offs and win-win discourses, as well as systems justice. This framework ties together the various analytical components of the dissertation into a normative, principled framework for use in planning large-scale energy systems.

Conclusions: Contemporary Energy Transformations

Part of what Hughes wrote about the development of electrical power systems in the United States, Germany, and England includes generalizable factors about how electricity systems develop that hold true today. Above I discussed how this study updates Hughes' findings to include the visioning phase and to account for the fact that electricity systems of the 21st are not built from scratch but built on top of existing systems. I also discussed how the conceptions of the spatial and temporal aspects of electricity systems should be updated. Below I discuss several additional findings related to theories on sociotechnical energy systems.

Situated emerging technologies and deferred dreams. I found that CSP, and the dream to build a massive energy system in the Sahara, have been deferred dreams for over a century and a half. This illustrates that the emergence of a technology is situated with its political development context and history. Time past, time present, and time future must be accounted for to contextualize a technology's emergence. Whether a technology is framed as emerging or mature depends upon the constellation of actors advocating for it. Today, in the Desertec vision, CSP is framed as a mature technology subsumed under a vision for a broader system. In Morocco, it is framed as emerging, and in need of research and development, because it is being pursued under Morocco's broader industrial strategy to help it emerge as a knowledge economy. Furthermore, the politics of these emerging and reemerging technologies are not set in stone. In the 1880s, CSP was framed as a technology to dominate nature and humans and later as a technology that could fight climate change and connect two culturally disparate continents.[19] (The one framing of CSP that remains consistent is that of an energy farm.)

Emerging technologies are deferred for a variety of reasons. The most important is their failure to be integrated into a system, which is often because they do not meet the system's scale and needs. Renewable energy has often been seen as too difficult to scale up, too weak, and incapable of contributing to a reliable power system. Alternatively, it is imagined as being built in a completely distributed fashion that does not fit the current systems configuration; these visions of renewable energy as distributed have impeded the progress of large-scale renewable energy. When CSP reemerged in 2005, it did so in the context of a vision for a broader system.

[19] See Chapter 3.

I found that the vision shifted along the continuum from imaged to constructed. Proving that the system, and the ensemble of technologies therein, was feasible was an important step in shifting the vision from designed to a constructed reality. However, when Desertec's promoters disagreed on the method of proving feasibility, it unmasked substantial value conflicts and pushed the system design backwards toward the dreaming stage.

New reverse salients. While Hughes examined technological asynchronicities, or reverse salients, that led to changes in systems, the main reverse salients in systems today are posed by broader environmental and social challenges—such as global climate change and population growth. Today, system builders are working within a complex context with broader sustainability goals not considered when the initial systems were built. In the 1800s, CSP was framed in terms of the domination of nature, but when it reemerged in 2000s, it became part of the sustainability debate about living harmoniously with nature. Unlike with the domination of nature framing, which sought to remove ethical restrictions from technological development, society now seeks to imbue democratic culture with ethical restraints to technological change. In the 2000s, people started asking not just whether CSP was technologically feasible, but whether it was socially feasible and environmentally desirable.

Rather than simply providing people with heat and light, electrical power systems are now being called upon to address integrated solutions. For example, meeting the challenges of the energy-water nexus was an important part of the initial Desertec vision but was lost in its second instantiation. When construction started on CSP in Morocco in a water scarce region, the question of the energy-water nexus reemerged, and it became clear that addressing the energy problem without addressing the water challenge was unsustainable.

Innovation. Unlike in 1880, system builders now perceive innovation as a deferred dream, and principles behind it, successfully taking root, rather than the deployment of novel energy technologies. A modern energy system is not necessarily an innovative one, but a vision whose time has come. This is evidenced by the relative absence of the inventor-entrepreneurs key to Hughes' story; instead, the system imaginers of today are "project accelerators" seeking to speed progress toward a particular future rather than invent technologies that scale up into systems. The drawback of this perspective on innovation is that it does not capture the massive system-level transformations entailed in deploying renewable energy, nor does it address how technologies should be designed to improve the capabilities of people living in specific contexts.[20] What largely goes unaddressed is that the innovation involved is in massive systems integration across nation-state borders and its management, more so than in developing renewable energy technologies.

Political development, sovereignty, and energy systems. A modern energy system is framed differently in different political contexts. Desertec's proponents have sought to accelerate progress toward what they have constructed as an inevitable future to make technologies whose time has come a reality. In contrast, Morocco is balancing its past, present, and future within its electricity policy, and is attempting to address multiple social challenges through a social pact for electricity generation. The Moroccan state has viewed a modern electricity system as a centralized one from the Protectorate through to

[20] See Chapter 8.

King Hassan II's giant dam building projects for irrigation and electricity that he continued after independence from France. As a technology long framed as an energy farm, CSP would balance Morocco's past and present as an agrarian society with its imagined future as a knowledge economy. Political development questions, such as how much power should be apportioned to public versus private actors in society, that were fundamental to the development of electrical power systems in the United States would be made at the multilateral level rather than the national level under the Desertec vision.

These political development differences and national specificities in power systems illustrate how difficult it would be to build across a region in reality. Visions for new systems face difficulties when they do not sufficiently account for the complex existing context in which they would be built. Regional systems pose unprecedented political development and multi-lateral cooperation challenges. A supranational regulatory body would have to be established to govern the regional system (called the High Authority in the case of the European Coal and Steel Community (Spierenburg & Poidevin, 1994)). A "region-state" with harmonized policies, standards, and rules would have to be established for the system to function properly. Warleigh-Lack & Robinson (2011) draw upon Hettne & Soderbaum's theorizing on the social construction of regions, to define a region-state (or regional multilateralism) as a "new, multi-layered organization that based on voluntary evolution by its member states has developed into a novel, heterogeneous form of statehood," or the highest level of "regionness" (p. 259). They also see the region-state as "hypothetical" and "unlikely" (Hettne & Söderbaum, 2000). Countries' lofty goals for their energy systems and their focus on developing national pride for them could be contradictory to the multilateral cooperation needed to build a regional energy system.

Chapter overview. *Chapter two* describes the multi-scalar methodology used in this study. At the global and historical scales, *Chapter three* illustrates how an energy technology's emergence is situated in particular contexts and time periods by describing CSP's century and a half long history as a deferred dream. By taking a longitudinal approach, it identifies how the framings for the technology have shifted over time, with the exception of the enduring solar farming frame. It identifies the reasons why CSP and other large-scale engineering dreams for deserts failed to take root. It also discusses other deferred dreams for engineered systems in North Africa, illustrating how the complex sociopolitical landscape prevented these dreams from becoming a reality.

At the regional scale, *Chapter four* illustrates how the Desertec vision is couched in the Mediterranean politics, its history, and national and global conceptions of energy security. Then it analyzes the various geographic representations and framings of the vision for Mediterranean regional systems integration and how these representations affect possible energy justice outcomes and reflect the politics involved in shaping a transnational sociotechnical system. Through this, the chapter extends Hughes' observations of how geography shapes sociotechnical systems, as well as how transnational sociotechnical systems are shaped. Also at the regional scale, *Chapter five* resumes CSP's history as it is enrolled in the sustainability debate in Europe in 2005. It illustrates that the power sector does not see innovation as deploying novel or radical technologies; rather, they see innovation as realizing a deferred dream for CSP and a renewable energy system in the proximal future. It describes the temporal tactics that actors use to attempt to root the vision in reality. To illustrate this, it compares and contrasts three versions of the Desertec vision over time and describes the societal factors that shaped them, especially regional politics and value conflicts within the Mediterranean region and among the stakeholders advocating for the Desertec vision. This comparison also examines the interplay between technology-level and systems-level framing. This chapter illustrates the importance of viewing renewable energy transitions as systems-level transformations—not as a matter of adopting new technologies.

At the national level, *Chapter six* voices Moroccan views on renewable energy integration in the Mediterranean and illustrates how the Morocco Solar Plan fits into broader plans for an integrated Mediterranean electricity market. It also explores the domestic political and social development issues related to renewable energy systems transformations at a nation-level. I found that Morocco's renewable energy strategy has become part of nation-building and nation pride as well as an evolving social pact for the benefits of electricity systems in post-Arab Spring Morocco. How Morocco imagines a modern electricity system relates closely to its political development. Morocco adopts the solar farming frame as a method of straddling its agricultural past and present with a vision to transform Morocco into a future knowledge economy with a robust national system of innovation. This illustrates a delicate balancing act among the past, present, and future that has long been important in Morocco's political development. While the first Desertec vision framed CSP as a mature technology, Morocco frames CSP as an emerging technology that could help it emerge as a knowledge economy, further illustrating that a technology's emergence is situated in political and historical context. Through it renewable energy strategy, Morocco is building its capacity as a country to be in a more advantageous position in the international community, free from coercion. This chapter also illustrates how a regional electrical power system would be couched in a complex backdrop affecting multilateral electricity systems planning.

At the local scale in Morocco, *Chapter seven* analyzes the effects of the siting and early construction phase of the world's largest CSP plant under construction in Morocco on local villages. It continues with the themes of political development and modernity in electrical power systems, exploring what the public engagement process around solar siting might mean for the broader decentralization of governance in Morocco. I found strong local support for energy integration but also found that the siting process lacked sufficient local buy-in and compensation. This chapter problematizes the win-win discourse relating to Mediterranean electricity systems integration, which generally does not consider the local scale. No system is a win-win; there are always trade-offs at different scales, especially as integrated challenges such as the energy-water nexus arise. Therefore, I compare the benefits and drawbacks of national-scale versus local-scale integrated development projects. At the level of multi-scalar systems justice, *Chapter eight* uses this multi-scalar empirical information to apply and test a framework for energy justice developed from the literature. The chapter ends with a summary of visions for just energy systems.

CHAPTER 2

MULTI-SCALAR METHODOLOGY

Overall, I used mixed qualitative methods drawing from history, social science, and communication studies to analyze the evolution of the Desertec vision at multiple scales. Qualitative data analysis often focuses on a single scale. This study's design is unique in focusing on multiple scales. In order to understand the effects of a transnational energy system, it is important to look at the scale of local communities, who will be affected by power plant siting; national governments, whose visions for their domestic energy policy and security affect the potential for multilateral electricity systems planning; regional processes and politics; and even global scale effects like climate change and the global history of CSP technologies. If I had looked only at the regional scale, I would have missed the significant effects of decisions made in Berlin on, for example, small villages in Morocco. These multi-scalar effects are important to the calculus of energy justice, as I will argue in Chapter 8. I brought a diverse data set, including documents, images, tweets, interview transcripts, observations, and news clippings, to bear on the research questions. I conducted fieldwork primarily in Morocco and Germany, as well as Egypt and Spain, including helping to lead two ASU study abroad trips to Morocco and Spain. At the global scale, I used historical methods to understand the evolution of CSP technology. At the regional scale, I interviewed decision-makers and conducted document analysis related to the development of the regional Desertec vision. At the nation-state scale, I used fieldwork, interviews, and document analysis to understand national Moroccan views on regional energy integration. At the local-scale, I used interviews and fieldwork to understand how local communities would be affected by the construction of a regional power system.

As an American studying Desertec and Moroccan energy systems, I was often asked to justify my presence as the exotic other. A key anthropological premise is that having distance from the culture is useful in observing *in vivo* issues that are so obvious to actors immersed in the culture that they are overlooked. Furthermore, energy issues are fundamentally international and multi-scalar; as a U.S. scholar it is still essential to understand the energy systems in other parts of the world in order to understand energy domestically. My perspective as an American researcher who has studied CSP siting issues in California and energy transitions in Arizona gave me an informal source of constant comparisons useful in understanding energy transitions in the Mediterranean. However, the researcher as a "human instrument" is at a disadvantage conducting shorter-term fieldwork in multiple countries, which requires quickly overcoming the early stages of culture shock to begin research. This was inevitably a research project seen through the lens of an American studying issues outside of her domestic context.

News Analysis

Prior to entering the field, I conducted news analysis on Desertec. I used Zotero to store and organize news clippings on Desertec and snapshots of webpages. This news analysis aided in understanding how the media was framing both the Desertec vision and the Dii, as well as the public responses to the vision that shaped it over time. I sampled Dii news articles by collecting articles over a two-year period through Google news alerts and email newsletters. Then I conducted a Google search, a Google news search, and a

LexisNexis search for “Desertec Industrial Initiative.” I gathered 396 articles, which was close to the population of unique, non-repetitive articles on Dii in English and French when I conducted the analysis in early 2013. I removed Dii and company press releases from the sample to distinguish Dii’s discourse from the media’s discourse. I analyzed Dii’s tweets and Facebook feed separately. Much of the coverage was in niche news sources on energy and environment (29%) and blogs (20%). European and North African newspapers (26%) and magazines (9%) represented the rest of the coverage, with sources including *The Guardian* (UK), *BBC* (UK), *Der Spiegel* (Germany), and *El Watan* (Algeria). The U.S. media rarely covers Desertec.

I uploaded these articles into NVivo software and coded roughly half of the sample (193 articles) for the metaphorical language used; descriptions of Dii; discussions of temporality and speed; and key words, such as vision, concept, and barren land. The metaphor analysis yielded 802 instances of metaphorical language, which I grouped into 82 metaphor themes. I further organized these groups into 16 categories. Coding can be a reductionist method. To address this in all of the coding I did throughout the study, I created longer codes including more context and wrote memos and annotations throughout the coding process. I triangulated this analysis with other document analysis, interviews, and fieldwork.

Document Analysis

I conducted extensive document analysis including reports and magazines from the CSP sector, especially through *CSP Today* magazine; flyers, pamphlets, and other promotional materials from conferences and industry events; Moroccan and European policy documents; and reports from various institutions advocating for Mediterranean electricity systems integration including TREC, Dii, the Desertec Foundation, the Desertec academic network, the Union for the Mediterranean, Medgrid, and Res4Med, as well as some similar initiatives to build clean technologies in the deserts of MENA (e.g., Sahara Forest). This allowed me to understand how the industry and policy sectors framed the project and how it fit into broader framings of energy security and foreign policy.

Six documents were particularly crucial for tracing how the Desertec vision evolved over time. The four volume (400-page) MedRing studies (final version 2010) on electricity integration in the MENA region provided a crucial starting point for understanding the current state of the Mediterranean transmission ring and its imagined future as an integrated power system with a particular, constructed geography. I did not code the Medring studies due to their length but instead analyzed them heuristically. Second, I analyzed the three Desertec feasibility studies from 2006 conducted by the German Aerospace Center, DLR (most importantly Trans-CSP, but to a certain extent also Med-CSP and Aqua-CSP). Third, I open coded the 2007 (first edition) Desertec White Book, a qualitative document outlining the problem Desertec sought to solve and reiterating the DLR vision, as well as the 2009 Desertec Red Paper, which was initially the Desertec Foundation's main promotional report. These documents allowed me to understand the construction of feasibility, the system goals, the technology properties, and other elements of the first version of the vision. Interview data helped to triangulate this information and understand the founding visionaries' perceptions of the vision and how it changed.

I then open coded the first half of the 142-page Desert Power 2050 report, Dii's first major study released in 2012. This report was instrumental to my understanding of the design of the system for which Dii was advocating, and it provided a point of comparison to the first vision. I studied, although did not code, the *Desertec Getting Started* study, which described the initial steps Dii thought should be taken to implement the vision. I triangulated this with extensive data from interviews with shareholder companies, particularly to fill in gaps about how they anticipated the system would benefit society. I found that open coding these lengthy technical documents yielded some insight but was generally unwieldy. More targeted coding of these documents for terms such as sustainability, foresight, social benefits, terms related to speed, and particular system and technology traits was in the end a better method for identifying the main goals for the technology and the system. This updated coding was informed by interviews with key systems imaginers who helped me to identify the main issues I should be analyzing.

Visual Analysis

I triangulated the results of the document analysis with analysis of visual images and video clips. Visual images offered concrete representations of Dii's vision of the future, illuminating the cultural milieu in which the vision was constructed and related biases, such as Orientalist prejudices. Data sources included visual depictions of the

Desertec vision (e.g., maps, transmission schematics, solar radiation maps); industry promotional videos from Dii and its shareholders, such as Flagsol's "We are developing the future"; shareholders' advertisements; and pictures I took in the field. I explored a variety of issues related to the composition of the images. What kinds of people—if any— are portrayed or left out of the images? How is the technology framed (e.g., portraying the technology's scale, relation to social progress, and revolutionary potential)? How is the landscape proposed for development portrayed (e.g. uninhabited, wasteland, wilderness)?

Moroccan Scoping Trip

I used Morocco as a case study within the vision for Mediterranean electricity systems integration. This case study allowed for exploration of North African perspectives on regional integration. It offered generalizable lessons for understanding how visions for regional integration relate to nations' politics, political development, and history. Additionally, Morocco would be a crucial node within the Desertec vision, and it is therefore important to understand its perspective on Desertec in order to evaluate the future prospects of Mediterranean electricity systems integration. However, caution should be taken in presuming that Morocco's support for Desertec applies to all countries in the MENA region, as it has closer relations with Europe than most other MENA countries. Chapter 6 further discusses the merits and drawbacks of Morocco as a case study.

I first visited Morocco in June 2012. During this trip I traveled to Rabat, Casablanca, and Marrakech. I then took the bus over the Atlas Mountains from Marrakech to Ouarzazate. The winding treacherous road underscored this region's isolation. A PhD student from my program traveled with me for part of the time, which provided an additional perspective during the observations. I made a number of contacts with Fulbright students, Peace Corps volunteers, U.S. embassy employees, and government officials in the renewable energy sector. I conducted preliminary interviews with the representatives from the World Bank and Association Tichka, an NGO working in Ouarzazate primarily on clean water issues and distributed solar energy. In Rabat, I met the head of the YAANI, the Young Arab Policy Analysts International, (which later became MENA Policy Hub), who was instrumental in helping me find housing and make contacts. This led to an ongoing collaboration and later a letter of intent for cooperation between ASU and the MENA Policy Hub. We had a half-day discussion/debate on sustainability with young professionals from MENA Policy Hub on the two study abroad trips.

Study Abroad Trips

I helped to lead two ASU School of Sustainability trips to Morocco and Spain in May-June 2013 and 2014, called "Sustainable Development Across the Mediterranean." These three and a half week long trips—with a third planned for 2015—were crucial for connecting my research to teaching, and it allowed me to see Morocco in a new light through the eyes of the students. The programs provided a mobile classroom through which we studied multi-scalar energy development from the upper echelons of the

Moroccan government in the capital city, all the way to NGOs that work at the village level, including the High Atlas Foundation and the Human Touch. We started in the capital city of Rabat, which added the following group meetings to my sample: two visits to the Ministry of Industry, Commerce, and New Technologies (later called the Ministry of Industry, Commerce, and the Digital Economy, as more agencies emerged to govern other new technologies) or *Ministère de l'Industrie, du Commerce, de l'Investissement et de l'Economies Numérique* (MCINet) to learn about Morocco's industrial policy; an additional visit to the *Société d'investissement énergétique* (SIE); a tour of the laboratory facilities and Q&A session with three officials at an energy research organization called Mascir; a meeting with an energy economist at the U.S. embassy; a meeting with officials from the German embassy and the German KfW development bank; two additional meetings with the Moroccan Agency for Solar Energy (MASEN), and a meeting with an official from the Ministry of Energy.

We traveled from Rabat to Marrakesh to Ouarzazate, where, in the second year, we stayed at Dar Taliba, a boarding school for rural young women, providing significant cross cultural interaction between ASU and Moroccan students and staff. Outside of Ouarzazate, we visited the village of Tasslemante, adjacent to the construction site of the Noor facility. We then traveled to Kelaa-Mgouna, the site of the Moroccan rose festival and a dagger cooperative to understand local development programs. From there, by way of the Valley of a Thousand Kasbahs, we journeyed to the desert town of Merzouga along the Algeria border, where we rode camels and camped in the desert, met desert nomads, and experienced an unreliable electricity grid. Next, we traveled through the village of Boumia where a Moroccan family with ASU connection served us a meshwi (sheep's leg), chicken, and couscous—the most generous meal a guest could be served. We also visited the family's organic apple orchard and learned about the challenges encouraging local farmers to try organic farming, as well as the difficulties accessing European markets. From Boumia, we visited the imperial cities of Fes and Meknes. After stopping at the beach town of Azilal, we journeyed to Tangier and then took the ferry across the Strait of Gibraltar to Spain through Morocco's brand new Tangier-Med port, a part of its industrial policy.

The journey between two continents allowed us to compare the conceptions of sustainable development between the two countries with widely different cultures. In Spain, we visited Sevilla and Granada, including the Alhambra, which illustrated the deep historical roots between the two countries back to Andalusia. We took a day trip outside of Granada to the Solar Plataforma in Almeria, a CSP research platform founded in the 1970s and described in detail in Chapter 3. The trip to Spain added data from another country to my analysis, to which I would not have otherwise had access, including meetings both years at the government Institute for the Diversification and Saving of Energy and a meeting with the Spanish transmission systems operator, Red Eléctrica. These trips provided me with additional opportunities for cross-cultural learning and meetings with people with whom I would otherwise not have had access.

Event Ethnography

I conducted short but productive event ethnographies at two in-person Dii conferences and one virtual conference. These conferences provided insight from officials who were too busy to schedule interviews. First, I attended a two-day conference held in Cairo in 2011. While in Cairo, I also attended the two-day Worldwide Wind Energy conference, which provided additional contacts and additional insight into a technology that later became important in the Desertec vision. I arrived in Cairo a week prior to the conferences in order to learn about the culture and visit historical sites. I visited Cairo at an opportune moment in history, just seven months after the revolution and only a week before Tahrir Square erupted in protest again. While in Cairo, I met with five young Egyptians through the couchsurfing website, who provided unique information about the culture and recent uprisings. Tour guides and couchsurfing friends graciously shared their moving stories of the revolution with me, and I remained in touch with many of them via Facebook.

I attended the 2012 Dii conference in Berlin online, as it was not financially feasible to attend in person. All panel events were available in real-time online. One benefit to attending online was that I transcribed a significant portion of the event.

I attended the 2013 Dii conference in Rabat in person. By this time, I was already familiar with many of the key actors. It provided a window into Dii's evolution and an opportunity to ask follow up questions to interviewees. I also forged a research collaboration at this conference with a German NGO, Germanwatch, that provided access to the villages adjacent to the Noor solar power facility in Morocco.

Interviews

Since many of my interviews were with elites from government agencies and large multi-national firms, I learned much about interviewing experts. I planned to ask open-ended questions to encourage the interviewees to consider broader social issues and to discuss the history of their involvement in regional systems integration. This was challenging because these experts were used to being asked highly technical, specific questions. If my questions did not illustrate sufficient technical expertise, I risked being dismissed as uninformed and unworthy of the person's time. To cope with this, I sometimes had to ask more technically say questions first and save questions about the social impacts of the vision for later in the interview. It also helped to explain initially that I was interested in broader socioeconomic and policy questions.

For the Dii/ Desertec sample, I contacted all shareholder companies and the Desertec Foundation for interviews. Given the stature of the involved companies, I was unable to secure interviews with all of them. LinkedIN was helpful for identifying the best contacts as one key individual from CSP Today connected me within one degree to numerous individuals working in the solar industry in the MENA region.

Over one month in Germany, I visited Munich, Stuttgart, Mannheim, Bonn, Cologne, Aachen, Essen, Hamburg, and Berlin. Overall, I conducted 32 interviews on the European/international level. The sample included four employees of the Dii plus a Dii consultant and the two Desertec Foundation directors. I interviewed nine Dii shareholder companies: two people at M+W Group, Munich RE, HSH Nordbank, ABB, Deutsche Bank; two people at Red Eléctrica; two people at RWE, Schott Solar; Cevital, plus two field visits to the Abengoa Solar Solucar plant in Spain (Abengoa was also a shareholder). One of the Dii interviewees worked for the shareholder company First Solar, and I also spoke informally with several First Solar employees in Arizona. To understand the initial Desertec vision, I interviewed two scientists from the German Aerospace Center (DLR) involved in the 2006 Desertec feasibility studies, as well as the father of the Desertec vision, Gerhard Knies. Outside of the Dii network, I conducted two interviews with the Union for the Mediterranean including the head of the Mediterranean Solar Plan (MSP) and a consultant from the German Development Corporation (GIZ) who works on the MSP, plus the head of the MENA CSP program at the World Bank, an official from the International Renewable Energy Agency (IRENA), and two German researchers who have studied Desertec. I interviewed government officials from BMWi, the German Foreign Office, the German Development Agency (BMZ), the German Environmental Agency (BMU), and the German development bank, KfW. I also interviewed an employee of BP to gain an oil industry perspective on Desertec. I conducted 23 of the interviews in person and eight via phone or Skype. The interviews lasted at least one hour, with many in-person visits to offices extending into two or even three hours. The majority were recorded on a digital recorder and transcribed verbatim in NVivo.

I conducted interviews in Morocco from mid-August of 2013 to mid-December of 2013. While there, I lived in an apartment in the conservative, working class neighborhood of Salé, Rabat’s sister city situated across the Bou Regreg River. There, I was embedded in how average urban Moroccans went about their days. In the first half of my time there, I had assistance arranging and conducting interviews from a Moroccan economics student. It was challenging to recruit interviewees from the Moroccan government since I was not working under the aegis of a Moroccan agency or organization, nor did the officials have any incentive to speak with me. It was also challenging to use snowball sampling within this cultural context. When I did secure referrals, the person to whom I was referred would often show deference to his colleague by stating that if I had spoken to him, in addition to himself, then I knew already everything there was to know. This made it inappropriate to persist in my request for a referral unless I could identify a very specific piece of knowledge or data I needed. Many people agreed to interviews but rescheduled them numerous times up until my departure date. I would have benefitted from more time in the country to navigate this labyrinth of contacts and time delays. That said, once I did secure interviews they typically lasted two or even three hours. Numerous Moroccans showed me the deepest hospitality and generosity I had ever experienced, and I am deeply grateful for their support.

In Rabat and Casablanca, I sampled based on representation from the three main energy agencies plus the state-run utility company, major industry actors, state-run investment funds, and energy researchers and research funding agencies. I conducted a total of 20 interviews in Rabat. The sample included two leading solar researchers, two officials from MASEN, the head of the state-run energy investment company *Société d'investissement énergétique (*SIE), three researchers from the country's leading research center *Centre National Pour Le Recherche Scientifique et Technique* (CNRST), two officials from the *Office National de l'Electricité et de L'eau Potable* (ONEE) (one in Casablanca and one in Ouarzazate), the head of the funding agency for Solar Energy and New Technologies called the *Institut de Recherche en énergie solaire et énergies nouvelles* (IRESEN), one official from the Energy Ministry, *Ministère de l'Energie, des*

Mines, de l'Eau, et de l'Environnement (MEMEE), the head of the Moroccan Foundation for Advanced Science, Innovation and Research (Mascir), and one official from the World Bank in Rabat. I also gained the perspectives of Germans working in Morocco by interviewing German officials who work on energy in Rabat including the Germany embassy, the U.S. embassy, and two people from GIZ who work within the *Agence Nationale pour le Développement des Energies Renouvelables et de l'Efficacité Energétique* (ADEREE) and one who works within the Moroccan Agency for Solar Energy (MASEN). I also interviewed the head of Sahara Wind, a Moroccan organization working on energy integration with Mauritania and building HVDC lines to connect Moroccan wind to European markets.

I filled in the gaps in my data by attending professional events. I attended the November 2013 Renewable Energy Exposition in Casablanca, Morocco, which featured dozens of booths with multi-national and domestic energy companies. At the exposition, I also attended a three-hour symposium sponsored by a group of researchers in the renewable energy sector called the Moroccan Society for the Development of Renewable Energy (*La Société Marocaine de Développement des Energies Renouvelables*, or SMADER) to discuss the changes that should occur in the Moroccan higher educational system to prepare students for the renewable energy marketplace. Furthermore, the 2013 Dii conference in Rabat featured speakers from the Union for the Mediterranean and all of the Moroccan government energy agencies. I also had dinner with the head of the Regional Center for Renewable Energy and Energy Efficiency (RCREEE) to discuss their Arab Energy Future Index report and lunch with Bertrand Piccard, who made the first transcontinental flight in a solar plane he built, and a group of young Moroccan climate change activists.

Fieldwork in Ouarzazate

Ouarzazate is currently Morocco's motion picture capital, but it is also envisioned as the world's new solar capital. It is located on a plateau between the High Atlas Mountains and the Anti-Atlas Mountains, with a mostly Tamazight (Berber) population of 69,364 people. Just outside of Ouarzazate, near the village of Tasslemante, the Noor solar facility is under construction. Noor is the largest concentrating solar power facility under construction in the world and is a major component of the Moroccan Solar Plan.

I made five trips to Ouarzazate. The first was the 2012 scoping trip described above. The second was on the first ASU study abroad trip, during which we visited the Noor site as construction was just beginning. Grading was in progress, and the water pumping station and roads had already been built. I took the third trip during my semester living in Morocco. During this trip, I conducted an additional two-hour long interview with the head of Association Tichka, and I accompanied one of their employees on a day trip to the village of Zaouite Sidi Ahmed to see an integrated development project include solar water irrigation for olive trees, an olive press, and spirulina farming. I interviewed the head of the Commune Ghesset, which is the commune of villages that is being affected by the construction of the Noor facility. This trip allowed me to better understand the local, small-scale development initiatives and challenges in the Ouarzazate region.

The fourth time I visited Ouarzazate was for a two and a half week trip in February 2014 to join part of the fieldwork led by Germanwatch. I have worked with Germanwatch since late 2013 to write a report on the social sustainability of CSP and the socioeconomic impacts of the Noor facility. In Ouarzazate, I joined a team of German, Morocco, and Egyptian researchers, as well as four highly skilled Moroccan student research assistants, to evaluate the socioeconomic impacts of the Noor facility. All of the researchers stayed together at the same lodge and shared all meals together in an immersive environment. I learned much about rural Moroccan culture by working in this close environment with our Moroccan collaborators. During the fieldwork, I helped to code data from interviews the student researchers were conducting and to being grouping these codes into social impact categories. I had access to an internal baseline report that Germanwatch wrote on the social challenges facing the Ouarzazate region. Additionally, I went into the field with the students to observe the interviews, landscapes, and villages. We visited the villages of Tasslemante, Idelsane, and Agdz to conduct interviews. Through these interviews, I learned about the lives of rural Moroccans and by driving around the region I gained a better understanding of the landscape of the Ouarzazate region. I observed five focus groups with citizens from Tasslemante, heads of local small and medium sized enterprises, women, farmers, and young college graduates. I had access to the data translated into English from roughly 100 interviews conducted in the Ouarzazate region in RQDA software. Readers should refer to the Germanwatch and Wuppertal Institute report, *Social CSP*, for the full socioeconomic impacts evaluation of the Noor solar power facility.

I took my fifth trip to Ouarzazate with the second study abroad program. We stayed for two nights at a girl's boarding school, which allowed for cultural exchange. We visited the Noor site again, after roughly half of the mirror fields and the beginning of the molten salt storage had been installed. This allowed for comparison between the two phases of the project. We visited the village of Tasslemante, adjacent to the Noor site with the NGO The Human Touch, which was formed by the Moroccan students who assisted with the Germanwatch research. We spent the afternoon interacting with primary school students from the village, including an educational clown show arranged by The Human Touch. We had to bring out own bottled water to make tea, as the village lacks clean drinking water.

Historical Methods

Historical documents and articles provided compelling context for the data on Desertec. I reviewed the literature on large-scale engineering projects planned for the Sahara Desert during colonial times to provide for comparison to Desertec. In order to understand the history of CSP across the globe, I drew upon French texts from the late 1800s (e.g., Royaumont, Pope) and magazine articles describing efforts to build CSP in Egypt in the early 1900s. Additionally, I reviewed the existing history of solar power (for example, Perlin, 2013). A textbook I purchased on a trip to the Solar Plataforma in Almeria, Spain was crucial in understanding the history of CSP research in the 1970s and 1980s (Ruiz Hernandez, n.d.). I combined this with current and historical data collected for my masters thesis on solar development in California. For the Moroccan case study, I drew upon nine articles written in French about the colonial electrification of North Africa (1911-1956), in order to understand how electrical power systems developed in Morocco, as well as an account by Swearingen that was useful in understanding how the Moroccan Solar Plan is tied to a long history of Moroccan dam building and irrigation for agriculture.

Methodological Drawbacks

Multi-scalar analysis has disadvantages. First, it is time consuming. My field research started with my time in Egypt in late 2011and then extended from mid-May 2013 through December with the study abroad trip, my month of fieldwork in Germany, and a semester in Rabat. The intervening time was spent on document analysis, which started in 2009 when I wrote a class paper on Desertec, as well as securing funding. Multi-scalar analysis often requires language learning, but it is not possible to learn all of the relevant languages. I learned French, since I had previous experience with it, and it is widely spoken in Morocco, especially in the government. I took introductory formal Arabic (Fus'ha) in Arizona, which allowed me to read the alphabet but this differed from the local Moroccan dialect of Darija, for which my skills are rudimentary; therefore I had to rely on translators in Ouarzazate. Fortunately, elite interviews in Europe could be conducted in English, and many educated Egyptians speak English, although I studied the Egyptian dialect before leaving and found my cursory Arabic served me well in bridging cultural divides. Even though multi-scalar analysis is time consuming, the time spent at each location was rushed. Multi-scalar analysis differs from long-term participant observation or ethnography in a single place—or even multiple sites— even though it draws upon similar methodological tools. While I wrote memos and reflections while in the field, I wrote very little thick description because my constant travel schedule did not permit it. This is a factor to consider for studies designed around intensive travel schedules. This methodological framework also requires collating and connecting a very large amount of disparate qualitative data, which can result in inaccuracies.

Another methodological challenge was that many of the interactions played out "backstage" (Hilgartner, 2000) outside of the view of the researcher. For example, much of Dii's work occurred at private shareholder meetings and was often misrepresented in the media. At times, these issues could be addressed interviews but not always due to the sensitivity of the information, such as government negotiations, personnel decisions within the Dii, and financial transactions related to the power plants. Furthermore, Moroccan society is highly stratified, making access to backstage information even more difficult to gain. As with all research, certain information was therefore unknowable.

Overall, the multi-scalar analysis aided in understanding the potential wide-reaching effects of a vision for a regional sociotechnical system. It also helped with evaluating energy justice by unmasking potential injustices that crossed scales, which were otherwise obscured by the actor's win-win discourse. Finally, it provided a broader and more comprehensive view of the anticipated system-level effects of the vision than could have otherwise been gained by focusing on a single scale.

CHAPTER 3

WHAT HAPPENS TO A DREAM DEFERRED? THE ONGOING EMERGENCE OF CONCENTRATING SOLAR POWER

Concentrating Solar Power (CSP) Timeline

1866: Augustin Mouchot presented his solar engine to Napoleon III who funded him to build a solar engine in Algeria

1870s: Major engineering projects for the Sahara were envisioned including the Trans-Saharan Railroad and the Sahara Sea

1875: Mouchot went on a scientific expedition to Algeria with the French Minister of Education to further test CSP

1877: John Mittell and George Ditzler were the first inventors to patent a solar device in the United States

1878: William Adams, a British colonist, in Bombay wrote *Solar Heat: A substitute fuel in tropical countries*

1882: Abel Pifre developed a solar powered printing press in France

1882: Louis de Royaumont published *The Conquest of the sun: scientific and industrial applications of solar heat*

1901: Kaiser Wilhelm II of Germany stated, in reference to German imperialism, "In spite of the fact that we have no such fleet as we should have, we have conquered for ourselves a *place in the sun."*

1901: Aubrey Eneas, an Englishman living in Boston, built a solar collector in California for irrigation.

1909: Frank Shuman built a CSP trough plant in Maadi, Egypt to irrigate cotton. Shuman imagined a project of 20,000 square miles in the Sahara desert to generate 270 million horsepower, or all of the world's energy demand in 1909.

1920: Atlantropa, a project to dam the Strait of Gibraltar to power Europe plus irrigate the Sahara desert, was proposed and promoted until 1960. It bears interesting similarities to the Desertec vision.

1954: Willy Ley wrote *Engineer's Dreams*, detailing incomplete large-scale engineering projects worldwide

1970: Arnold Goldmann wrote "A Working Paper on Luz," which developed a Jewish philosophy for CSP technologies[21]

1976: United Nations Environment Program published report "The Prospects for Solar Energy in the Mediterranean Region"

1977: The Solar Plataforma was founded in Spain

1977-1982: The Spanish government took interest in renewable energy. Isofoton was founded and long-time engineering firm, Abengoa, in Seville began work on the Solar Plataforma (solar research platform)

1979: Luz Energy was founded

1981: Italia-Sicilia 1 MW- Eurelios CSP plant constructed

1981: 1 MW SSPS CSP plant was completed at the Plataforma with the participation of nine countries in Spain

1982: The Solar I power tower plant was commissioned at Daggett, California

1983: New Mexico 1 MW CRT plant was commissioned

---

[21] Exact date unknown. A copy of the work is no longer available.

1983: 1 MW CESA-1 Tower was commissioned at the Solar Plataforma in Spain

1984: France- Targasonne 2.5 mw Themis CSP plant

1986: Crimea built 5 MW SPP5 CSP plant

1984: SEGS I CSP plant was constructed in California by Luz Energy

1990: SEGS IX (the final stage) was commissioned by Luz in California

1991: Luz Energy filed for bankruptcy

1990: EU Council established the Energy Charter to promote energy cooperation between the east and west of Europe and the former USSR

1995: Solar I was converted into Solar II, adding heliostats and molten salt storage

1990-2007: The "long dark solar thermal night," which was followed the by "solar spark"[22]

2004: New Spanish electricity law was adopted creating the conditions for solar thermal growth

2004- 2007: German Aerospace Center conducted Desertec feasibility studies

2005-06: Russian-Ukraine natural gas crisis

2007: EU Council established 20/20/20 targets for 20% renewable energy, 20% energy efficiency, and 20% carbon dioxide reductions from 1990 levels by 2020

2007: PS10 CSP plant in Spain started delivering power to the grid

2007: Nevada Solar I was constructed (by Solargenix, a subsidiary of Acciona Energia in Spain)

2009: Andasol I CSP plant was completed in Spain

2009: PS20 CSP plant was completed in Spain

[22] According to Ruiz Harnandez, n.d.

2010 - MASEN (Moroccan Agency for Solar Energy) was founded to build CSP plants, including the Noor facility

What Happens to a Dream Deferred?

Does it dry up
like a raisin in the sun?
Or fester like a sore--
And then run?
Does it stink like rotten meat?
Or crust and sugar over--
like a syrupy sweet?

Maybe it just sags
like a heavy load.
Or does it explode?

-- Langston Hughes

Concentrating Solar Power (CSP) has been framed as an emerging technology for a century and a half. This chapter explores CSP as a deferred dream, initially couched in the colonial enterprise and then in large-scale engineering projects that sought to landscape the desert through CSP and other technologies. Dreams for large-scale engineering projects in the Sahara described in this chapter have been remarkably persistent, lasting for decades with strong advocates who conducted reams of feasibility studies. However, CSP was never built en masse in the Sahara desert, primarily because it failed to gain sufficient traction to be scaled up into systems for a variety of reasons, and when CSP was imagined as part of a system, the system imaginers lacked political support and underestimated the sociopolitical complexity of the landscape in which they sought to build. Additionally, these deferred dreams faded from imagination due to major world events, changing priorities, priority given to nuclear technologies, and changes in the goals actors had for the electricity system. Yet they were resilient enough to reemerge later in new forms. This chapter also shows that Andalusia and the Sahara have been framed as attractive places to build CSP for over a century. Desertec is therefore one of the latest instantiations of the dream deferred to scale up CSP in deserts.

By examining CSP's history, this chapter illustrates how a technology's emergence is constructed and situated in particular time periods and contexts. The term emerging technology is often used as a static concept in the literature, but it would be better analyzed as an actor category that is strategically constructed over time. A technology's emergence should also be considered in the context of other emerging and mature technologies and systems; for example, CSP has reemerged in times when nuclear power has fallen from favor and coal was feared to be running out. Scholars might expect that a technology like CSP that did achieve closure and was not successfully integrated into a system would disappear, like Betamax tapes did when the video industry became path dependent on VHS (Liebowitz & Margolis, 1995). Instead, CSP's emergence is ongoing as it has been born and reborn in different cultural contexts, rarely changing significantly, not successfully integrated into systems, but also never dying. Each time the technology has emerged, its advocates have worked to frame it as feasible. Proving feasibility is a necessary but insufficient step for a deferred dream to gain the momentum required to reach the construction phase.[23] Overall, this dissertation explores CSP's rise and fall from 1850 to the present, from the United States to Morocco, illustrating how societal goals have led to resurgences of the technology but numerous factors described below have caused it to be deferred.

The history below shows that, despite being framed as feasible, the dream for CSP was deferred numerous times between 1850 and 2000, most importantly because CSP failed to become integrated into a broader system design. I argued in Chapter 1 that energy transformations have important scalar aspects; the ability of an energy technology to appropriately fit the scale of the existing system is key to its emergence. Electrical power systems are not complex systems in the postmodern sense, which lack central control—for example, the World Wide Web has been defined as "scale-free"—they are still hierarchical systems, as will be illustrated in Chapter 5. CSP has the advantage of being a substitutable technology that could fit fairly well into this existing, centralized system. Even so, CSP suffers from problems with being integrated into a system at sufficient scale, which illustrates how challenging it is to build new energy infrastructure on top of the old. In the 1850s, CSP was seen as too difficult to scale up, too weak, and incapable of providing sufficient power during peak hours of electricity usage. CSP was briefly envisioned as part of a system in the early 1900s but was halted by World War I. Some viewed CSP as impeding the reliability of the conventional electrical power system because it was too weak and capricious to generate reliable power.[24] In the 1970s, CSP was again briefly considered in California as part of a transition toward renewable

[23] See Chapter 5 for a continued discussion on feasibility and visions for sociotechnical systems.
[24] See Chapter 1 for an explanation of the importance of reliability as a systems trait.

energy, but ironically environmentalists, who focused instead on small-scale generation, impeded it.

CSP's failures related to several other factors including the rise and fall of nuclear technologies, opposition from the fossil fuel lobby, bad luck and poor timing due to intervening world wars, the untimely death of prominent advocates, and economic crises. Chapter 5 illustrates how the CSP dream reemerged in Europe in the 2000s as part of the first Desertec design for a system in which CSP would have provided the specific and crucial systems property of dispatchability. However, CSP played a minor role in the second system design, because the system design changed to obviate the need for dispatchability, which led CSP to be deferred again. CSP's reemergence is examined in the Global South in Chapter 6 and Chapter 7, where it is the focus of the Moroccan Solar Plan due to its perceived ability to meet socioeconomic goals.

By taking a longitudinal look at an emerging, or a deferred, technology, it is possible to see how the technology's politics and framings have changed over time. The politics of CSP were not cemented but shifted as CSP was enrolled in meeting various goals. Ironically, the CSP technologies that are today framed as utopian and sustainable have their roots in empire building as they were enrolled in the search for cheap and abundant sources of fuel to power resource extraction in North Africa. CSP began with a domination of nature framing during a period in which scientists sought to remove ethical restrictions imposed by religion on the exploitation of nature. Large-scale engineering projects for the Sahara, along with CSP, stemmed from the ambitious dreams of colonial engineers who sought to reshape desert landscapes into productive zones, with profound consequences both for the environment and its human inhabitants, who were often written out of the landscape or at least imagined as not needing energy. When CSP reemerged during the 1970s energy crises, system builders sought to replace fossil fuels in electricity systems to increase countries' energy independence and sovereignty. CSP faded along with the energy crisis; a general challenge for CSP is that government support for it has been directly tied to the goals developed during crises that eventually fade. When CSP reemerged in the 2000s, it was part of a profoundly different sustainability and climate change debate. By this time, it was clear CSP was a feasible technology—CSP *can* be built, but *should* it be built and in what places? CSP faltered as environmental activists in California opposed it for being 'out-of-place' in the pristine desert landscape and, while it met carbon dioxide reduction goals, it did not, in their view, meet overall sustainability goals. Across the Atlantic, the first Desertec vision framed CSP as a technology that could bridge continents in the post-colonial world, provided the technology was integrated into a massive system. Thus CSP, which was developed to dominate nature, was enrolled in a complicated debate about ethics, sustainability, preservation, and global climate change. These complex, contemporary goals relating to CSP illustrate how different the energy transformation challenge is in the 21^{st} century than the original sociotechnical systems construction process Hughes studied.

One framing of CSP that did endure over time is that of the solar farm. This history illustrates that CSP is a technology of the frontier, constructed by pioneers in depressed desert zones to make the desert bloom through irrigation powered by massive solar farms that reap abundant rays in virgin landscapes. The solar farming metaphor used today frames the technology as benign but also references a potentially insidious colonial metaphor. Chapter 4 illustrates how the 2006 version of the Desertec vision framed a modern energy system as one based on energy farming. Chapter 6 then describes how Morocco is currently developing these “solar farms” in a way that reflects its agricultural policy dating back to the Protectorate era. One drawback with this agricultural framing in terms of CSP’s success is that individual farms do not necessarily scale up to form centralized power systems.

Since CSP’s emergence relates not just to the technology itself but its integration into systems, this chapter illustrates why it is important for energy policy in the 21st century to consider emerging technologies within the context of the existing sociotechnical systems landscape. This landscape cannot simply be clear-cut for solar farms. Emerging, low carbon energy technologies would need to be used to refurbish the existing system, or a complete paradigm shift in how electricity is generated, distributed, and consumed will be needed. Either way, emerging technologies must fit into an existing and complex sociopolitical terrain shaped by histories that matter to citizens and policymakers. Visions for CSP have often developed within an energy landscape that was far more socially and geographically complex than the system imaginers acknowledged and were often based in false assumptions and social stereotypes. Furthermore, today’s sustainability challenges are integrated challenges that bring together complex intersecting domains, for example, water, poverty, and energy. This dissertation explores the sociopolitical complexity and systems complexity into which emerging technologies attempt to take root and how this complexity shapes dreams for future electrical power systems.[25]

Overview of CSP Technology

A CSP tower plant consists of a field of heliostats, or towers with garage-door-sized mirrors that concentrate sunlight on a central power tower receiver, heating air or water to drive a steam turbine to generate electricity. CSP parabolic trough plants, which are the most widely deployed technology, concentrate the sun's energy on a tube attached to a parabolic mirror rather than a tower to drive a steam turbine. This steam turbine generating system is very similar to that of a conventional power plant, although the heat comes from the sun rather than from fossil fuel combustion. This power is then delivered to consumers through transmission lines. A less popular type of CSP is the Stirling dish engine, which resembles a satellite dish and concentrates sunlight onto a focal receiver attached to the disk. The Stirling engine heats a gas connected to a drive shaft to power a generator, providing electricity to transmission lines. The pictures of CSP below illustrate how similar the technologies have remained over time.

[25] Chapter 8 describes different types of complexity and how it relates to energy justice outcomes.

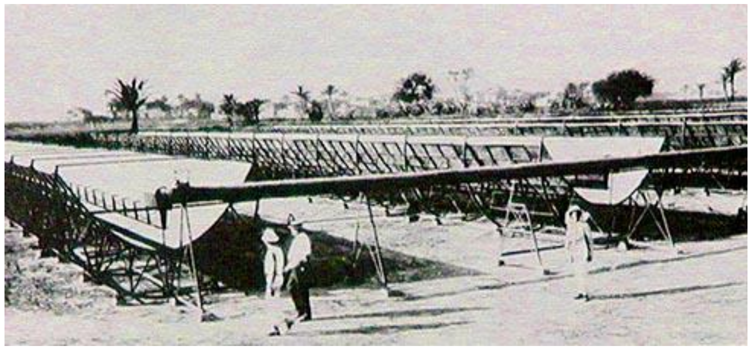


Figure 4. Frank Shuman's Solar Engine I: Meadi, Egypt, 1909 (Suburb of Cairo). From PESWiki (public domain)[26]

Figure 5. Kuraymat CSP Trough Field Added to a Natural Gas Plant, 2010 Near Cairo, Egypt. Photo by Author.

26 http://peswiki.com/index.php/Reprint:Tesla%27s_Solar_Ideas

Figure 6. The CRS Tower Plant in Spain, 1981. Source: Plataforma Solar de Almeria website. Used with permission.[27]

Figure 7. One of BrightSource Energy's Ivanpah Towers, 2013. Source: BrightSource Energy Ivanpah website. Used with permission.[28]

[27] http://www.psa.es/webeng/instalaciones/receptor.php
[28] http://www.ivanpahsolar.com/photos-and-videos

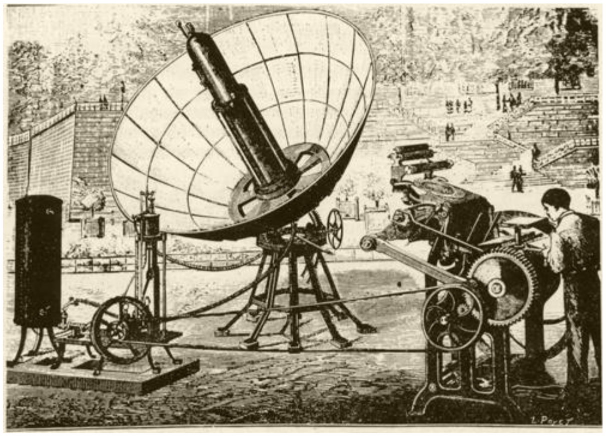


Figure 8. Mouchot's Solar Engine Used to Power a Printing Press, 1882. Originally from Scientific American, reprint from Cabinet Magazine (public domain image).[29]

Figure 9. Eurodish Stirling Engine, Solar Research Platform, 2013. Source: Plataforma Solar de Almeria website. Used with permission.[30]

These pictures illustrate the different types of CSP technology and show that today's technologies are similar in design to the first models developed in the 1880s.

Large-Scale Engineering Visions for a Coveted Sahara Desert

While the media frames contemporary dreams to build CSP in the Sahara as unprecedented, they are situated in a long history of deferred dreams for large-scale

[29] http://www.cabinetmagazine.org/issues/6/beautifulpossibility.php
[30] http://www.psa.es/webeng/instalaciones/receptor.php

engineering projects in the desert. This section briefly outlines the history of non-solar large-scale engineering dreams for the Sahara Desert before addressing solar power specifically. The Sahara has long been an important landscape for large-scale engineering dreams, for the development of CSP, and for the contemporary Desertec vision. This section illustrates the historical roots of several themes developed later in the dissertation: technological systems in the Sahara as improving connectivity and accessibility, the geopolitical motivations for Mediterranean integration, and the importance of the construction of feasibility.[31]

Since colonial times, technology has been used by developed nations as a metric for judging civilization and progress in the Global South (Adas, 1990). According to Adas (1990) the colonial project was underpinned by a civilizing discourse that the colonized were backwards savages, incapable of progress without European technology and that Europeans had a normative duty to civilize others (ibid). For example, the French justified their intervention in North Africa by asserting that their engineers could properly exploit its natural resources.

For colonialism to be successful on the coasts of North Africa, the desert could not be ignored but had to be pacified through military and technological control (Bisson, 2003). As colonial empires were forming, the Sahara was a "coveted desert," viewed by Europeans as *terra nullius* (land belonging to no one) and a virgin and unoccupied space (Bisson, 2003; Heffernan, 2011). The North African deserts were difficult to access, and several prominent expeditions ended in shipwrecks along the Atlantic Coast of Morocco. This contributed to the image of a remote Sahara shrouded in mystery (Bisson, 2003). In

[31] See especially chapters 4 and 5.

the 1850s, conquering the desert became the focus of imperial design and scientific curiosity (ibid). As exploration began, it was a “bitter surprise for the conquerors who believed the Sahara was empty of men because it was not only space that they had to conquer but also the Saharans themselves!” (Bisson, 2003, p. 61). Although the French saw the Sahara as useless land outside of the Mediterranean agricultural zone (ibid; Swearingen, 1988), it became the focus of arguably the most ambitious colonial technological projects, such as the Trans-Saharan Railroad.

It is clear that technology played an important material and discursive role in colonization in the Sahara, but less scholarly attention has been given to colonial-era dreams for massive engineering *systems* that would radically reconstruct colonized deserts. How did these visions for systems evolve? Why were they so persistent, and what happened to them when they were deferred? What services did they seek to provide and for whom were they anticipated to benefit? Europeans imagined roughly a half-dozen ambitious Saharan technological systems during the colonial period and pursued them without success over decades (Bisson, 2003). These failed projects “allow [for] an exploration of the outer edges of the French colonial imagination in Africa” (Heffernan, 2011 p. 619), as well as a lens for understanding contemporary regional development projects. Because of these grandiose dreams, engineers “loomed large in colonial mythology” (Slavin, 2001, p. 92).

I offer three examples of incomplete dreams for Saharan systems in order to address the questions above. These engineering systems have in common immense scale and plans for the massive provision of water and electricity for irrigation and resource extraction to the extent that they could be called geoengineering projects in today’s lexicon.[32] They all focused on improving connectivity between territories and shifting the Mediterranean region's geopolitical weight through technological integration.[33] Each vision was backed up by years of feasibility studies, publications, and advocacy by project proponents. They all unmask problematic and even racist/Orientalist assumptions of the time period. As one would expect for the time period, the plans do not consider the environmental effects. The visions were popular enough that they did not "dry up like a raisin in the sun," rather they faded from imagination as priorities changed, new technologies were introduced, and new goals were identified. These visions left behind a wealth of knowledge supporting them, which is part of the reason they endured over decades and later reemerged in new forms.

In *Engineers' Dreams*, published in 1954, Willy Ley described nine large-scale technological projects imagined by engineers worldwide that were technologically feasible but "incomplete dreams," because the ideas were clear but missing a crucial piece of the development—what I refer to in this dissertation as deferred dreams. He said that "engineers' dreams are things that can be done as far as the engineer is concerned," but that many of these projects remain dreams due to "political barriers." Four of the nine projects he described were for the deserts of the Middle East-North Africa (MENA) region. This illustrates that even as MENA nations were gaining their independence in the late 1950s and early 1960s, the MENA region was still imagined as a space to be redesigned by engineers. The book has "staying power" and "continued currency" because of the grand scale of the projects and their demonstration of engineering's

[32] I am not referring to climate engineering here, but to a project of such scale that it would affect the entire globe.
[33] These themes are continued in Chapter 4 on the Desertec vision.

potential for major planetary change (Petroski, 1997, p. 3). It seems geoengineering is not such a novel idea but has roots in large-scale Saharan sociotechnical systems such as those described below.

Replacing the trans-Saharan trade routes with new technologies of transport was one of the earliest large-scale engineering schemes for the Sahara first envisioned through rail and much later pipelines and transmission corridors.[34] Colonial powers sought to conquer, pacify, and connect the desert through a Trans-Saharan railway running north-south through the Sahara (Bisson, 2003). Bridging the desert would provide territorial continuity among the North African colonies (ibid), accessibility to the desert, and allow for the transportation of people and colonial goods. This focus on connectivity and continuity through desert technology persisted over a century to the present.[35] While the project was never constructed, the vision extended from the 1870s to the end of the North African colonial period in the 1960s (Heffernan, 2011). Over 500 books and articles were written about the railway, a commission was formed to investigate its feasibility, and meetings were held to promote the feasibility of the project and its economic and political benefits (Heffernan, 2011). The project waned during World War I and the Great Depression. In 1941, construction restarted using Jewish slave labor but ceased after the Anglo-American invasion of North Africa (Heffernan, 2011). Heffernan argued that the railroad project faded away toward the end of the colonial period after the discovery of hydrocarbons, which are more efficiently transported long distances through pipeline rather than rail. (Saharan hydrocarbons were largely exploited after the colonial period,

[34] See Chapter 4.
[35] See Chapter 4.

which had focused instead on agricultural development (Bisson, 2003).) There was also social opposition from the Toureg people in the desert—who had defeated the initial surveying team. Horden (2012) argued that the failure of technological systems like the Trans-Saharan railway "added further to the myth of Saharan inaccessibility and "anarchy" (p. 32).

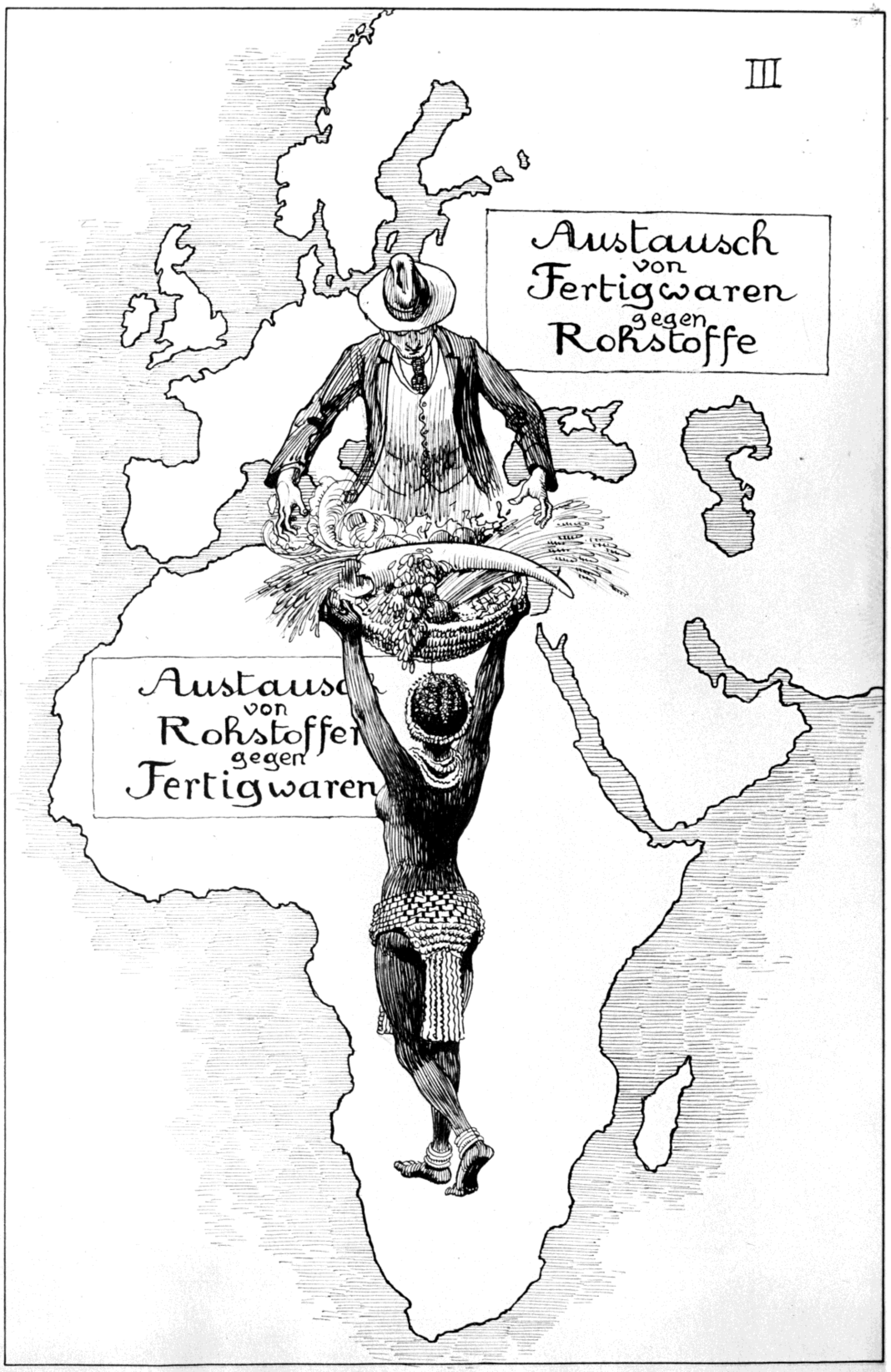
Another persistent engineering dream for the desert was the Sahara Sea, which Jules Verne wrote of in *Invasion of the Sea*. Initially, the French and British hoped to find the mythical Lake Tritonis, described in ancient texts as somewhere in present-day Tunisia. They envisioned building a canal from the lake to the Red Sea to irrigate cotton (Bisson, 2003). When Lake Tritonis was not discovered, the French developed plans to engineer a Sahara Sea by piping Mediterranean water into a desert depression. Surveying missions deemed it infeasible because the depression was higher than sea level (Ghassemi & White, 2007; Ley, 1954). A German government-employed architect, Herman Sörgel later imagined that the Sahara Sea could be developed by refilling dwindling Lake Chad with seawater and then forming a massive Congo Lake south of the 'Chad Sea' (ibid). Building a major waterway in the middle of Africa would improve access to the Sahara and connectivity (ibid). Sörgel argued that it would be cheaper and easier to navigate North Africa by boat rather than the Trans-Saharan railway (ibid). As late as 1957, Project Artemis[36] again sought to develop a plan to use an interior sea for hydroelectricity, seawater desalination, and mineral mining, although little documentation of the project exists (Bisson, 2003; Ghassemi & White, 2007). As late as 1983, the Tunisian and Algerian governments formed a society to further pursue this

[36] Association de Recherches Technique pour l'Etude de la Mer Intérieure Saharienne

vision, which concluded that it was unprofitable and had negative social and environmental impacts (Ghassemi & White, 2007).[37]

Sörgel's more popular project, which was introduced in the 1920s, was Panropa, later called Atlantropa. The vision framed North Africa as an unproductive wasteland waiting to be put to use as an agricultural and hydroelectric "hinterland" for Europe (Muller, 2005). Sörgel's geoengineering dream included a massive 35-kilometer, 365,000 MW dam that would plug the Strait of Gibraltar, plus two dams added later near Italy and the Dardanelles strait, connecting the Aegean Sea and the Sea of Marmara (Ley, 1954; Credit Suisse Group, 2003). Atlantropa would reduce the size of the Mediterranean by 250,000 cubic kilometers of water and introduce 220,000 square miles of new land (ibid). It would increase physical connectivity in the region, putting back in place the former land bridges theorized to exist between Spain and Morocco, Tunisia and Sicily, and Greece to the eastern end of the present sea, irrigating the Sahara to turn it into a breadbasket for Europe (ibid). The project would also raise the ocean level by three feet everywhere else (Ley, 1954) illustrating its scale as an early geoengineering dream. Atlantropa was not the fantasy of a single engineer but was backed up by a social movement led by the Atlantropa Institute, which persisted until 1960 (Credit Suisse Group, 2003). Four books and roughly 1,000 publications were published on the topic (ibid). Gene Roddenberry even depicted a dam on the Strait of Gibraltar in his 1979 book, *Star Trek: The Motion Picture*.

[37] Société d'Étude Tuniso- Algérienne de la Mer Intérieure



WIE DURCH ATLANTROPA DIE WIRTSCHAFT EUROPAS WIEDER AUF JAHRHUNDERTE ZU EINEM OEKONOMISCHEN KREISLAUF ANGEKURBELT WERDEN KANN.

Das ueberindustrialisierte, mechanisierte Europa und das jungfraeuliche, rohstoffreiche Afrika ergaenzen sich in ihrer Austauschbeduerftigkeit .

Figure 10. Atlantropa, Deutsches Museum, Used with Permission

The plan had racist overtones, reflected the civilizing discourse, and was explicitly imperialistic. Sörgel saw Atlantropa as a peaceful alternative to 'living space' (*Lebensraum*, or the displacement of supposed 'inferior races' by the supposed 'Arayan master race') by creating more land by desiccating the Mediterranean. The vivid images that promoted the project, such as the one above in which an African woman is handing a bountiful harvest up to the white European colonist, illustrates this racial superiority complex. Such Orientalist advertising was common for overseas imports to Germany. "Colonial goods," such as chocolate, spices, and coffee, were luxury products that advertisers marketed as exotic goods by using images of black people and oriental servants (see *Figure 11*). Chapter 5 questions whether electricity from North Africa is being treated as an exotic export.

Figure 11. Colonial Goods Advertising. Photo taken by author at the Cologne Chocolate Museum. Used with Permission.

Geopolitically, Atlantropa was envisioned to provide a united Mediterranean, in which Europe controlled the energy, land, and water resources of North Africa, to balance out the rising forces of Asia and America (Trischler & Weinberger, 2005). While Atlantropa's geopolitical aspirations were popular at the time, Trischler & Weinberger (2005) argued that it was put to rest by the rise of nuclear power, which offered similar promises for European integration.[38] In Chapters 4 and 5, I will illustrate how CSP currently offers promises for Mediterranean electricity integration.

Visions for Euro-African technological integration did not end with the colonial empires, and technology played an important role in the vision of an integrated Euro-African community. In the 1960s, the Méditerranée-Niger plan sought to create a new Saharan state south of Morocco and Algeria—retaining visions for Saharan territorial continuity— and *Le Plan de Strasbourg* of 1952 imagined a Euro-African community (Bisson, 2003). The Euro-African imaginary sought to maintain the integration of Europe's Mediterranean colonies as part of an expanding European Union (Muller, 2005). Muller explained that engineering played an important role in this stating,

> Pan-European imperialism often reveals a striking faith, pseudo-religious, in technology…For most of the twentieth century, part of the interest in Africa is the

[38] German readers can find more information on Atlantropa at Gall, Alexander. *Das Atlantropa-Projekt: Die Geschichte einer gescheiterten Vision: Hermann Sörgel und die Absenkung des Mittelmeers.* Frankfurt: Campus, 1998.

fact that it is deemed void, like a blank page provided to the brush of European engineering"[39] (p. 360)

French agro-industrial projects in North Africa and the Atlantropa movement were emblematic of this faith in technology (ibid). Chapter 4 shows the pictures painted of a new large-scale engineering system for the Mediterranean—a single transmission grid. Even into the 1960s, Africa was seen as an El Dorado because of its space and sun, with the possibility of a zone of free pan-African exchange (ibid). Electricity played an important role in this. Muller stated,

> White Africa and its government will make Africa a techno-utopia. The divine electricity will arrive. 'Africa will emerge from the shadows of the back of God. The light and electrical power will kill the darkness…In one fell swoop, electricity will civilize it or there will be no civilization….' Africa asleep, henceforth electrified, civilized, and full of energy… 'will jump forward'… and turn into 'a new world…'[40] (Muller, 2005, quoting Peter Penn *Tomorrow's Continent*, in 1948, p. 366).

---

[39] "Le pan-impérialisme européen révélé souvent une foi saisissante, pseudo religieuse, dans la technologies….Pendant la plus grande partie du XXe siècle, une part de l'intérêt pour l'Afrique vient du fait qu'elle est réputée vide, comme une page blanche offerte au pinceau du génie européen."

[40] L'Afrique blanche et ses gouvernements feront de l'Afrique une techno-utopie. La divine lumière électrique arrivera : « *L'Afrique émergera de l'ombre du dos de Dieu. La lumière et la puissance électrique tueront les ténèbres [...]. En un seul coup l'électricité civilisera là où il n'y avait aucune civilisation.* »… L'Afrique endormie, désormais électrifiée, civilisée, pleine d'énergie …transformera en « *un nouveau monde [...]*

Muller went on to say "For the Europe of tomorrow, three elements are lacking: space, energy, and primary materials. Europe, in exchange, must deliver men, technique, and capital," which could be realized in a Euro-african framework (ibid, p. 384).[41] In the 1960s, Africa supplied uranium for atomic energy projects in Europe, and it was viewed as a new source of salvation for Europe (ibid). This discourse is still popular today, but the Euro-african community failed when its developers became sensitive to neocolonial critiques, Germany opposed privileging North Africa over other regions for investment, and former colonial powers were concerned that they would fund unprofitable development projects in the region while other countries reaped the benefits of profitable projects (ibid). I will explore Euro-africa's new instantiations in Chapters 4 and 5. International relations scholars have argued that "new regionalism" emerged after the formation of the European Union, based upon globalization of trade, a break down of sovereignty, and the removal of barriers that impeded connectivity across nation-state borders. Old regionalism, in contrast, sought to build up regional might to counter forces such as the Soviet Union. When compared to Desertec, the visions for regional technological systems illustrate many parallels between the framing and use of technology in regionalism from 1860-1960 and today's regionalism. Technology is still seen as the glue that ties the region together, providing connectivity, bridging disparities

---

41 « *Pour faire l'Europe de demain, trois éléments lui manquent : l'espace, l'énergie, les matières premières. L'Afrique peut les lui offrir ; l'Europe, en échange, doit livrer hommes, technique, capitaux. Quoting* Jean-Michel de Lattre, « Le Sahara, clé de voûte de l'ensemble eurafricain français », *Politique étrangère*, n° 4, 1957, pp. 360, 366, 384.

in the distribution of natural resources between South and North, and compensating for the lack of space in Europe.

Who benefits from these systems?. These engineering dreams were underpinned by false assumptions and stereotypes. From an energy justice perspective, Willy Ley's engineering dreams were incomplete because they had a limited imagination for who needed energy in the region and for what social good. He depicted these areas as needing electricity for resource extraction, not for inhabitants. Through this, large-scale engineering was wrapped up in colonial electricity policy, focused on powering resource extraction and viewing the desert as barren of people, and certainly barren of people deserving of electricity.[42] Besides Atlantropa and the Sahara Sea, the projects Ley described include a hydroelectric plant on the Jordan River to pump water from the Mediterranean Sea to power a mining operation or to fill up the Qattara Depression in Egypt, one of the lowest elevations in Africa, for hydroelectric power. About a proposed dam on the Red Sea at the Strait of Bab el Mandeb (Djibouti/Eritrea/Yemen area), Ley said "But nobody in the general area of the Strait of Bab el Mandeb needs such quantities of electrical current" (p. 156). About the Qattara Depression project, which is still under consideration today, Ley said,

> There isn't anything in particular in the way of such a plan except an absence of customers for the current generated. While the cities of the Nile Delta are within easy reach for the high-voltage wire, they are not industrial cities and do not need much electricity (pp. 116-117).

[42] See Chapter 6 for a related discussion of colonial electricity policy in Morocco.

Today, the Cairo area (current population 17.8 million) cannot meet its domestic electricity demand and suffers daily from rolling blackouts. Yet the myth that this region does not need much electricity and is an uninhabited desert persists today and was foundational to the Desertec vision.[43] Similarly, Cronon (1991) observed about the presence of Native Americans in the connectivity of the Chicago region in the United States that "the dream would not contain them" (Kindle location 1306). Often projects viewed as appropriate for local people were small-scale systems, such as the French colonial approach to building small hydroelectric and drinking water projects in the mountains of Morocco to win the "hearts and mind[s]" of villagers (Swearingen, 1988, p. 88) while building large dams to power resource extraction. There is a risk that contemporary dreams for electricity in the Sahara do not contain the people who live in the desert and do not seek to connect them to premium-networked spaces.[44] This indicates a lack of recognition justice, which I will discuss in the energy justice framework in Chapter 8.

The Colonial and Agricultural Framings of CSP

Like other deferred dreams for the Sahara, CSP developed within a colonial context over a century before it became enrolled in the sustainability movement and the fight against climate change. This section illustrates that, to use Winner's terms, CSP

[43] This is explained in Chapter 4 and the point is revisited in the energy justice chapter (Chapter 8).
[44] See Chapter 4.

originally had the politics of a colonial technology. The mechanical use of solar heat was developed in 1767, when Horace de Saussure invented a hot box, essentially a shoebox-sized glass greenhouse (Perlin, 2013). William Adams, an English settler in Bombay, was one of the first people to imagine solar heat being put into service for the colonial mission. He patented a solar cooking device featured in *Scientific American* (Pope, 1903). In his report in 1878, *Solar Heat: A substitute fuel in tropical countries,* he argued that solar energy could replace coal despite its intermittency (ibid). Some British imperialists were skeptical that solar was strong enough to supplant coal, while others were already concerned that the world was running out of coal and that CSP was needed as a new energy source (Ragheb, 2011; Royaumont, 1882).

The focus on the human domination of nature through science and technology (Leiss, 1972) shaped CSP's framing. In 1882, Louis de Royaumont published *The Conquest of the sun: scientific and industrial applications of solar heat* (*La conquête du soleil, applications scientifiques et industrielles de la chaleur solaire (héliodynamique*)). He began with a derisive history of the "indigent natives" who worshiped the sun, and he argued that the Arabs were backward because they did not give up this primitive sun worship when they converted to Islam. "The people of the Arabian peninsula were desperate worshipers of the sun which seems, in fact, the only sovereign [ruler] of the desert" (p. 6).[45] Royaumont viewed solar engines as the scientific conquest of the sun, or the ultimate control of nature, which was reject these "primitive" religious beliefs. On the front page of the book (below), an anthropomorphized sun is perturbed that man has

[45] Les habitants de la presqu'île arabique étaient d'acharnés adorateurs du Soleil qui semble, en effet, le seul souverain du désert.

conquered its rays. Royaumont stated, “science and philosophy have joined forces; philosophy freed the slave, science enslaved the Sun” (p. 311).[46] This domination of nature framing is surprising for a technology framed today as having the politics of a benign and environmentally friendly technology.

CSP’s framing was also shaped by international technological competition. Royaumont saw the mechanical use of solar heat as a means for France to regain its scientific standing in the international community, which he viewed as having fallen behind the United States, Germany, and England. While England was using its coal to industrialize rapidly, France lacked domestic coal deposits, making it difficult to compete with England (Perlin, 2013). Royaumont asked, “Is [solar power] to satisfy the needs of a scientific mission made with the burning heat of the tropical deserts or a body of colonial troops fighting for the defense of the national flag?’[47] (p. 264). It was ultimately seen as both. Settlers could use solar cookers to prepare food, purify water, and distill wine far from the “civilized center”. Sappers could use it on desert caravans for water or even for the construction of the Trans-Saharan railroad. CSP was shaped by the civilizing discourse; a French newspaper called the invention of CSP “a glory for a civilizing and generous France”(ibid, p. 271). [48]

[46] La science et la philosophie ont joint leurs efforts ; la philosophie a affranchi l'esclave, la science a asservi le Soleil.
[47] 'S'agit-il maintenant de satisfaire aux besoins d'une mission scientifique aux prises avec l'ardeur des déserts tropicaux ou d'un corps de troupes coloniales préposé à la défense du drapeau national? pg 264
[48] «Cette invention, dit le même journal, est une gloire pour la France civilisatrice et généreuse. 271

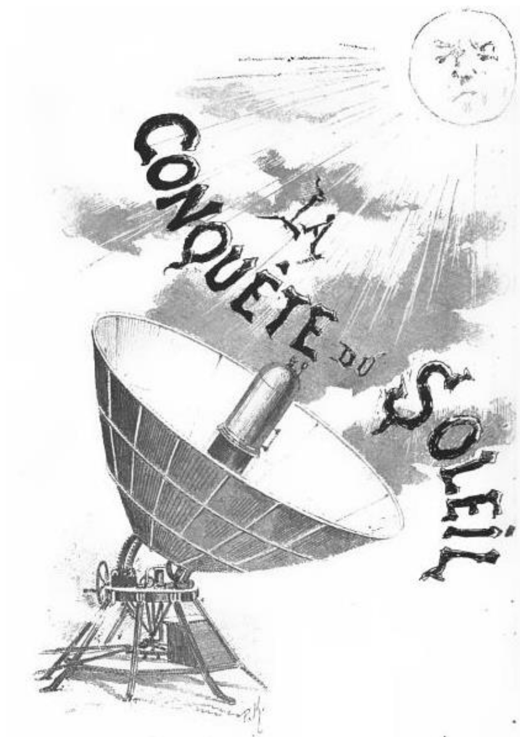


Figure 12. The Cover of de Royaumont's *La Conquête du Soleil*, 1882, Source: Google Books (public domain).

In 1866, Frenchman Augustin Mouchot constructed one of the first solar steam engines, an *insolateur* (insolator), in the shape of a dish (Ragheb, 2011). In 1903, Pope described him as "the greatest of pioneers in solar enginery. The world owes him a large debt" (Pope, 1903, p. 35). While France increased its coal production in the second half of the 1800s, Mouchot thought that coal would run out quickly and CSP would replace it, creating a goal for CSP that become obsolete when this energy crisis faded (Perlin, 2013). In the summer of 1866, he presented this engine to Napoleon III who funded him to build a solar engine in Constantine, Algeria. The French government thought that solar power might replace costly coal in its colonies, which they were importing from England (Perlin, 2013) (Hydrocarbons were not discovered in Algeria until much later.)

CSP's applications were still open to the imagination. In 1870, Mouchot's funding waned due to the Franco-Prussian war, but he supported his efforts through the wine industry, which used the solar engine to distill alcohol (Perlin, 2013). In 1875, the French Minister of Education launched a scientific expedition to Algeria with Mouchot to verify Mouchot's results and to test his solar oven, or *marmite solaire* (Royaumont, 1882).[49] Mouchot also tested solar water pumps for irrigation in Algeria (Perlin, 2013). The Minister said that it was "indeed under the sky of our colony, a sky always ardent, much more than under the sky in Paris"[50] that solar power should be developed (ibid, p. 233). This was perhaps the earliest reference to the assertion that North Africa is the appropriate place for solar energy due to its high solar insolation. Mouchot received 5,000 francs from the Counsel General in Algeria, 5,200 francs from the French Association for the Advancement of Sciences, and 14,428 francs from the Minister of Agriculture to build a larger solar engine for the universal exposition in Paris. Several years later, people at the exposition were astonished to see Mouchot's solar engines cook food and distill wine without coal (Perlin, 2013; Royaumont, 1882). Pifre, Mouchot's engineering assistant realized it would be an interesting paradox to use the solar engine to make ice at one of these fairs (Royaumont, 1882). He also used it to power a printing press (Pope, 1903). In 1880, Mouchot sold his patents to Pifre and an inventor in London (Cordier) to continue on his work (Royaumont, 1882).

Royaumont thought solar power's primary application was to cultivate the desert through solar irrigation, which he emphasized was not a utopian but a feasible idea and

---

[49] This reflects was what Shapin & Schaffer (1985) called the visual attestation of the technology.

[50] *L'était en effet sous le ciel de notre colonie, ciel toujours trop ardent, beaucoup plus que sous le ciel in constant de Paris.*

reflects the long-standing relationship between CSP and farming. He saw Senegal as the most promising country, where rum could be made with solar distilleries, and Algeria, which could regain its status as "the Granary of Rome," reflecting another poignant myth about the Sahara that will be discussed in Chapter 6. With solar power or heat, Algeria and Tunisia could grow alfalfa, exploit their forests, and distill dates to produce alcohol. He also imagined that the Sahara Sea could be developed using solar engines.

In addition to irrigation and food preparation, CSP had the broader potential to complete incomplete engineering dreams. It played a role in at least one of the large-scale colonial engineering schemes described above. Mr. Fournier, the Minister of Public Works in 1880 in Algeria, instituted a "solar heat" commission to investigate whether the sun could fuel the construction of the Trans-Saharan railroad. Two sub-commissions were formed in Montpellier and Constantine. They approved of using solar *insolateurs* for the railway. However, Pifre had insufficient resources to pursue this, and his biggest advocate, Mr. de Freycinet, left his post shortly thereafter leaving the work to waste away in boxes. Pifre formed the Central Society for the Use of Solar Heat (*Société Centrale D'utilisation de la chaleur solaire*) composed of men with experience and a good reputation in science and industry, including Alphonse Courvreux, who helped plan the Suez Canal. They tried to make solar engines lighter and cheaper for industrial use. The Society declared "Our goal was to take the utilization of solar heat at its origin and follow it up to its complete development. This goal was reached" (Royaumont, 1882, p. 278).[51]

[51] *Notre but était de prendre l'utilisation de la chaleur solaire à son origine et de la suivre jusqu'à son développement complet. Ce but est atteint.*

CSP was again declared to be feasible, but these solar engines were never successfully integrated into a project or a system.

Ultimately, CSP's proponents did not convince the colonial government that it could meet the needs of the emerging electricity system in North Africa. Royaumont also envisioned that solar *insolateurs* could be taken on French desert caravans to purify water through pasteurization and cook food, and Mouchot's *insolateurs* were carried on the first scoping mission for the Trans-Saharan railway. A commission convened to study the use of solar *insolateurs* on caravans, but they disapproved of the technology because it did not work during the night. CSP did not match energy needs in North Africa because Saharan settlers saved the most grueling physical work for 6pm to midnight (ibid). (Peak load is still 6-9pm in Morocco as people are arriving home from work and turning on air conditioning and other appliances, as discussed in Chapter 6.) Mouchot developed a method of heating water in an insulated box during the day and then this water was used to vaporize a liquid that would boil at a low temperature, similar to today's CSP storage. CSP did not sufficiently fit electricity needs in North Africa. Thermal storage for CSP was still under investigation when de Royaumont published his book, and this storage technology eventually led Desertec promoters to value CSP for its ability to generate dispatchable electricity, including at night. However, the French ultimately decided that solar energy was not reliable enough, and the mirrors were too expensive to polish (Perline, 2013).

Across the Atlantic, CSP developers in the United States framed CSP's use more explicitly as a pioneering technology to irrigate desert frontiers in the Southwest. In 1877, the first inventors to patent a solar device in the United States were John Hittell and

George Ditzler. Hittell wrote a book, *The Resources of California*, which drew the world's attention to California's agricultural methods (including the French protectorate in Morocco, as described in Chapter 6) (Pope, 1903). In 1870, an American named John Ericsson developed solar engines similar to Mouchot's, but in 1884 he changed his design to parabolic trough-shaped mirrors with a coating to prevent them from tarnishing (Perlin, 2013; Pope, 1903). Ericsson garnered interest among farmers for using his design for irrigation, but he died in 1889 before his plans could be implemented (ibid).

Despite Ericsson's death, interest in CSP grew in the United States, again due to coal strikes and concern that coal was running out (ibid). In 1901, Aubrey Eneas, an Englishman living in Boston, built a solar collector in California that further illustrated CSP's agricultural roots. He used it to power a water pump with 1,788 mirrors that concentrated sunlight onto a boiler. Eneas' patent stated that his solar generator "is especially intended for use in connection with irrigation of the arid plains of the west" (Eneas, 1901). Eneas used conical reflectors because he believed they were stronger than the parabolic trough. He displayed his solar engine at an ostrich farm in southern California. By using the solar engines to pump groundwater, Eneas said "the region ceases to be a desert, and can be made to blossom as the rose" (Pope, 1903, pp. 86-87). Pope (1903) stated

> The grain-grower and the orchardist and horticulturist join him [the farmer] in asking for water-raising apparatus; and the Auteil machine and the Pasadena [solar] engine are his reply. *Pure country power* may be had as well as "pure country milk;" and *the costless engine* may replace the expensive ones now

enjoyed by but a small part of the people who need them (pp. 122-123, original emphasis).

This quote illustrates CSP's persistent framing as a farming and agricultural technology and the assertion that power from the sun is free. Eneas later built solar engines in Chandler and Tempe, Arizona in 1903 (Perlin, 2013; Pope, 1903). He proclaimed, "sun power is now at hand!" (Perlin, 2013, loc. 1725). Willsie and Boyle also experimented with solar boilers using ammonia and hot boxes with the aim of powering irrigation and mining (Perlin, 2013). Given CSP's exclusive focus on irrigation in the United States, it most likely would have been necessary for CSP to have been integrated into the large-scale plans for irrigation under the U.S. Reclamation Act of 1902 for to have been successfully adopted at this time.

Figure 13. Eneas' Pasadena Pumping Engine. Note the similarity to the Sterling engines developed at the Solar Plataforma in Figure 6. Source: SolarEnergy.com, public domain[52]

Soon after, solar was again developed to improve colonial agriculture, and the CSP trough design took hold. In 1911, Frank Shuman developed a 2,700-meter

[52] http://solarenergy.com/power-panels/history-solar-energy

demonstration solar plant in his backyard in Philadelphia and founded the Sun Power Company (Ley, 1954). Shuman effectively advertised CSP's benefits to industry and agriculture in the world's sunbelt (Perlin, 2013). He secured initial funding in the United States, but the funds he needed to build a large-scale power plant came from London (Jones & Bouamane, 2012). The British were looking for energy to support the colonial enterprise, which suffered from a lack of cheap coal, especially for irrigating cotton plantations. Shuman argued that he could produce 25% more steam in a "tropical environment" using hot boxes to heat ether to drive an engine (Ragheb, 2011; Perlin, 2013).[53] The investors asked a prominent physicist, Sir Charles Vernon Boys, to review Shuman's design. He recommended a parabolic trough design, and investor support was made contingent on Shuman's acceptance of Boys' parabolic trough design. While Shuman lamented that the new design would provide less horsepower, he accepted the parabolic trough design (Ley, 1954), which today remains CSP's most popular design. Shuman's plant had about 5% efficiency, which was acceptable for the time period (ibid). In 1913, Shuman built "Solar Engine One," consisting of five parabolic troughs, in British-controlled Egypt using local material and labor in Meadi (or Maadi). Meadi was a farming village and is now a relatively affluent suburb of Cairo. Solar Engine One used a storage tank to operate around the clock (Perlin, 2013). At the plant's inauguration Shuman touted the benefits of solar power: "high efficiency, low installation, capital, and operation and maintenance costs, well defined length of service, and the possibility of operation with local labor without the need for specialty training" (Ragheb, 2011, p. 46).

[53] The colonies were called tropical environments, from Morocco to India.

As Ragheb argued and I illustrate later in this dissertation, Shuman's principles still largely apply today.

After the completion of the plant, Shuman said,

> Sun power is now a fact and no longer in the beautiful possibility stage. We have proved the commercial profit of sun power and… after our stores of oil and coal are exhausted the human race can receive unlimited power from the rays of the sun ("American Inventor Uses Egypt's Sun for Power," 1916)

Again, solar power was proclaimed to be feasible. Shuman agreed to build a system to irrigate 30,000 acres of cotton in Sudan, which was under British control. He also presented his technology to the German Reichstag, which offered him 200,000 Deutsche Reichmarks to build a solar power plant in German East Africa (Ragheb, 2011; Jones & Bouamane, 2012; Scientific American 1917).

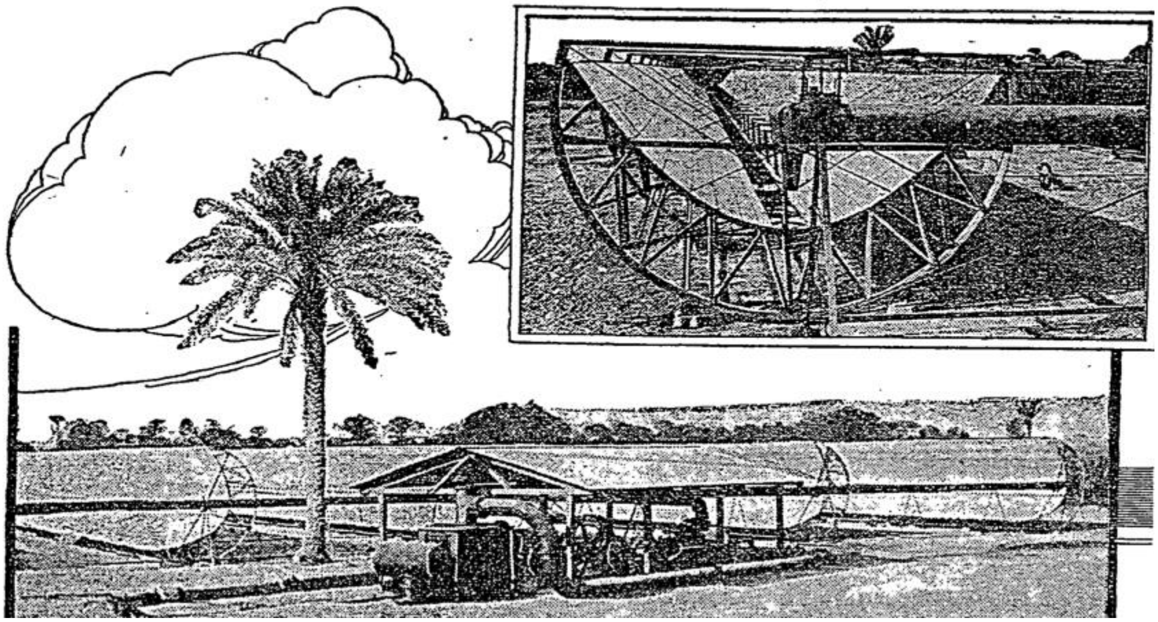


Figure 14. Shuman's CSP Plant. Source: *New York Times*, July 2, 1916, public domain.

As enthusiasm for Shuman's power plants grew, CSP was fleetingly imagined as part of a broader system to supply electricity to the region. Foreshadowing the Desertec vision, Shuman imagined a project of 20,000 square miles in the Sahara desert to generate 270 million horsepower, or all of the world's energy demand in 1909. He stated, "deserts in remote corners of the world could be made to bloom with the aid of sun-powered irrigation" (Jones & Bouamane, 2012, p. 8) He was not the first to imagine that distant locales could power the earth using heat from the sun. In 1903, Pope wrote that through solar heat "distant cities may be illumined from some 'long, sequestered vale,' where sunshine bestows its noiseless benison [blessing]" (p. 123). He went on to say that 320 acres covered with solar should power the railroad that would link up to a manufacturing center rivaling the largest in the world. Developing solar heat was a vision to dominate nature and, implicitly along with it, the Saharans. Pope stated

> Many lands have large tracts which have heretofore passed as deserts because of the abundance of the sun's downpouring; this very fact is destined to make Algeria, the Soudan, Egypt, India…grow opulent when the utilization of solar heat is carried to the point of simplicity and economy. An indescribably large benefit will accrue to hundreds of millions of people by the subjugation of the sun to common human service. What a motive to the truly humane inventor and capitalist!...If the desert may be made to blossom, what has prevented the Sahara from being turned into one magnificent oasis? Solar heat is 'no dream;' *it is:* let no man hereafter speak a word of question (pp. 140-42-45).

Here CSP is again declared to be a feasible reality. Furthermore, Shuman viewed it as a technology that will have development benefits through the human subjugation of the sun.

Shuman's plan ended in crisis. The British coal industry was prepared to fight the scale up of CSP in North Africa. Furthermore, Shuman's plan did not get far as World War I began and the British reneged on their contract with Shuman and dismantled the system for scrap metal. The engineers working on the project returned to their home countries. Some speculated that the plant was dismantled because the British were angry that Shuman agreed to work with the Germans (Ragheb, 2011). Shuman was originally of German descent and spoke German.[54] Shuman was welcomed in Germany as a native (Ragheb, 2011). The idea was dealt another blow as Shuman unexpectedly died of a heart attack in 1918. The postwar recession followed by the Great Depression and the British

[54] He had changed his name from Schuman to Shuman to sound less German.

nationalization of the Anglo-Persian Oil Company prevented a post-war reemergence of CSP.

Despite its lack of success, from its inception through 1920, CSP's promoters declared the technology to be feasible. Royaumont stated, "[CSP] is now a practical reality" (Royaumont, 1882, p. 227).[55] What constitutes reality here is viewed as material, an engineered reality, yet it was not successfully adopted within a system. Below I will illustrate that each discovery was disjointed from the last, and utterances that "solar is now a practical reality" were made over the course of more than a century. The end of the coal crisis, World War I, the death of prominent advocates, the lack of reliability, and the inability to meet peak demand in North Africa—as well as CSP's overall failure to be integrated successfully into electricity systems—prevented it from taking hold. While this could have easily been the end of the technology, it reemerged in the late 20th century.

CSP's Resurgence in the 1970s: La Plataforma Solar de Almería

Solar energy received scant attention from governments from World War I until the energy crisis in the 1970s, resulting in its relative dormancy. For example, in 1935, Germany passed the German Energy Industry Act, which put the government in charge of the energy sector and solidified the monopolies of existing energy companies, cutting out small-scale generation for 60 years (Berlin Technology Museum, 2013).[56] Starting in the

[55] «C'est maintenant une vérité pratique! »

[56] Shortly thereafter, Hermann Honnef envisioned building monolithic wind turbines providing 130 GWh per year, which enthralled Hitler although nothing was built (Berlin Technology Museum, 2014; Metcalfe, 2013).

1950s, most of the Western world was focused on nuclear power, not solar, with visions of atoms for peace and electricity too cheap to meter. The technology was kept alive during this period because individual researchers continued to experiment with the CSP technologies that are still used today. For example, in 1930s, the Secretary of the Smithsonian Institution, Dr. C.G. Abbot, an astrophysicist who studied solar radiation, patented solar cookers, distillers, and hot water heaters. He also built a solar trough similar to Shuman's design but with a more advanced method of tracking the sun (Ley, 1954). Solar development was a hobby for Abbott, who used his solar demonstrations to garner public interest in solar physics (Devorkin, 1998). In 1933, the Russians built a small experimental CSP plant in Tashkent, the capital of the Uzbek Soviet Republic, which was one of the only recorded government CSP projects during this time (ibid). In 1949, Felix Trombe built a solar furnace in the French Pyrenees, similar to technology later built at the government-funded solar research platform. Some other minor experiments were undertaken as described by Spencer (1989), but significant research did not begin again until the 1970s.

During the 1970s oil crises, governments across the world renewed their support for CSP. Although the crisis was not caused by a successful embargo but was instead due to consumer panic that led to over-purchasing petroleum and government mismanagement, it provoked fear of the Arab “energy weapon” and the “limits to growth” due to finite world resources (Mitchell, 2011). Shortly thereafter, CSP reemerged as a government-supported project. In the early 1980s, many industrialized countries developed experimental CSP plants, including Italy, Japan, the United States, France, Spain, and Crimea (Ruiz Hernandez, n.d.). Germany also invested 10 million euros in CSP in 1974 and a German CSP company called Solar Millennium was founded in 1998. However, it is relevant to note for the Desertec vision that CSP was not developed on German soil, likely due to its land and solar insolation needs. The only CSP plant in Germany is a very small 1.5 MW experimental tower plant build in Julich in 2008 to test air cooling and storage systems. Germany has long looked overseas for its CSP ambitions.

Solar hot water heaters and solar PV panels were the focus of “solar for hippies” (Perlin, 2013, Kindle loc. 4685) during the small is beautiful movement of the 1970s to decentralize energy production and put it in the hands of the people. In contrast, the goals for CSP related to national security, independence, and national technological prowess. Several factors affected CSP’s framing during this period, which will be described in the next section. First, CSP was torn between being a technology of international cooperation and one of national pride and energy independence. Second, CSP continued to be framed as a technology of the frontier, developed in economically depressed deserts by pioneers. Third, CSP trailed after nuclear power and was designed in its image in the United States. Fourth, the rise of environmental consciousness contributed to CSP’s resurgence, although this is a more important framing in the 2000s.

Unlike wind power, which was developed by small eco-friendly organizations and later co-opted by large corporations (Hess, 2005; van der Vleuten & Raven, 2006), CSP has long been a large-scale, corporate technology developed initially during this resurgence by major electricity, defense, and military contractors. At the solar research platform in Spain, Martin Marietta and Iteratom built CSP’s mirrors or heliostats, Siemens built the control system, Initec provided engineering consulting, 3M provided glue for mirror bonding, and the Spanish engineering firm Abengoa also provided heliostats. Some of the research on CSP in the United States was conducted at national laboratories prominent in the nuclear research, such as Sandia National Laboratory, which built CSP in the image of nuclear power.

Shortly after Franco's death, Spain arguably made the most concerted efforts worldwide to that point to develop a CSP R&D program. The Spanish engineering giant founded in 1941 in Seville— Abengoa—began to work on CSP technologies, later becoming one of the leading CSP developers. In 1976, Juan Temboury, the director of the Spanish Ministry of Industry and Energy, attended a meeting of the International Energy Agency and learned about plans to develop the Small Solar Power Systems Project (SSPS), a CSP tower plant, among nine countries (Ruiz Hernandez, n.d.). He was determined to win the project for Spain to jumpstart its solar energy industry. He conducted a feasibility study, and in 1977, the IEA named the German Aerospace Center (DLR), Germany's NASA, as the operating agent and Spain as the host country.[57] The task was, again, to "prove the feasibility of producing electricity from solar energy" (Barrera, 2010).

In 1977, *La Plataforma Solar de Almería* (PSA, or the Solar Research Platform in Almería) was founded, and it went into operation in 1981. The data used below is based on oral histories compiled by Ruiz-Hernandez (n.d.) about the PSA in a 510-page book and video, as well as in-person visits to the PSA I made in June 2013 and 2014. The PSA researchers and Protermosolar, the lobbying group for the Spanish CSP industry, published the PSA book and video, which commemorated the heroes of solar energy.

[57] Previously DFVLR, now DLR, the developer of the Desertec feasibility studies.

They emphasized that the Spanish researchers and companies working on the PSA should be recognized and listed names of people involved in the project in almost Old Testament fashion.

The PSA researchers saw themselves as young, idealistic innovators who “are going to be the pioneers” in reviving an economically deprived desert to make the solar “utopia become reality,” reflecting CSP’s frontier/farming framing. They chose the Tabernas desert in Almería, a Mediterranean province in Southern Spain and the only desert in Europe, because of its high solar radiation and flat land. After the researchers identified the Almería coast on a solar radiation map, they met with the head of the provincial council there who said, “you can have the whole coast” (Barrera, 2010). Almería was a key example of what Roux (1997) termed a “depressed Mediterranean zone.”[58] Its main industry was the filming of spaghetti westerns. One engineer described Almería as a “ghost town” when he arrived. Another said, “these facilities in the middle of a barren landscape, some of which seem to have come from the future, make up the biggest test center in Europe…” To illustrate their commitment to rural uplift, the researchers used the Indalo as the project logo for the SSPS, which is an ancient symbol of a man holding a rainbow in his arms over his head (see *Figure **15***).

Figure 15. PSA Logo. Source: Estela.[59]

[58] “*zone Méditerranée défavorisée »*

[59] http://www.estelasolar.eu/index.php?id=34

The Indalo was used as a good luck charm in Almería of in the middle of the 19th century when the region was suffering from droughts and economic downturn ("Inland Almeria, villages in the province of Almeria Andalucía, Southern Spain," n.d.). Running water, electricity, and telephone service lagged behind other areas of Spain (ibid). The electricity grid in the area was unreliable, and the closest access to transmission was a measly 32 kV line of questionable quality (Ruiz Hernandez, n.d.). The PSA constructed a 66 kV line and improved the reliability of electricity infrastructure in the area. After the PSA was built, they referred to the Tabernas as "the international laboratory for concentrated solar experiments," which fit into a longstanding discourse on deserts as scientific laboratories. However, not everyone in Almería was enthralled with the PSA. Some thought that it was causing drought. Citizens criticized the project for using more energy than it generated. The head of the local electricity company ridiculed the unusual technologies.

National Spanish leaders, however, were excited to have the project during their transition to democracy. Spain believed that it was left out of the Industrial Revolution, and advancing its progress in renewable energy was seen as a "Third Industrial Revolution" (Frolova, 2013). "Spain was aware from the very beginning that it had to be in the front row and not miss the train like it did in other processes of technological development" (Ruiz Hernandez, n.d.). CSP was part of Morocco's post-Arab Spring political transition decades later.[60] Jose Luis Rodriguez Zapatero, the previous President of Spain, opened the textbook by framing Spain as an innovative, technological pioneering nation due to its work in CSP. He stated

[60] See chapters 6 and 7.

> For a long time, Spain's image has frequently been associated with sun and sand. A Mediterranean country, with a culture as diverse as it is rich, of friendly open people. Too often the enterprising character of its citizens and the talent of its researchers are forgotten. A trait which, however, thanks to the work and perseverance of persons such as those mentioned in [this book], has made it possible for Spain to also be seen today as a daring and innovative country…Spain is now one of the pioneering nations in renewable energies… (Hernandez, 2010, p. 19).

President Zapatero captured the nationalistic attitude toward CSP and its importance to Spanish pride. CSP was also a source of political power, and the video in the PSA's visitor center in 2013 even referred to concentration as a "secret weapon" in technological innovation.

The Spanish vacillated between framing the PSA as a distinctly Spanish nationalist effort versus an international research center with nine participating countries, which was recognized as a European Large Scientific Installation in 1990. Financially, the United States was the largest contributor to the first power plant SSPS-DCS, a 1.2 MW parabolic trough, followed by Germany, followed by Spain. The project used American cylindrical parabolic mirrors with German tracking technology. The researchers recounted that the PSA was driven by a fear that they were falling behind the United States in the development of CSP, even though the project was supported by U.S. funding and U.S. contractors. After a year, the German government wanted to pull out to focus on PV and nuclear but were convinced to stay. In 1986, the Spanish-German cooperation agreement included a renewed commitment to the PSA collaboration. CSP was always an extra-territorial obsession for the Germans. While Spain proceeded with CSP at home, Germany pursued PV and later looked to North Africa to provide dispatchable solar power to balance out the intermittent PV it built into its grid.[61]

The Spanish researchers were injured by derisive comments that the PSA was "that German thing in Almería" (Ruiz-Hernandez, n.d.). The German who was most liked on the project was the first to learn Spanish and to adapt to the local culture. One researcher reflected on how proud he was to be a Spaniard when they connected the project to the grid. Another said

> the truth is I never felt dependent on the outside world. We considered this to be our own project and it used our own resources. It was our know-how and skills. Everything we needed was at hand and we threw ourselves into it.

One researcher said ""[The development of the PSA and CSP] was done with 100% Spanish technology, 100% Spanish workers and all of us really young. And it worked…" He mentioned that the EU green and white books advocating for the use of renewable energy are the colors of the Andalusian flag.

In contradiction with this nationalism, the international collaborative process at the PSA was also a source of pride, and the video in the visitor's center stated that the researchers worked with different cultures and languages to "[learn] how to concentrate

[61] See Chapter 5.

knowledge.” The researcher quoted above about the Andalusian flag also called Germany “the motor of the SPSS project” (p. 197). The project encompassed both the complexities of developing innovative technologies and of balancing international collaboration, and he stated, “all this was like an enormous puzzle in which pieces were coming from different countries without any previous cross knowledge and with different companies supplying different components.” Another said that the mutual trust developed between the Spanish and Germans contributed to the project’s success stating that “the prospects for a truly sunny future in German-Spanish co-operation have seldom been as good as they are today!” Another called the PSA a “Spanish-German plum cake”.[62]

Figure 16. SPSS. Source: The PSA, Used with Permission

[62] There is emphasis in the oral histories of the PSA of meals and apartments shared, bars visited, life events celebrated, deaths mourned, and a general solidarity built up from living in a remote location where researchers found little entertainment. Some researchers, however, insinuated that there was a lot of conflict in the “collaboration-confrontation” with the installation companies, the story of which was too early to tell.

Figure 17. CESA-1. Source: The PSA, Used with permission

Figure 18. Eurodish Stirling Engine, Solar Research Platform, 2013. Source: Plataforma Solar de Almería website. Used with permission.[63]

Figure 19. DISS Parabolic Trough. Source: Plataforma Solar[64]

In 1986 the PSA suffered a devastating blow from a sodium fire in the SSPS, which occurred only five months after the Chernobyl nuclear accident. Sodium is also used in fast breeder reactors, so the PSA gave a press conference to reassure the public

[63] http://www.psa.es/webeng/instalaciones/receptor.php

[64] *http://www.psa.es/webeng/instalaciones/parabolicos.php*

that the sodium was not radioactive. The PSA lost momentum as support “went up in smoke,” although support was already waning as the energy crisis faded from memory. The Spanish Ministry of Industry, Trade, and Tourism, questioned why this “outlandish” technology had been built “in the middle of nowhere” (Ruiz-Hernandez, n.d.). The United States and Germany wanted to tear down the power plants. The PSA used a loophole in its founding documents to collect insurance money from the fire to continue its work. The unexpected death of the PSA’s head also disrupted the PSA. The PSA researchers conducted freelance work for the European space program to keep the PSA operational. One of the PSA’s engineers referred to this persistence as “the vigor of some green shoots that have colonized an inhospitable land” (ibid, p. 226). International donors withdrew from the project, making it a Spanish project under the Spanish research center, CIEMAT. One of the PSA employees saw this loss of international support as the beginning of the solidification of Spain as the world leader in CSP

> …I had a baptism of fire” [before the sodium fire]…”But it was not the end. It was the rebirth. Like the phoenix that is born from its own ashes, we saw how that famous (or infamous) fire turned a new page in the history of the PSA…[it] later took off, leaving [the Germans and Americans] behind and making Spain the world leader in concentrating solar thermal energy technologies (pp. 364-65).

The PSA is still operational. It spurred the construction of 46 commercial solar thermal power plants in Spain. Many of the involved companies still operate in the CSP sector and continue to frame the Mediterranean as the ideal place for CSP. Michael

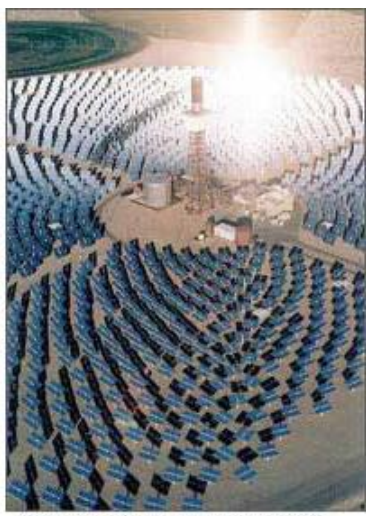
Geyer, International Director of Abengoa Solar proclaimed “We have brought Andalusian solar technology to the world.” Geyer calls himself “a German from Almería” (Ruiz-Hernandez, n.d., p. 246). At the commissioning of the PS20 plant, Jose Monzonis from Acciona, a Spanish construction firm, stated, “The Mediterranean has significant potential not just for the countries in North Africa but in the medium term for all Arab countries and southern Europe” (Barrera, 2010) Currently, Acciona is constructing the Noor I solar trough plant in Ouarzazate as the technology is being adopted in the MENA region.

While environmentalists often blame the fossil fuel villains and detractors for solar energy’s failures, CSP has equally suffered from bad luck. The PSA textbook’s commemoration and celebration of the technology and its pioneers were premature. They tried to solidify and close the technology, but three years later, crisis ensued. The weighty effects of the Eurozone crisis in Spain led to negative public perceptions of the feed-in tariff subsidy that was essential for supporting renewable energy, which was later dubbed “the feed-in debt”. In 2013, the Spanish government revoked the feed-in tariff, not just for new installations but for existing installations, replacing it with a flat rate of return of roughly 7% over a plant’s lifetime (Hashem, 2014). At the time of publication, Spain was facing lawsuits from several renewable energy developers for reneging on its subsidies. In March 2014, the *CSP Today* industry magazine quipped that Spain can “say adios” to CSP investors as they look to the Middle East and North Africa instead (Hashem, 2014). Today, the PSA does not give the impression of a high-tech research facility, like the clean rooms of PV manufacturing facilities, but resembles the remnants of a failed experiment from the 1980s, with loose pieces of equipment strewn about and many of the original technologies still standing. The 2013 video in the PSA's visitor center boasted that the PSA uses advanced equipment, which evoked laughter from our student audience visiting the PSA as the video pictured researchers working on unwieldy computers from the 1980s. The video has since been updated to portray the PSA as modern and cutting-edge.

Designing CSP in the Image of Nuclear Power: California in the 1970s

The U.S. focus on solar thermal technology from the 1970s onward was on building it at a large scale (Ruiz Hernandez, n.d.). The U.S. Electric Power Research Institute and the U.S. Department of Energy optimistically estimated that by 2010, electricity from CSP would cost 4 or 5 cents per kilowatt-hour (ibid). Since it seemed likely that the cost of fossil fuels would continue to skyrocket, utility companies invested in CSP to maintain their centralized system configuration while substituting fuel from the sun. Government CSP research was shaped by the U.S. nuclear legacy. National laboratories developed during World War II for atomic weapons programs, like Sandia and Livermore, began focusing on building solar power plants "in the image of nuclear" in a way that could be plugged into the grid.

Sixty to 70 percent of the research conducted on solar by U.S. government and industry focused on CSP tower (Boesman, 1994), emphasizing centralized sources of renewable energy over distributed. The U.S. Energy Research Development Administration (the precursor to the Department of Energy or DOE) and a U.S.-Israel company called Luz were the leading developers of CSP. The Electric Power Research Institute, which had an industry-run CSP R&D program, saw the power tower, not the solar trough, as the most likely candidate for central electricity generation (Metz, 1977). Solar PV received some attention but was not the primary focus. In 1982, the DOE, utility companies Southern California Edison and the Los Angeles Department of Water and Power, and the California Energy Commission completed construction on Solar One, a solar power tower demonstration plant in Daggett, California. It was a 10 MW plant with a field of 1,818 mirrors that focus heat on a central tower (Boesman, 1994). It was redesigned in 1995 with an innovative molten salt storage system, allowing the plant to generate power through the night. In 2010, it was torn down and replaced with a trough plant, as the CSP industry continuously vacillates between the two designs.



Solar One in Daggett, California

Figure 20. Solar I, Daggett, California (completed in 1981). *Source: California.gov*[65]

[65] http://www.gosolarcalifornia.ca.gov/about/gosolar/california.php

Figure 21. Solar I with the Old Solar One Tower in the Background and the Trough in the Foreground. Photo by Author.

CSP's emergence should be understood in the context of nuclear power. Critics of this R&D agenda complained that the program was "making solar after nuclear power" and focusing on solar power tower technology at the expense of solar photovoltaic panels. (Hammond & Metz, 1977, p. 241). Amory Lovins called ERDA's work "ingenious high technology" but criticized it for supplying "energy in a form and scale inappropriate for most end-use needs (Lovins, 1977, p. 42). The Congressional Office of Technology Assessment also criticized the ERDA for devoting much of its resources to utility-scale solar. They argued that the CSP program was set up like the nuclear breeder reactor program, scheduled to proceed from a small test to the first commercial plant in four stages (Hammond & Metz, 1977).

Luz International developed the most successful commercial demonstration of CSP during this time period, which was couched in a religious framing of the technology. In the 1970s, Luz, now BrightSource Energy, was experimenting in Israel with parabolic trough technology. In the 1970s Luz's founder, Arnold Goldman, published *A Working Paper on Project Luz*, and *Moving Jewish Thought to the Center of Modern Science,* which illustrated his personal convictions for the technology that were influenced by the Israeli Kubbutz movement and what he called “Jewish thinking,” or tying knowledge to concrete action (“Meet BrightSource’s Arnold Goldman,” 2010). Goldman imagined Luz as “a utopian eternal city” “[symbolizing] both light and consciousness” and “turning rays of light into celestial power” (Berger, 1998). CSP’s image shifted from one of humans conquering nature by harnessing the sun while leaving behind primitive sun worship, to a resurgence of CSP as a divine, utopian technology operating harmoniously with the environment. In 1979, Goldman raised $2 million from a jointly funded US-Israeli initiative for the parabolic trough technology and incorporated Luz International. Luz’s funders were Patrick Francois, a marketing entrepreneur, and Neto Becker, who was the world’s largest individual investor in Israeli technologies (Berger, 1998). Luz started out by providing solar energy to textile companies in Los Angeles.

In 1979, Luz secured a contract with Southern California Edison to build a CSP plant on land adjacent to Solar One. They built the Solar Electric Generating System I (SEGS I), which is a 13.8 MW plant consisting of 82,960 square meters of parabolic mirrors that rotate to track the sun throughout the day (LA Times, 1985) (See Figure **22**). The mirrors concentrate sunlight in a central tube filled with oil, which heats to 750 degrees Fahrenheit to drive a steam turbine. This became the first commercially operated CSP plant in the world, built for $62 million compared to Solar One’s $108 million (Boesman, 1994). It is still operational today. Mitsubishi provided the turbine, Bechtel conducted feasibility studies, and CH2M Hill provided consulting services (Berger, 1998); these companies still play significant roles in CSP today. Luz went on to build eight more facilities in this area—collectively called the 354 MW Solar Electric

Generating System (SEGS)— which sells power to Southern California Edison (Lotker, 1991). Luz Industries Israel became one of the top ten Israeli exporters of goods between 1986 and 1990 (Berger, 1998). "If we can keep going strong past 1988 we will prove that we are not just an experimental company but the first new legitimate source of energy since nuclear, Goldman [enthused]" (J. L. Cumps & Cumps, 1991).

Figure 22. SEGS I. Wikimedia Commons, Bureau of Land Management[66]

However, CSP suffered from scalar conflict. In terms of financing, the National Energy Tax Act provided a 15% federal energy tax credit for investment in renewables, and California provided a state-level 25% renewable energy tax credit (Kemp, Rip, & Schot, 2001).[67] Furthermore, the 1978 Public Utilities Regulatory Policy Act (PURPA) both supported and impeded Luz's plants. While PURPA's goal is often colloquially thought to be the expansion of renewable energy, the political goal was in fact to disrupt the vertically integrated monopolies that utilities had over electricity distribution and power generation. PURPA allowed small-scale independent energy generators, including

[66] http://www.ca.blm.gov/cdd/alternative_energy.html

[67] For a detailed discussion see Van Est, 1999.

but not limited to renewable energy generators, to sell their energy to the grid (ibid). Federal legislators left the implementation of PURPA up to individual states. California's Governor Jerry Brown, who was then supportive of small-scale technologies like wind and solar, strictly implemented PURPA (Hirsh & Serchuk, 1996).

In 1983, the California Public Utilities Commission required utilities to sign contracts with "qualifying facilities (QFs)," or facilities that produced less than 30 MW of electricity under PURPA (Blumstein, Friedman, & Green, 2002). (Compare this, for example, to California's 2,240-MW Diablo Canyon nuclear reactors.) These 20-30 year contracts locked utility companies into paying a rate determined by mistaken assumptions that the price of oil would continue to increase rapidly (Hirsch & Serchuk, 1996). Wind and solar producers, including Luz, sold their energy to the grid through QF contracts, although much of the QF generation came from cogeneration plants[68] (Lotker, 1991).

The energy policy community widely assumes that Luz failed because the Reagan administration did away with the federal energy tax credits, but the reason is more nuanced. The energy tax credits were extended after they expired in 1985 (four years into the Reagan administration), but Congress had to renew them annually, creating an atmosphere of uncertainty and rushing construction times for each phase of SEGS (Lotker, 1991). Furthermore, PURPA's focus on small-scale generation stunted CSP. CSP is not a small-is-beautiful technology like PV in which economies of scale come from the factory size not siting, but a standard steam-turbine technology in which economies of scale come from the size of the power plant. Luz built the SEGS plants in

[68] Cogeneration, which is also called combined heat and power or CHP, is a means of reusing the leftover heat from electricity generation. Typically this heat is released through cooling towers at power generation plants. Cogeneration plants use this waste heat to heat in homes or for other purposes, such as use in factories.

30 MW phases because of PURPA's limitations, which limited their economies of scale and resulted in a higher electricity price of 25 cents per kWh (ibid). They successfully lobbied the federal government to make the last plant 80 MW, bringing the levelized cost of energy (LCOE) down to 10 cents per kWh (ibid). In 1989, Congress extended the Energy Tax Credits for only nine months. Furthermore, extending the California property tax exemption for solar installations was controversial since it was essentially a tax credit for only one company (ibid). The California legislature approved the credit, but the governor delayed signing the bill into law (ibid). This compressed Luz's construction time from 10 to seven months in order to secure the tax credit. The tax credits were extended again from 1990-1991, but the shortened construction schedule had already consumed Luz's net worth. Luz also admitted that it had significant management difficulties. Political uncertainty prevented Luz from securing financing for another plant, and it filed for bankruptcy in 1991.[69] Some speculate that CSP's greatest commercial success might have also been its greatest failure, as investors were turned off by Luz's bankruptcy (Feld, 2012). The important point to note is that a conflict over the appropriate scale of energy was at least equally important to the uncertainty in the tax environment to the failure of CSP.

The New Solar Gold Rush

In the mid-2000s, the goals for the reemergence of CSP changed as it was enrolled in the sustainability and climate change debate. California sought to use CSP to

[69] In 1992, many Luz engineers took the intellectual property rights to form a company called Solel, to build parabolic troughs. (Solel was bought by Siemens in 2009 and went bankrupt when Siemens left the CSP sector in 2012).

meet renewable energy and climate change targets, but these environmental goals also made it vulnerable to criticism. Metaphors portraying solar as California's "new gold rush" or "solar gold" or a 21st century El Dorado made headlines, reminiscent of the 19th century colonial search for El Dorado in the deserts of North Africa. In 2004, Goldman resurrected Luz as BrightSource Energy. But Arnold Goldman's utopian dream was again corrupted in 2007 when environmentalists criticized the site selection for BrightSource's first power plant in California—the Ivanpah Solar Electric Generating System (ISEGS) (see *Figure 23*)— due to the project's negative effects on the local desert environment. In this time period, it was clear that CSP was technologically feasible—it could be built. But *should* it be built and in what landscapes? Activists criticized Ivanpah and similar proposed solar projects for their industrialization of public land in remote areas and their effects on endangered and threatened species like the desert tortoise and rare plants and sites of spiritual importance to Native Americans. They questioned whether large-scale solar fits the desert landscape and advocated instead for distributed, point-of-use renewable energy generation. Ivanpah uses dry-cooled technology, but in wet-cooled power plant siting cases in California and Arizona activists were outraged by CSP's water usage. For these activists, Goldman's machine had entered the garden (or the "old growth desert" as the activists called it), but in a way that violated sacred values, rather than connecting earth to the heavens. In Spain, the Andasol solar trough projects drew similar criticism from the local community. BrightSource won the siting permit, in part, by launching a public relations campaign that effectively portrayed their project as inevitable. Substantive conflicts were presented as mere delays; their emerging project was not an "if" but a "when."

During ISEGS's construction, it became clear that it would affect the tortoise population more significantly than expected (660-880 tortoises would be harmed on the project site, rather than the original estimate of 30). As ISEGS started operation, observers gawked as "streamers"—birds, insects, and debris—lit on fire in the air when they approached the mirror field. (Perhaps the solar farm had come to resemble slash-and-burn agriculture.) Currently, skeptics in the United States and abroad are questioning whether CSP meets the criteria of a sustainable technology or if it has become a technological juggernaut. These challenges that cut across environmental, social, and technological domains illustrate the integrated challenges relevant to the construction of sociotechnical electricity systems in the 21st century.

Figure 23. **The Ivanpah Solar Electric Generating System (2014). Source: BrightSource Energy.**

In Europe, CSP reemerged during this time period as part of the Desertec vision, originally as a technological solution to the "limits to growth" framing of environmental problems.[70] However, after Germany withdrew from the PSA, and the Chinese began

[70] See Chapter 5.

heavily investing in PV, CSP lost its strong government advocates outside of the United States. The head of the Desertec Foundation stated in an interview with me,

> So then all the money that the companies put in research and development, was put in wind and photovoltaic [because of the renewable energy conditions in Germany and CSP not being feasible there]. Because the German market was so interesting. But CSP...is a kind of child without a father.

Chapter 5 examines the reemergence of CSP in Europe in the mid-2000s a “mature technology” subsumed under a system-level vision for a Mediterranean-wide electricity system.

Conclusion

This chapter described CSP’s birth in the mid-1800s followed by its reemergence in the 1970s during the energy crises and finally its latest instantiation in the 2000s. It began by illustrating how contemporary large-scale engineering visions to put the Sahara desert into service by building enough solar generation there to power the world reflect certain aspects of plans for colonial-era Saharan techno-utopias like the trans-Saharan railway, the Sahara Sea, and the Atlantropa project. The chapter then illustrated that CSP was born in colonial Algeria and Egypt in the mid-1800s to early 1900s. Government support for CSP plummeted due to the world wars, the Great Depression, and the support for nuclear power post-World War II. It resumed during the 1970s oil crisis. Numerous Western countries developed CSP plants in the 1970s and 1980s, with the center of activity at the international solar research platform in Spain, as well as the U.S. solar demonstration plants constructed by NREL and Luz (later called BrightSource Energy) in California. As the energy crisis waned, Luz Solar filed bankruptcy in 1991, beginning the “long dark solar night” in which government support for CSP lapsed. In the mid-2000s, CSP reemerged in the United States and Europe as part of the climate change and sustainable energy debate. More recently, the technology is shifting toward North Africa and the Middle East as solar subsidies were recently slashed in Europe and the United States during the economic crisis.[71]

Although it is often assumed that CSP was developed during a rising wave of environmental consciousness of the 1970s, it was actually developed during the late 1800s and was viewed as a means for humans to dominate nature. In the 17th century, Francis Bacon argued that scientific knowledge would allow human control over nature and would act as an instrument of self-control by means of rational intelligence (Leiss, 1972). Bacon attempted to remove ethical strictures against the control of nature while trying to avoid upsetting the powerful church (Merchant, 1989). Bacon’s view largely won out and, at least in the United States, democratic culture has been paired with a liberal attitude toward technological process (Ezrahi, 1990). Winner’s core observation in *Autonomous Technology* is that people think artificial things are easier to control than natural things, partially as a result of dualistic thinking that emerged during the Enlightenment between nature and society. Yet many large-scale technologies are often

[71] See Chapter 3.

viewed as having their own agency as they become part of systems that are beyond any individual’s control (Winner, 1977). As actors look at green technologies such as the recently completed Ivanpah power plant with skepticism—or for some activists, abject horror— about whether it meets the criteria for energy justice and sustainability, society seeks to imbue democratic culture with ethical restraints to technological change.

Hence, energy system builders are faced with a new challenge, to shift energy systems toward the often ill-defined concept of sustainability, which certainly means something other than dominating nature and involves ethical precepts. Too often solar is assumed to be intrinsically sustainable. More recently, activists interested in solar power are not just asking ‘can we?’ (e.g., is it feasible?) but ‘should we’? Can these systems be built without the oppressive and authoritarian technologies Winner (1986) critiques while increasing energy access? This challenge is coupled with the fact that the sustainability agenda must refurbish and retrofit existing technological systems. CSP, as an emerging and reemerging technology, must be successfully integrated into this system in order to take root. The rest of the dissertation describes the complex sociopolitical landscape in which CSP is being built today and how it shapes visions for energy transformations. Then Chapter 8 presents an energy justice framework to aid in evaluating the ethical principles entailed in energy technology and systems change.

In today’s fight against climate change, CSP and the green electrons it provides may have a different set of politics than in the past. Since CSP developed within a colonial context in Algeria and Egypt, the politics of conquest might endure in their design, but it is equally possible they will develop differently within a different time period and social context. Today, the debate about CSP’s value is intertwined with complicated questions about what counts as a sustainable technology across the triple bottom line and the role of renewable energy in sustainable development. If the end goal is the elusive construct of sustainability, rather than the domination of nature, CSP looks less like a solution. For the activists at Ivanpah, CSP was not sustainable because it resulted in a perverse trade-off between preserving an "old growth desert" teeming with life versus reducing greenhouse gas emissions. In the developing world, the question has become whether CSP—a technology rooted in imperial conquest— can deliver multiple ancillary benefits to society such as the development of supply chain industries, job opportunities for both educated and undereducated populations, and a green electron export commodity, as well as improving energy equity.[72] How do the ideological promises made for deferred dreams change as it reemerges, and are these past cultural expectations for the future of the technology ingrained in it? Or does the technology need to become a material reality in order for these expectations to stick? The following chapters will continue to explore these themes, finding that, in the visioning phase, a technology's politics are not completely cemented but dependent upon the level of procedural justice in its development.

[72] See Chapter 7.

CHAPTER 4

ENVISIONING MEDITERRANEAN ELECTRICITY TRANSFORMATIONS: THE SPATIAL ASPECTS OF ENERGY JUSTICE

> *"[Desertec] it's rather like what Mark Twain said of Wagner's music; it's not as bad as it sounds. This idea is catching on. This idea is the idea of the future and it's probably going to be the biggest single project which will bring together North Africa, the countries of the Arab League, and the European Union."*
>
> *– Sir Graham Walton, EU Parliament, Dii conference 2012*

Introduction: Envisioning Energy Transformations

In 2012, Sir Walton suggested that the deferred Desertec dream was ahead of its time but would be the political integration project of the future. One year later at the 4^{th} Dii conference, Bertrand Piccard stood in a black flight suit in front of an audience of investors to convince them that the Desertec dream could still take off. Piccard and his team had developed a solar airplane that could fly without fuel even at night. His maiden voyage from Switzerland to Morocco in June of 2012 traced the path of the transmission line under the Strait of Gibraltar connecting Spain and Morocco. A team of dignitaries, including the head of the Moroccan Agency for Solar Energy (MASEN), which is strongly supported by the King, met Piccard when he successfully landed in the Moroccan capital, illustrating the political significance of his trip. Piccard viewed himself as a European ambassador of renewable energy, a pioneer of innovation, and an energy refugee who fled over the Strait of Gibraltar to escape a foundering European energy policy. The Strait of Gibraltar is sometimes called the Strait of Death because immigrants die trying to cross it.

Piccard's cross-continental flight symbolizes the goals and challenges of the Desertec vision and some of its implications for justice that will be addressed in this chapter. Methods of depicting connectivity across the Mediterranean Sea, like Piccard's voyage, have been used to substantiate a vision for infrastructural and geographic connectivity for the Mediterranean region. However, centrifugal forces, like the politics of immigration, pull the region apart. In its early stages, the Desertec vision promised to develop North Africa to halt immigration to Europe, deeply integrating technological infrastructure and providing equal access to it but keeping Mediterranean politics largely separate. Later on, it promised to deeply integrate Mediterranean infrastructure and policy to bind the region together to address shared problems. In a best-case scenario, the first version would offer energy equality, ensuring everyone has equal access to energy through reliable, interconnected infrastructure while the region remains culturally and politically separate. The second version could offer broader energy equity and justice outcomes that strike at the core of cultural and political integration issues in a region encompassing deep sociopolitical differences and inequities. Both depictions of the Desertec vision struggle with issues of political and social feasibility. The first assumes that technological integration could be achieved without political integration and the second assumes that unprecedented political and technological integration would lead to overwhelmingly positive, win-win outcomes.

This chapter explores the themes of energy equality and equity and political and technological integration from a spatial perspective, showing that the vision for an integrated Mediterranean electricity system was shaped by various geographic representations and framings of the region and that these representations also affect its possible energy justice outcomes. These geographical framings emphasized connectivity, empty space, and various system benefits. For example, system imaginers used the metaphor of an electricity “island” to argue that a regionally integrated transmission infrastructure and electricity market would be more efficient and sustainable than building disconnected, or distributed, electricity systems. This chapter empirically demonstrates the argument made in Chapter 1 that energy transformations reconfigure space in ways that matter for politics and society.

Hughes (1983) described how sociotechnical systems are shaped by the uneven geographical distribution of energy resources. This chapter expands upon that observation by illustrating how constructed, political representations of geography shape the development of sociotechnical systems. The Desertec system has not been merely influenced by where the energy resources are but by how the landscapes are envisioned, mapped, and perceived and by the politics underpinning this process. Furthermore, the existence of energy wealth itself is necessary but insufficient for framing a landscape as an appropriate place for energy generation.

Chapter 1 also asked what would be the possible sociopolitical and justice outcomes of a transnational electricity system, which will be explored in this chapter. This process of envisioning landscapes is no longer confined based upon nation-state boundaries as it was in the past, but is occurring at a regional level. Hughes (1983) used comparative multi-country case studies to understand how sociotechnical systems are shaped. Today's electricity systems are shaped by regional geography, transnational and national politics, and an envisioned globalization of energy, making the context for sociotechnical systems development completely different. Significant political development challenges are at stake today in the evolution of transnational sociotechnical systems. The first section of this chapter discusses the Desertec vision's significance as a regional case study and then describes how the Desertec vision has been shaped by transnational and Mediterranean politics. Then, I describe the geographic shaping of the Desertec vision and its implications for energy equity and equality. This chapter argues that visions for energy systems are shaped by constructed geographies and that these geographies are politicized, thereby affecting the implications of the vision for energy justice.

A Macroscale Overview of the Desertec Vision Within Mediterranean Electricity Policy

This section argues that the Mediterranean region is a strategic site for understanding energy development, security, and justice. The Mediterranean is a region encompassing deep cultural differences, disparities, and inequality, with a storied history of cooperation and conflict that set the stage for contemporary plans for regional energy integration. It is a heterogeneous region, but its member nations share problems with transportation networks, overpopulation, urban crowding in coastal cities, the challenges of a fragile environmental system (Roux, 1997), and energy. As explained in Chapter 1, Edwards (2004) argued that multi-scalar analysis is important for understanding the development of modern technological systems. This section provides the regional-scale political context of the Desertec vision. I illustrate that Desertec is not a *sui generis* vision but is integrated into Mediterranean, European, and German energy policy and illustrative of the system-level stakes of European energy policy. Plans for Mediterranean energy partnership reflect 1) German-led efforts to expand the European Union to adjacent regions, as well as German industrial and foreign policy goals 2) a regional, or even, global framing of energy security that Desertec and some in the German government imagine could be achieved by spreading German technologies and know-how to surrounding regions. As such, political support for Desertec exists despite it immense scale and ambition.

The Mediterranean region offers an advantageous case study for understanding energy inequity, inequality, and justice because it encompasses tremendous energy wealth and poverty amidst profound sociopolitical differences. It is an important region for understanding conventional energy systems—it includes important global oil producers such as Saudi Arabia, Libya, Oman, and natural gas giant Algeria. Thirty percent of the world's petroleum traverses the Mediterranean, linking this fossil fuel wealth to European and global markets (Dryef, 1997). It is less often noticed that the region also has great energy disparities, inclusive of fuel-poor countries including Jordan, Lebanon, Morocco, Tunisia, and the Palestinian territories (Samborsky, Myrsalieva, & Mahmoud, 2013). Additionally, Sudan and Yemen suffer from energy poverty (ibid).

Together, the MENA region faces skyrocketing electricity demand, which could exacerbate these challenges and inequalities in energy access. A reversal of the significant gains in energy access achieved over the past decade in the MENA region would be detrimental to quality of life, because those who have come to depend upon reliable, 24/7 grid electricity access could lose it. The current population of MENA is 355 million people (World Bank, 2015),[73] compared to 397.5 million in Western Europe. While Europe's population is stagnating, MENA's population is expected to double by 2050 (to 700 million people) and to reach the same level of energy consumption as Europe, or a quadrupling of current consumption. As one European energy expert explained in an interview "by 2050 [MENA] will be of the same size with regard to electricity demand…we are seeing another Europe growing." Furthermore, following demands for increased political participation during the Arab Spring, many of the institutions responsible for energy policy in the region have been in turmoil. I found in my interviews that Mediterranean energy experts anticipated that some countries in the region, like Qatar, are poised to meet this skyrocketing demand while others lack the stability and capital. Egypt, for example, is running out of natural gas supplies and has suffered from blackouts since the 2011 political revolution.

While MENA countries face the common challenge of increasing electricity demand, their energy security concerns diverge widely. For oil-rich MENA countries, energy security generally relates to security of demand for oil exports and high global oil prices. The downside to oil wealth is that many of these countries lack economic

[73] This figure includes Algeria, Djibouti, Egypt, Iran, Iraq, Jordan, Lebanon, Libya, Morocco, Syria, Tunisia, West Bank/ Gaza, and Yemen.

diversification and heavily subsidize domestic energy demand. Of the 550 billion in fossil fuel subsidies worldwide, about half are spent in the MENA region (International Energy Agency, 2012). According to a German energy expert, Saudi Arabia subsidizes oil for domestic consumption at $5 a barrel that could be sold on the international market for roughly $100 per barrel. He joked that they would be better off selling the oil and then burning the dollars. Furthermore, oil-rich desert countries have significant idle electricity generation in the winters due to lack of demand during temperate weather (45% idle generation in Saudi Arabia for example) (Clercq, 2013). While not a security concern per se, this is a significant waste of resources that could be used for export.

Saudi Arabia recently announced a transition to 41 GW of renewable energy by 2032 to free up its oil for export. Other MENA countries are less certain that their fossil fuel wealth should be prioritized for export. For example, Algeria is questioning whether it would best serve their energy security and development goals to use their natural gas wealth to meet industrialization goals and growing domestic demand or to sell it for higher prices on the international market (Ghosn, 2009).

For oil-poor MENA countries, energy security entails ensuring a reliable, affordable supply of fuel for their growing economies, reducing the energy subsidies that are straining government budgets not supported by fossil fuel wealth, and finding alternate means of economic growth.[74] Oil-rich countries typically view energy export as their exclusive means of economic growth, while oil-poor countries search for other sources. For example, following a presentation given by a Moroccan energy advisor on Morocco's energy strategy at a meeting of Arab states, audience members from oil-rich

[74] See Chapter 6 for Moroccan perspectives on energy security.

states were in disbelief that any economy with such fuel poverty could survive or grow. S/he had to explain that there were other areas of the economy that could be developed.

Renewable energy for export is one potential avenue for economic growth for oil-poor countries. In some cases, renewable energy exports would provide a source of foreign revenue but would not be essential for the development of a renewable energy sector (Euro-Mediterranean Energy Market Integration Project, 2010). In other cases, renewable energy export to the EU would be necessary to finance a substantial renewable energy market in oil-poor countries. Renewable energy could also secure supply and insulate oil-poor economies from the price volatilities associated with fossil fuels (Samborsky et al., 2013).[75] From an energy justice standpoint, countries must decide whether exporting electricity would be appropriate if domestic electricity shortages exist or are projected.

While the MENA region seeks to address skyrocketing energy demand, unreliable electricity infrastructure, a lack of capital, a lack of economic growth or diversification, and political instability, the EU seeks to source low carbon energy to mitigate climate change, to phase out nuclear power, and to address security of supply. Climate policy is a major driver of European energy policy ("The Energiewende-- is there a Nordic way?," 2012). In recent years, Europe's energy policy has centered on its 20-20-20 goals— to implement 20% improvements in energy efficiency, to source 20% of its electricity from renewable energy, and to reduce greenhouse gas emissions by 20% of 1990 levels by 2020.

---

[75] Countries in the south Mediterranean are deciding whether to pursue renewable energy, nuclear, or coal (Euro-Mediterranean Energy Market Integration Project, 2010). Jordan, for example, has chosen to pursue nuclear power instead of renewable energy.

Unlike the United States, the EU frames itself as already inextricably energy dependent due to existing natural gas and oil dependency. However, there are some parts of the broader Mediterranean neighborhood that they view as better to be dependent upon than others. For example, the EU energy security strategy focuses on energy interdependence on countries other than Russia and within the European Union. Russia's Gazprom currently supplies 40% of Europe's natural gas overall, and 38% of Germany's natural gas (Daly, 2013). Conflicts between Ukraine and Russia over natural gas have been formative to European framings of energy security. The European Commission's video outlining their energy security strategy explained that in 2009 the natural gas dispute between Ukraine and Russia left "half of the continent shivering" (European Commission, 2009). Tensions have remained high, and in 2014 a U.S.-EU sanctions package forbid new investment in Russian energy. The European Energy Commission's strategy stated,

> Above all, to improve its energy security, Europe needs to develop a well functioning internal energy market. At present, energy flows often stop at member-state borders because of lack of interconnected infrastructure leading to inefficient supply and wasted resources. The solution: greater interconnectivity of the natural gas and electricity grids. This will allow permanent exchange of energy…The EU supports major gas and electricity infrastructure projects to link Europe to North Africa and gas rich regions like the Caspian… (European Commission, 2011).

In summary, Europe's energy security at least discursively focuses on greater EU integration and greater integration with markets to the south.

Efforts to source natural gas outside of Russia, as well as the perceived benefits of interconnection, are essential to understanding EU and German interest in the Desertec vision. Desertec is one of several projects that would link the European energy community to its southern neighborhood, instead of Russia, to address security of supply and climate change mitigation. The German-born EU Energy Commissioner Günther Oettinger saw Desertec as one of several large-scale projects to secure supply, including the proposed Nabucco pipeline that would have run from eastern Turkey to Austria, bypassing Ukraine, to bring oil imports from the Caspian Sea to Germany. In a 2011 Dii pamphlet he was quoted as stating that the "[European] Commission will create a framework to secure alternative supply routes and sources to enable large-scale projects such as Nabucco and Desertec." The discourse on natural gas integration is identical to Dii's copper plate discourse on electricity described in the next chapter—to build bidirectional pipelines that provide energy "where and when it is most needed."[76] The Commission stated that the "European way of life depends" on the "modernization of our networks" (European Commission, 2011). Nabucco would be a "bridge" to Asia, just as Desertec would "bridge" electricity transmission and markets between North Africa and Europe, facilitating greater interconnection with parts of the neighborhood outside of Russia.[77] Nabucco failed in 2013 because, like Desertec, it was opposed for being too expensive, large, and complex, and it failed to garner sufficient support from the transit

---

[76] This vision is called the "copper plate," which is a flat, perfect diffuser on which electricity is instantly available on every point on its surface.
[77] Fatih Birol interview, available at http://ec.europa.eu/energy/fpis_en.htm

countries. Nabucco illustrates that even integration projects for traditional sources of energy face major challenges. Nevertheless, Europe, having largely acquiesced to its energy interdependence, must address where it will source tomorrow's energy and at what cost to the environment and climate.

European energy integration alone is a possibility, although Desertec proponents argue that it is not as cheap or efficient as integration with the Southern Mediterranean, will not allow for a 100% renewable energy future, and will still require the import of primary fuels. The Connecting Europe Facility funds such cross border European infrastructure including high voltage transmission lines. In February 2015, an EU Energy Union was announced with a 10% electricity interconnection target across EU nation-state borders (although much of Europe is already connected at 10% or higher). Whether Europe will pursue greater internal integration or seek greater integration with neighboring regions is partly a matter of whether it decides to pursue climate change mitigation alone or it attempts to bring the rest of the world along with it ("The Energiewende-- is there a Nordic way?," 2012).

Under Germany's *energiewende*, or energy turn around or revolution, Germany has taken significant strides toward increasing the percentage of renewable energy in its system, as well as efficiency and conservation measures. It seeks to reduce its greenhouse gas emissions and to phase out nuclear and fossil fuel generation. It also shifted toward distributed generation, and it implemented a large subsidy (feed-in-tariff) on rooftop solar photovoltaic installations. Germany—one of the European Union's most powerful countries— is committed to expanding climate mitigation and energy policy to the broader region. German supporters of energy integration seek to export the German energy revolution to meet domestic and global energy security goals and industrial policy goals.

The German-led push for energy integration outside the EU is intensified by the fact that the reforms made in Germany's *energiewende* are a matter of national pride. At a 2013 renewable energy exposition in Casablanca, Morocco, the Germany Ministry of Economy and Technology (BMWi) advertised, in the largest booth at the center of the convention hall, that the *energiewende* "is equally possible in your country. We put at your disposal our experience, our expertise, and our proven products."[78] Anecdotally, many Germans assume the word *energiewende* has become as familiar to Americans as the word kindergarten. An interviewee from the German Ministry for Economic Cooperation and Development stated, "Germany sees itself, since we have abandoned nuclear energy…as [an] expert on….renewable energy and satisfying demand. So it's an idea we also try to *export*, and we think it's good…for the rest of the world."

While some European renewable energy advocates, such as Eurosolar, see the *energiewende* as an effort to source more homegrown, green energy, Desertec conceives of the *energiewende* as part of the supranational process of expanding the EU frontier. As the Dii CEO stated at the 2012 Dii conference in Berlin, "I always call [Germany's *energiewende*] the small, local energiewende—we also support all of you in the big *energiewende* because it makes no sense only to do the whole thing in Germany and then the rest of the world is in misery." He explained that it was not a coincidence that the conference was held in Berlin at "the center of the energy transition" and that the goal

[78] *Ceci est également possible dans votre pays. Nous mettons volontiers a votre disposition notre expérience, notre savoir-faire et des produits qui ont fait leurs preuves.*

was to expand the energy transition to Europe, North Africa, and the Middle East as a whole. He stated, "no single country can do much in the big energy transition…we have to open up our minds. We have to think beyond borders."

Spreading sustainable technologies and techniques developed in Germany to the rest of the world is also part of Germany's industrial policy. The *Renewable Energy: Made in Germany* report explained that, "German businesses and consultants are already sharing this experience [on the energy transition] with many other countries." While the Renewable Energy: Made in Germany slogan could initially be assumed to be a discourse about stimulating home-grown green energy production, it concentrates equally on developing green energy technologies for export.

Germany established bilateral energy cooperation agreements with Morocco and Tunisia in 2012. According to an interviewee from BMWi, these partnerships will "pave the way for investments and projects in industry," with the long-term goal to import renewable energy from Morocco via the European grid. As part of the Moroccan-German energy partnership, Germany finances experts to work within the Moroccan energy ministry. The partnership focuses on renewable energy and energy efficiency cooperation, a Desertec pilot project, development cooperation, and grid development. A German expert in Morocco stated that Desertec is "the main driver for the [energy] partnership between Germany and Morocco."

While Germans view themselves as having exceptional energy technologies worthy of export, they generally do not perceive themselves as having sufficient, affordable primary energy (fuel). An interviewee from BMWi explained that there are two dimensions to energy security— quantity and price. In terms of quantity, it is sufficient to generate electricity only in Germany, but this does not account for the price or the consideration that the fuel must be imported anyway. Therefore, he argued that Germany should look to electricity imports simply if they are cheaper. In interviews, advisors to Desertec described Dii's focus on electricity imports from North Africa as a political strategy, because the imports would provide the German government with an energy security interest for supporting projects in the region. These imports help to achieve a "win" for the European side of the partnership.

To others, the motivation for Desertec is not merely cheap supply but the unquantifiable benefits stemming from regional integration. Cornelia Pieper, German Minister of State of the Foreign Office, stated at the 2012 Dii conference that Desertec is part of the strategic foreign policy and energy policy in the ministry to

> secure the energy supply not only of the North African region but also of Europe…from the point of view of security and foreign policy, one of the essential questions is how the energy relationship between Africa and Europe can be shaped in a way that energy is not just a product that we compete for but an important pillar of the stability and cooperation between our two regions. This means that energy is one of the core elements of our foreign policy. We believe that desert energy from renewable energy sources will play a major role. In Europe, it will only be possible to have secure energy supply if we establish that system with our partners and our neighbors.

In this framing, Desertec meets Germany's overall foreign policy foci— multilateral cooperation, economic soft power incentives rather than militarization, and its role in deepening the EU as its largest country and most stalwart advocate (Green, Hough, & Miskimmon, 2011). Furthermore, it relates to Germany's goal of regional stability in the Middle East (ibid).

Desertec supporters also emphasize that countries should think beyond their national interests and prioritize integration. The CEO of Munich RE asserted that the notion that each region should have its own energy production "is the old dream of complete autonomy and independence." Desertec could either bring together a more unified Europe based on common values or "risk" falling back on national solutions. Sir Graham Walton from the EU Parliament bemoaned the rise in isolationism in Europe following the Eurozone crisis, arguing that "in times of crisis, you're better looking out and working with your neighbors than you are retreating into yourself." An interviewee from the Desertec Foundation explained that European countries are too small to be energy independent and that climate change disregards nation-state borders.

This transnational thinking, as well as efforts to broaden the *energiewende* frontier, underpins a regional or even global framing of energy security absent from the U.S. energy independence discourse. The Desertec Foundation's goal with the Desertec Atlas released in 2014 is to "enthuse others for a global energiewende". Dii's founding MOU depicts a global framing of energy security stating, "The DESERTEC concept involves making use of the abundant unused energy in the deserts to promote *global energy security* and help protect our climate" (emphasis added). Since the Desertec vision is transferable to other regions, large in scope, and focused on integration, Desertec envisions the possibility of "global" energy security where others emphasize only energy independence. Chapter 8 expands upon this concept of global energy security.

Mediterranean integration. Desertec has also been shaped by ongoing Euro-Mediterranean identity building and political integration efforts. As Hettne & Söderbaum (2000) put it "mostly when we speak of regions we actually mean regions in the making" (p. 461). Much of the focus on Mediterranean regional integration has been on dreams for integrated energy systems. Starting after the Cold War, the Energy Charter Treaty laid the foundation for integrating the energy sectors of the Soviet Union and Eastern Europe into the European markets (ibid) to facilitate energy cooperation, stability, and reliability. This is similar to the Desertec discourse. The European Union has been viewed either as the model of regional integration to emulate or as the European Fortress of regional protectionism (Panebianco, 2003). The Treaty of Rome established the European Economic Community in 1957 but did not include the Maghreb or Mashriq,[79] which were relegated to the status of Mediterranean Non Member Countries (Pace, 2006). In 1994, the EU increased its focus on the broader Mediterranean region, and the Mediterranean Forum sought to promote political dialogue, mutual assistance, and greater cultural understanding (ibid). In 1995, the EU launched the Euro-Mediterranean Partnership (EMP), also known as the Barcelona Process. It included 15 EU countries and 12 neighboring states/entities in the Mediterranean.[80]

Building a regional identity depends upon with whom regional actors imagine themselves being in a community (Panebianco, 2003). Mediterranean political integration processes seek to construct this imagined community by framing common, regional

[79] The Maghreb typically includes Morocco, Algeria, Tunisia, Libya, and Mauritania. The Mashriq typically includes the Arab countries east of Egypt (Egypt, Lebanon, Palestine, Jordan, and Syria).

[80] It included Algeria, Cyprus, Egypt, Israel, Jordan, Lebanon, Malta, Morocco, Syria, Tunisia, Turkey, and the Palestinian Authority. It excluded the Balkan countries and Libya. Mauritania was included as a special guest.

challenges. The background report on the Barcelona process written by the EU argued that the economy in the Mediterranean has lost competitiveness compared to the rest of the EU (Roux, 1997). The "interior EuroMediterranean" outside of the coasts especially has development problems and a weak economy (ibid). There are disparities between the north and south Mediterranean based on “development, commercial exchange, migratory phenomenon, cultural characteristics, and political regimes" (ibid). The EMP, or Barcelona Process, identified three common areas of collaboration: political and security, economic and financial (which includes energy), and social/cultural/human (ibid). The action plan for the Mediterranean adopted in Barcelona sought to fight erosion, improve the rural economy, stop emigration, and open the region to the world. The Barcelona process also included a “European Mediterranean Free Trade Area.” The Process demonstrated strong support for regionalism facilitated by shared knowledge and technology to solve common problems in the Mediterranean.

As part of region-building efforts, the European Commission funded the Euro-Mediterranean Energy Market Integration Project (Med-EMIP) in 2001 to promote Mediterranean electricity integration. Med-EMIP conducted a four-volume study (600 pages) of the Mediterranean electricity loop, or “Medring,” which explored the technical feasibility of interconnecting the entire transmission infrastructure in the Mediterranean basin. The power system in the Mediterranean currently operates in four separate blocks—ENTSO-E/ SCR (Europe); Morocco-Algeria; Libya-Egypt-Jordan-Syria-Lebanon; and Israel-Palestinian Territories, plus Turkey. In 1997, the only underwater transmission cable between the North and South of the Mediterranean was built between Spain and Morocco under the Strait of Gibraltar, and a new cable was installed in 2001.

Linkages in the ring are missing between Turkey/ Bulgaria-Greece, Turkey/Syria, and Israel-Palestinian Territory/ Jordan-Egypt. Connectivity is also lacking in the EU, and the lines between France/Spain and France/Italy are the most congested in Europe.

The Medring studies found that the EU grid is unprepared to handle several gigawatts (GW) of solar imports from the South Mediterranean. A Mediterranean transmission infrastructure for domestic consumption would be shaped very differently than one for export. They concluded that a full AC synchronization of the grid in the Mediterranean would be "quite complicated" due to disturbances from continuous changes in demand and transmission line switching (Ferris, n.d.).[81] With AC interconnections, small disturbances in the electromechanical oscillations can compromise network stability (e.g., between Georgia and Yugoslavia). In November 2005, an attempt to interconnect the lines between Tunisia and Libya failed because of structural weaknesses in the system, which also led to a collapse of the interconnection between Morocco and Algeria (Euro-Mediterranean Energy Market Integration Project, 2010). For the ring to be successful, the power plants in it must provide "reliable and high quality power" 24/7/365. The first design of the Desertec vision described in the next chapter envisioned that CSP would provide this "reliable and high quality power" and that the ring would be closed through HVDC lines instead of AC.

This background on the politics of regional energy integration illustrates that renewable energy policy for the Mediterranean has been interwoven in a long and complex history of Mediterranean and European energy policymaking that did not exist

[81]According to Ferris (n.d.) "Transmission lines are switched in and out of the network in order to maximize economic efficiency of generation dispatch on a bulk electricity network."

when the initial electrical power systems Hughes (1983) studied were under development. Furthermore, Mediterranean electricity system builders are not starting from scratch in terms of building the infrastructure. Existing infrastructure and energy interconnections—such as Russian natural gas dependency—must be reconfigured, refurbished, and reshaped. Regional energy integration would allow for very high levels of integration of renewable energy into the grid without changing the centralized system configuration, but system builders would have to integrate the disparate energy policies and goals of the diverse countries in the Mediterranean region. If regional integration efforts were abandoned, European countries committed to low-carbon energy would need to radically reconfigure their domestic energy systems to allow for high renewable energy penetration. The rest of the chapter describes the geographic shaping of this vision and the geographic aspects of energy justice.

The Spatial Reconfigurations of Energy Transformations

Visions for energy systems are shaped by perceptions of geography at different scales. This chapter addresses the regional-scale geographic shaping of the sociotechnical vision, while Chapter 7 addresses the local-scale. How actors in power imagine the region affects the design of the sociotechnical energy system and its possible implications for justice. The actors involved with the Desertec vision constructed the regional scale by depicting the Mediterranean as a coherent region through measurement, mapping, abstraction, and scalar techniques, as well as in relationship to framings of the region couched in long histories. This geographical construction is also closely linked to how social problems and conflicts are framed in the region. Such techniques do not merely depict physical geography but are used to convey social unity or separation, as well as who is imagined as part of a region and who is excluded. For example, early maps of the Desertec vision depicted the North African deserts as empty. Additionally, some countries have attempted to reframe their regional geographical position for strategic purposes; Malta and Morocco depicted themselves as energy bridges in the Mediterranean to secure a position as a key node in the Desertec vision. Since the system is still in the visioning stage, the region's geography has been sometimes redrawn to better fit the technological system (e.g., nation-state borders have been erased on maps, boundaries have been redrawn to fit power systems). These visualizations of the region tangibly illustrate the dreams of system imaginers, who is included in the dream, and whose vision is dominant. They pose several considerations for energy justice that will be addressed at the end of the chapter, including the availability of energy for local populations, sovereignty over solar resources and recognition justice, and immigration politics.[82]

Enduring Mediterranean and Saharan framings. The Mediterranean and the adjacent Sahara have long been imagined as part of "barriers, bridges, and borderlands" (McDougall & Scheele, 2012). Three framings of the Mediterranean region are relevant to this study. They illustrate the long history and biases reflected in visions for

[82] The Medring studies depict the unseen Mediterranean. Based on 2 million coordinates, the study visualized the rugged and, in parts, very deep Med seabed. The Mediterranean has a very complex morphology and depth with valuable flora. Understanding this disrupted the feasibility of the vision, as people realized that even from a technological standpoint it would be difficult to build transmission lines underneath the Mediterranean.

sustainable, regional electricity systems. In the first framing, which emerged after World War II, the Mediterranean region is depicted as a shatterbelt, characterized by political fragmentation, linguistic and ethic diversity, and contested boundaries ("Shatterbelt," 2010). In the second framing, developed by Orientalist scholars, the Sahara is depicted as a bridge and an empty space to be crossed to reach the North African coasts or Europe, representing "a trans-Saharan rather than intra-Saharan trade" (McDougall & Scheele, 2012). The Sahara Desert is seen as a path of connectivity to the north but a boundary to the south

> … dividing the Mediterranean world from 'real' (i.e., sub-Saharan) Africa, isolating the countries of North Africa from their southern and eastern neighbors, and demarcating distinct areas of study for scholars and students (McDougall & Scheele, 2012, p. 4).

The third framing, stemming from more recent scholarship on Mediterranean history, views the Mediterranean as groupings of interconnected microecologies where life depends on connectivity, exchange, and widespread networks of support (Horden & Purcell, 2000). Building upon this newer framing, McDougall and Scheele (2012) viewed the Sahara "as part of densely interconnected networks…a global borderland." There is more intra-Saharan trade than trans-Saharan trade (Scheele, 2012). There are still constraints on motion, such as national boundaries, but people smuggle goods across them (McDougall & Scheele, 2012). Each framing has been reflected in visions for Mediterranean electricity systems. However, the predominant framing has been the second old-world view of the Mediterranean characterized by trans-Saharan trade routes, in which the empty Sahara acts as an energy bridge to the north and a boundary to the south.

Framings of the region's geography have been used to help legitimate technological choice, as well as to identify the landscapes appropriate for this technology, within the vision. The old world framing is reflected in abstract pictures and maps that emphasize the strength of solar energy resources in the world's empty deserts (see *Figure **24***) and the potential for Mediterranean green electricity trade through transmission lines (see *Figure **27***). A documentary about Spain's Solar Plataforma[83] framed the world's deserts as appropriate for large-scale CSP generation by abstractly depicting the world's "sunbelt," or the area with the most solar radiation, from above. The sunbelt framing constructs a contiguous, alternative source of energy wealth—ripe for export—on an abstracted, empty landscape.

System imaginers argued that electricity should be generated in landscapes like the sunbelt where the resources are strongest and then exported, just as Champagne is best grown in the terroir of France. This Ricardian model of trade is based on a single factor of production, in this case a geographical advantage. Export based upon a comparative advantage is indicative of the logic underpinning globalization. It suggests that system imaginers are proposing not just a trans-Saharan trade of green electrons but in some sense a globalization of electricity. As I argued in Chapter 1 that there is a trend toward the globalization of electricity, spurred in part by renewable energy. In this case, renewable energy would spur greater energy interdependence across the Sahara and the globe.

[83] Described in Chapter 3.

Figure 24. A Representation of Earth's Sunbelt. Source: Desertec Foundation. Used with Permission.

By framing desert landscapes as empty, energy-rich zones waiting to be turned into “powerhouses,” they have been depicted as the “perfect sites” for solar electricity generation for domestic use or export. I observed this discourse while studying the CSP industry for six years, from the siting of the Ivanpah Solar Electric Generating System in California to siting solar power plants in the Sahara, including the Moroccan Noor CSP plant and the Egyptian Kuraymat ISCCS (natural gas combined with CSP) plant. A perfect site is foremost the sunniest available site, because that makes the energy cheaper; other priorities include flat land, good drainage, access to other infrastructure, access to worker populations, and access to water. One-fourth of the renewable energy capacity in Europe is in Spain, but Spain has fewer solar sites than in North Africa. In the Desertec feasibility studies, North Africa is framed as the best place to site CSP, as it would yield more electricity in Egypt than in Madrid, Spain and even more than in Freiburg, Germany, which frames North Africa as having a comparative advantage for

CSP generation and export. However, no site is perfect; siting decisions inevitably have trade-offs, as illustrated in Chapter 7.

Although CSP requires large swaths of contiguous land, CSP's proponents often trivialize the total amount of land required. Flagsol, a German CSP company that developed the Kuraymat plant stated in its advertising materials that there a "*nearly unlimited number* of local options" for siting solar power…On a worldwide scale there is an *abundance of vast deserts* and semi-arid regions. Less than three percent of the Sahara desert would suffice to meet the world's energy demand with parabolic trough power plants" (emphasis added). A 2011 Dii brochure described Desertec as "a long-term vision: using the *abundance of space*, wind and sun to generate renewable energy in North Africa and the Middle East" (emphasis added). The red boxes on the map in *Figure **27*** emphasize how little land would be needed for electricity production from CSP.

Figure 25. Worldwide Wind Energy Conference Logo, PV Panels with Small Camels, Photo by Author.

Techniques of measurement and visual abstraction were used to solidify the framing of deserts as the ideal sites for tomorrow's sustainable power infrastructure. The logo for the Worldwide Wind Energy Conference, held prior to the 2011 Dii conference in Cairo, used scale to portray the vastness of desert landscapes. It featured giant PV panels in empty, sandy deserts, below which people on camels were the scale of ants (see *Figure* ***25*** in the background). In terms of techniques of measurement, the solar industry relies on abstract GIS methods, including meteo stations and shadowband pyranometers, to identify the best spots for solar power. A technician stated,

> Before we build a solar thermal power plant we need to know the exact conditions at the respective locations. This includes direct solar radiation above all . . .

> [Meteo stations with pyranometers are] how we establish certainty with regard to planning and investments, because we know exactly where the sun shines most. (Solar Millennium AG and Tamia Film &TV, 2010)

The resulting solar radiation maps illustrate the potential of North African solar power and the best parts of the region (in red) (see *Figure **26***.)

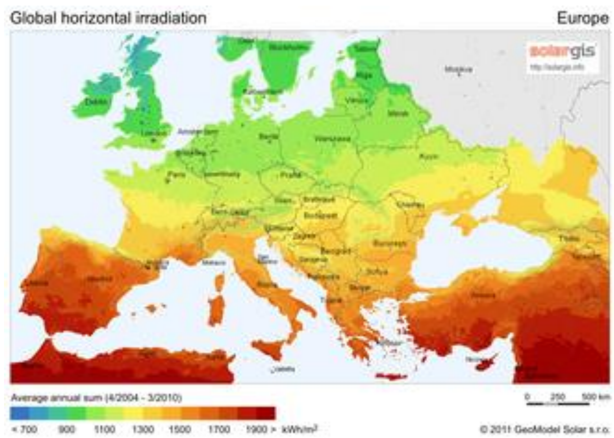


Figure 26. Solar Radiation in the Mediterranean Region. Source: Creative Commons License, SolarGIS © 2015 GeoModel Solar

Through visual methods, system imaginers depict the two regions as connected through infrastructure. The original picture for the Desertec Foundation's concept showed lines from technology connecting the continents, not from nation-state borders (see *Figure **27***). The European continent is green, while the MENA region is yellow, indicating barren land appropriate for CSP.

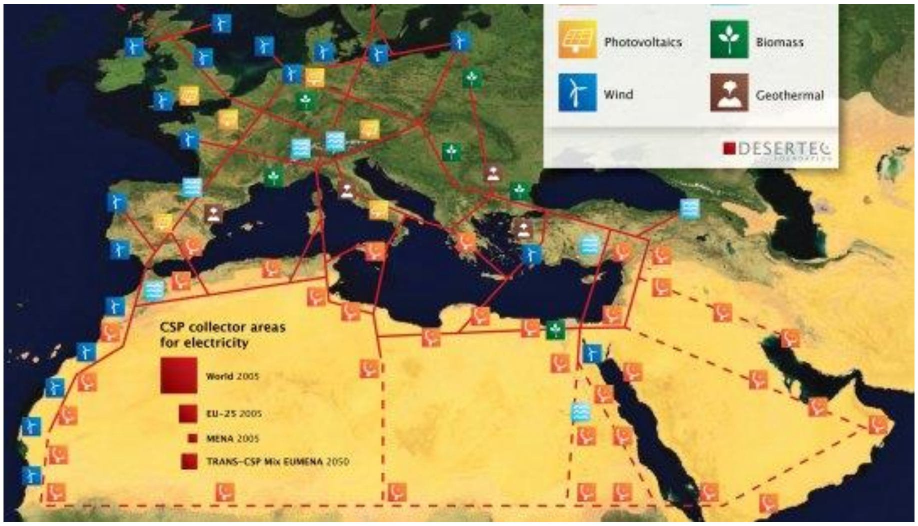


Figure 27. Desertec Foundation's Representation of the Desertec Vision

According to the vision, the technology belt in Europe must be linked to the sunbelt to provide the means of harvesting the energy in it. German initiatives to export renewable energy and techniques from the *energiewende* would provide the technology for a modern electricity system. In the advertisement below, *Figure **28***, German photovoltaic technology is compared to the engineering feat of building the pyramids. It states, “innovative solutions, award-winning quality, and proven reliability.” This reflects the second old-world framing of the Mediterranean as the birthplace of civilization, science, agriculture, and technological progress.

Figure 28. CentroSolar Advertisement Stating "Innovative solutions. Award-winning quality. Proven reliability."

As the birthplace of modern agriculture, the Mediterranean has been viewed as an ideal region in which to develop a modern electricity system. System imaginers framed CSP plants developed in the Fertile Crescent and elsewhere as energy farms. Chapter 3 illustrated that while some framings of CSP have shifted over time, the farming metaphor has persisted over a century and a half. While farming solar power may seem to refer to rudimentary technologies, the original Desertec vision framed connected energy farms as the epitome of modern energy system. The Desertec feasibility studies explained that thousands of years ago humans evolved from nomadic hunter-gatherers to settlers and farmers except for in the energy sector in which,

> Civilization is still gathering different forms of fossil energy like our ancestors collected berries and hunted animals. Fossil energy resources are still sought and gathered until the last drop is spent…It becomes evident that this is not a civilized

behavior, and certainly not a sustainable one, because there is no other planet in view to move to after resources are depleted and the atmosphere is spoiled.

This quote framed farming energy as more modern and sustainable than generating it with gathered fossil fuels. Electricity systems, which are often viewed as society's most modern infrastructure, were therefore framed as backwards, evoking Frank Shuman's warning in 1910 that humanity must source power from the sun or "revert to barbarism."[84] CSP technology, therefore, has been viewed as part of a modernization process to harvest energy from the sun. It has not just been viewed as a single solution to a regional problem but as part of global technological progress in energy systems fostered in the Mediterranean. While the sustainability literature often portrays distributed, small-scale, bucolic solutions as the most environmentally friendly, the Desertec vision framed large-scale farming connected to regional markets as more compatible with nature. The Desertec vision is not viewed merely as a single solution to a regional Mediterranean problem but as part of global technological progress in low-carbon energy systems fostered in the Mediterranean. (Chapter 5 will illustrate how these energy visions are connected to sustainability problems beyond energy, and Chapter 6 will explore how the solar farming metaphor has evolved as part of Moroccan political development.)

The farms themselves would be distributed but the connection to markets would be regional and centralized. A later version of the Desertec vision emphasized that it would consist not of a single project but of numerous renewable energy farms distributed across the region, connected to a regional grid. The red box in *Figure **26*** broke off into

[84] Discussed in greater detail in Chapter 3.

many smaller boxes and, in videos, zoomed into project locations with a disclaimer that the Desertec Foundation never presumed all of the projects would be sited in one place (see *Figure **29***).

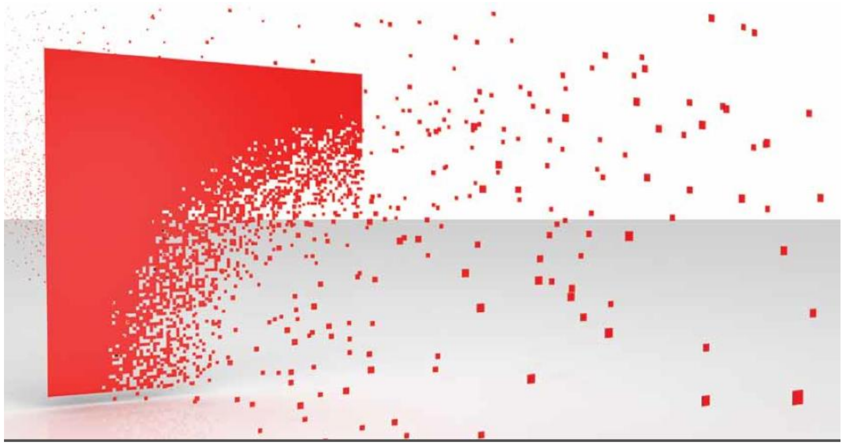


Figure 29. Desertec Foundation, Distributed Projects Emphasis. This image breaks up the red box from Figure 27 to illustrate that the power plants will not be sited in one spot but across the region. Used with Permission.

Mediterranean and Desert Connectivity

The harvest from these remote desert farms must be brought to markets through increased Mediterranean connectivity. Once electricity from the best sites in North Africa has bridged the Sahara, the Mediterranean would serve as a hub for connecting the electricity to Europe. Describing the beginning of the vision, an interviewee from DLR stated, "and they painted the first picture of a EU-MENA region – Europe, Middle East, North Africa— as a whole. Understanding the Mediterranean Sea not as a boundary but as a transport means" (see *Figure **27***). To establish this connectivity, desert frontiers would need to be reframed metaphorically and then technologically from boundaries and remote spaces to bridges that can be "put into service" (Zickfeld, Wieland, Blohmke, Sohm, & Yousef, 2012) to generate electricity from solar power and to connect it to a broader grid. An analysis of this metaphorical reframing helps to illustrate the logic that has underpinned this ambitious plan to build a regional energy system and the properties for which the electrical power industry values centralized systems.

Chapter 3 illustrated the long-standing importance of the connectivity discourse in large-scale engineering dreams for the Saharan frontier, from the Trans-Saharan Railroad to the Sahara Sea. Today, numerous visions for engineering projects in the desert emphasize connectivity. For example, the Desert Corps project developed by the Planck Foundation seeks to boost the economies of Africa and West Asia, turning deserts into areas of economic productivity through seawater irrigation with halophyte crops for "manmade Amazons" (compare to the Atlantropa vision in Chapter 3). They state, "deserts are now often large barriers. They could become connections. Infrastructure is what makes the difference" (Planck Foundation, n.d.) Similarly, the Sahara Solar Breeder project proposed by the Science Council of Japan aims to create a "global clean energy super highway *connecting* GW scale PV power stations located at various desert areas with high-temperature superconductor (HTSC) transmission lines" (http://www.ssb-foundation.com/). Additionally, the Sahara Forest project, advanced by a Norwegian LLC, seeks to "green the desert" with CSP and greenhouse synergies to address the "interconnection" of challenges (i.e., food, water, electricity) (http://saharaforestproject.com/). Deserts are framed as the final frontier to be developed and connected to the modern world. By connecting the sunbelt to the technology belt deserts become powerhouses, although the nexus of social power underpinning them would likely be in Europe rather than the empty Sahara.

One of Desertec's founders framed desert connectivity as essential to humankind's very survival, reflecting the third conception of Mediterranean connectivity as essential to humans' survival in the desert,

> The North Africans are not typical developing countries because more than 90%, more than 95%, are on the grid because you live in a desert. And if you live in a desert you live in a community. If you are alone you are dead. So they are already very well connected to most of the infrastructure.

As part of the connectivity focus, the Desertec vision imagines the Mediterranean as a transportation hub or bridge through which electricity flows due to borderless cooperation across the Sahara and the Mediterranean. Desertec proponents conceive of the Mediterranean as "a bridge between two continents." For example, Dii's slogan for the first three years was "renewable energy: bridging continents," and the *Desert Power Getting Started* report asserted there is "no choice but to understand the Mediterranean as a hub rather than a border." Energy cooperation itself has been described as a bridge at Dii's conferences. At the Dii 2012 conference, Cornelia Pieper, Minister of State from the Federal Foreign Office, explained that it is "obvious" that Europe will get power from North Africa because they have a more favorable climate for generating this energy. This again represents a Ricardian model of a single economic advantage for exports. Desertec epitomizes this vision and will help to reassign the Mediterranean its previous role. "It is not only a water body that separates us, but it can also be a bridge between our two continents." The program for Dii's 2011 conference in Egypt stated "it's about connecting people, cultures, and continents" with a picture of empty, sandy desert space and pyramids. In contrast with the quote, the imagery frames deserts as interstitial zones through which energy will travel to link cities around the Mediterranean. While the bridge and hub metaphors are mixed, they suggest different outcomes—one bridging empty space and the other making the Mediterranean the center of vibrant transnational trade.

Transmission lines provide connectivity. The Desertec vision originally sought to connect the region through a "backbone HVDC grid" linking the Middle East, North Africa, and Europe. High voltage DC lines connecting the continents would act as long-distance interstate highways, while local AC grids would act as country roads and city streets. The first transmission line built underneath the Mediterranean reflected this framing. In *Transmission & Distribution Magazine* the Moroccan utility company ONEE and the Spanish TSO Red Eléctrica referred to the transmission line under the Strait of Gibraltar as "a bridge between two continents" (Granadino & Mansouri, 2007). They framed the line as "the first link in the [Medring] chain" (Manuel Rodriguez Garcia, 2010).

The depiction of the regional connectivity in a later version of the vision by Dii focused on market connectivity. The map was still borderless but had more emphasis on solar radiation resources because the measurement had become more precise since the original vision was developed (see *Figure **30***). The markets flowed internally within North Africa and toward Europe, instead of just toward Europe.

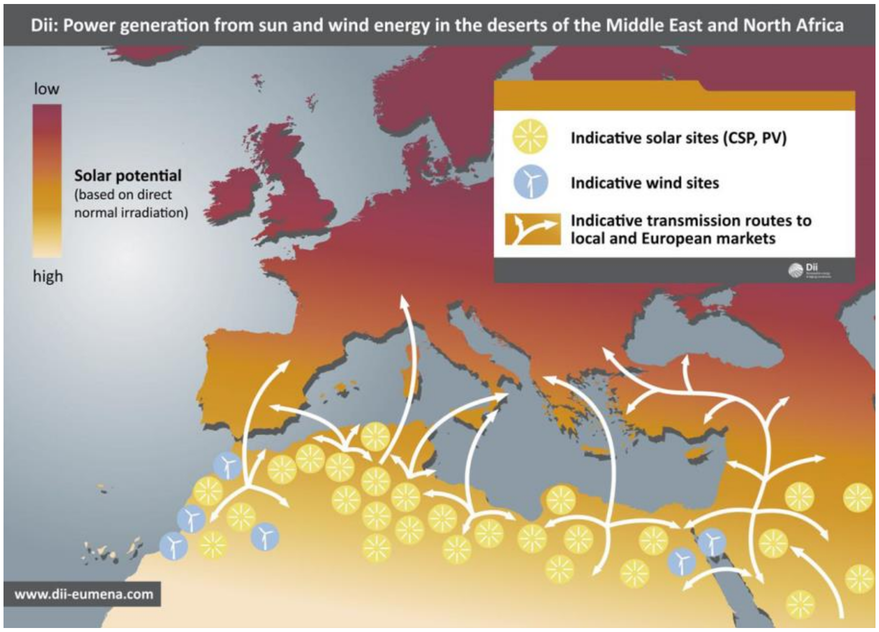


Figure 30. Dii's Project Vision 2009. Source: Dii, Used with Permission.

Dii’s *Desert Power 2050* report presented a completely integrated vision of desert and Mediterranean connectivity (see *Figure* ***31*** and *Figure* ***32***). Dii called this vision the “copper plate,” which is a flat, perfect diffuser on which electricity is instantly available on every point on its surface. *Desert Power 2050* envisioned a market and infrastructure for electricity that would be so deeply integrated that electricity would be instantly available where it is needed, when it is needed. This would flatten any problems and intermittencies from peak hours of electricity usage and fluctuating renewable energy supply. *Figure* ***31*** and *Figure* ***32*** depict deep integration but also significant abstraction, constructing the region as a whole with percentages, targets, and a bird’s energy view of increasing demand and need for supply. These images do not illustrate the sociopolitical complexity of the region they would be connecting. Such abstraction may obscure issues at a more fine-grained level, such as those discussed in Chapter 7 surrounding the siting of Morocco’s first solar power plant.

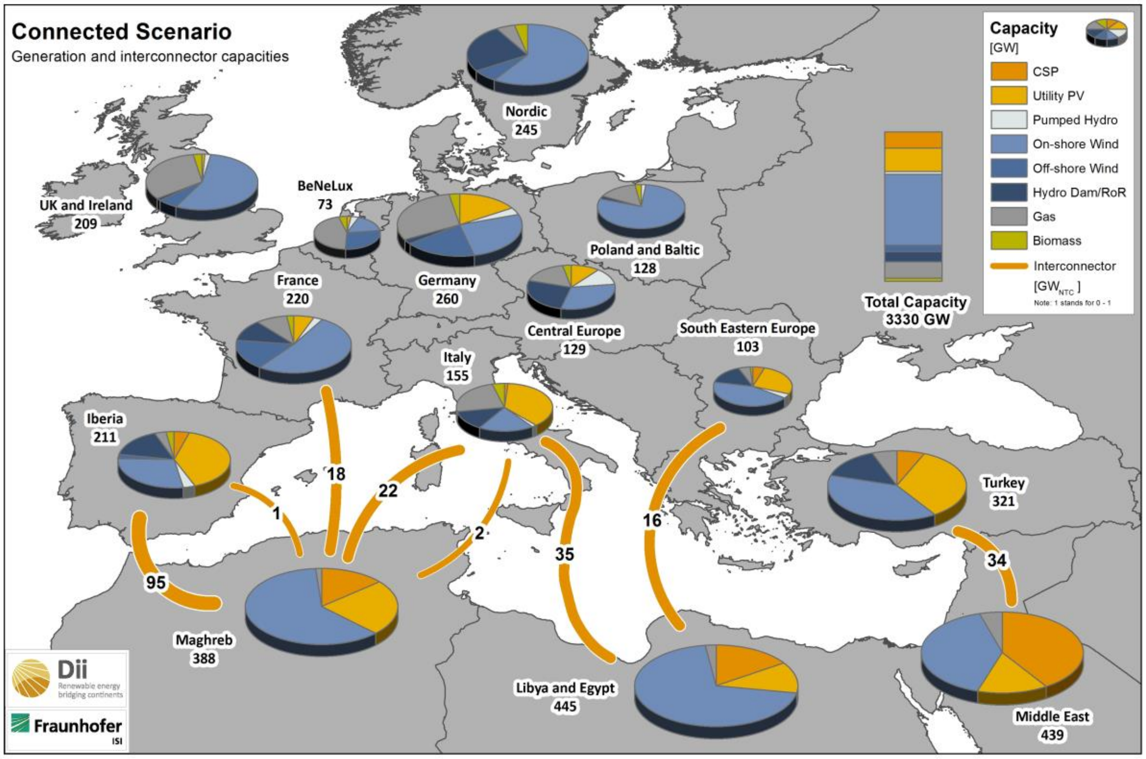


Figure 31: Desert Power 2050 Report, Dii, EU-MENA Connected Scenario, Source: Dii, Used with Permission.

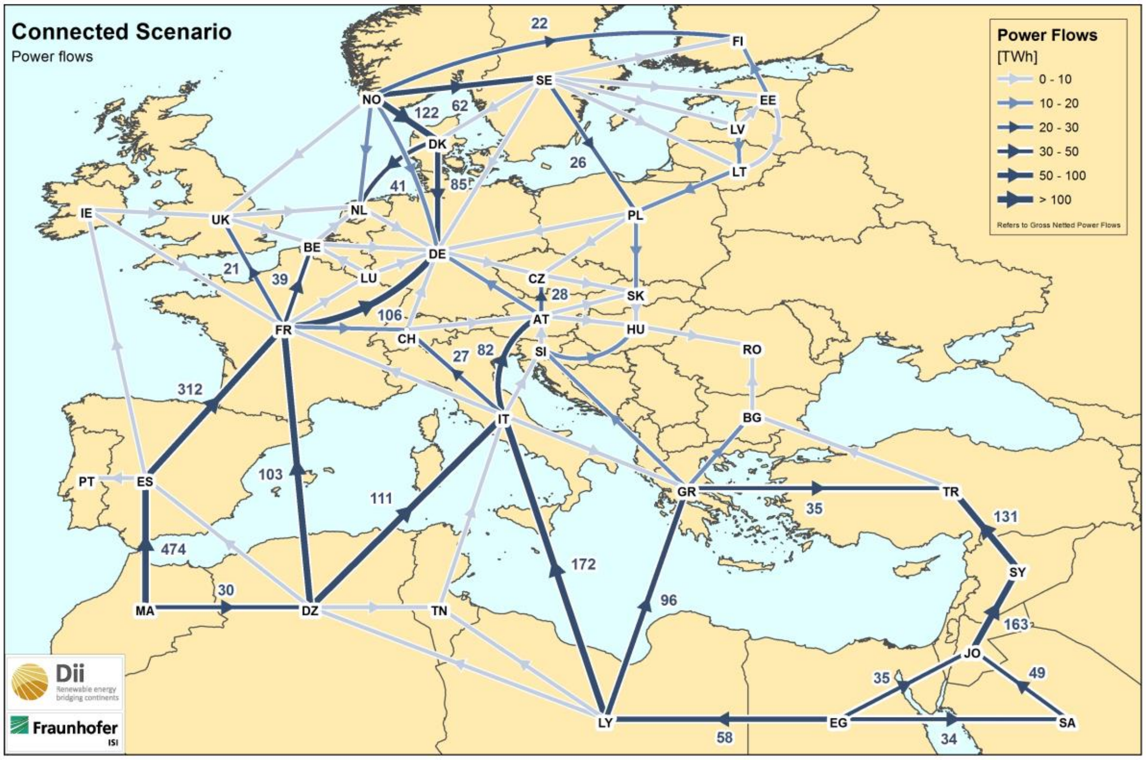


Figure 32. Desert Power 2050 Report, Dii, Connected Scenario. Source: Dii, Used with Permission.

The front cover of the Desert Power 2050 report is even more abstract, depicting energy use and energy flows (see *Figure **33***). It is a borderless picture, and it emphasizes the massive scale of the vision by depicting the edges of the globe. Through its nighttime view, it also emphasizes areas of demand, but it uses today's depiction rather than a projection of 2050 demand, which would have illustrated MENA's electricity needs as roughly equal to those of Western Europe.

Figure 33. Desert Power 2050 Report Cover. Source: Dii, Used with Permission.

These visions emphasize connectivity because they depict the most sustainable, efficient electricity system as one that would expand the centralized system benefits to adjacent regions through deep interconnection. This would compensate for renewable energy's intermittency. In contrast, a distributed energy system with point-of-use renewable energy generation would not offer the system benefits Desertec argues a regional system would have. Hughes (1983) illustrated that systems grow through transfer of technology across regions of a country. Today electricity is crossing national borders and is envisioned to extend to the regional scale, in part due to the goal of integrating more renewable energy in the system. Desertec's creators imagined that Desertec would modernize and globalize electricity supply and consumption by extending the system across the entire Mediterranean.

Electricity Islands. The electricity sector uses the metaphor of an island to further emphasize that a highly interconnected electricity system would be more efficient and sustainable. Islands are the worst positions in a system that prioritizes interconnectivity. When an electrical power system is "islanded" it means that it is isolated or not fully synchronized with its neighboring systems. To connect to the broader grid, the islanded grid must match the same frequency and phase. The Iberian Peninsula, for example, is an electricity island because it is not fully synchronized and interconnected with the grids of surrounding countries. According to industry experts, "traditionally, islanding has been seen by utilities as an undesirable condition due to concerns about safety, equipment protection, and system control" (Greacen, Engel, & Quetchenbach, 2013). Islanded grids are inefficient because they are more likely to shed the load (i.e., experience a blackout) because power cannot be sourced from a neighboring grid or to curtail excess generation that cannot be transmitted elsewhere. Mediterranean system imaginers perceived that extending the centralized electricity system logic with its benefits of efficiency, reliability, control, and safety— while addressing its "reverse salient" (Hughes, 1983) of skyrocketing carbon dioxide emissions with centralized renewable energy—would be more advantageous than building a distributed electricity system and leaving behind isolated islands.

The Desertec vision implies that the most efficient, feasible way of transitioning to renewable energy is through expanding the networking logic of the existing system across the region. Connecting solar resources into the grid could allow for more flexibility in managing solar energy's intermittency (ibid). At the Dii 2013 conference, CEO Paul van Son emphasized that countries cannot generate electricity in an isolated way unless they are on an island in the ocean. Furthermore, there is nothing worse than living on an island because of its lack of economic diversification. System synergies could be captured through cooperation and connection that cannot be gained on an island. The recently announced (February 2015) EU Energy Union seeks to avoid islanding within Europe.

Islands also lack the “vast” area of deserts and are not well suited for large-scale power generating facilities. Policy officials from the island of Malta support the Desertec vision because they lack space for energy generation. The Maltese minister said at the 2012 Desertec conference, “due to its geographical location, Malta has historically been a bridge between the North and Southern shores of the Mediterranean on a political, cultural, and social level.” Through this, Malta attempted to strengthen its geopolitical weight by reframing itself from an island to a bridge. It would both gain access to electricity generated on North African land and serve as a hub in the Mediterranean for electricity flows.

This reframing of the region as interconnected used mixed metaphors that may subtly suggest different energy justice outcomes. A bridge implies that there is a barrier to be traversed, such as an interstitial zone of an empty desert, over an obstacle from one point to a second point. The bridge metaphor is unidirectional, or bidirectional at most, and may reinforce the common fear that Desertec would result in Europe extracting electricity from North Africa. The hub metaphor suggests the Mediterranean is the center of activity, with spokes extending out to connect the entire region, possessing a center and a radius. The hub suggests multidirectional flows. In a different case, Starosielski (2011) found that Guam is the hub for much of the world’s Internet traffic. While maps of this undersea Internet cable infrastructure simply illustrate lines, this does not demonstrate the significance of the geographies of power that they connect (ibid). Under the influence of U.S. military and private telecommunication companies, Guam is a powerful actor in Internet infrastructure (ibid). Similarly, Malta could play this role as a hub within the Mediterranean. The bridge versus hub metaphor is significant in framing who might benefit and who might lose from regional electricity flows and interconnection. Who would be at the center and the periphery of this hub? In what direction would electricity flow across bridges? Would the people living in the zone that the bridge crosses be recognized and benefit?

One challenge to avoiding islanding through connectivity is that significant political collaboration would be required to harmonize policies, standards, and codes for islanded grids to be connected with the main grid. Achieving this would likely require a history of political collaboration with mutual trust and increased integration over time. Grids with limited interconnection that operate in islanded mode may reflect a lack of political integration. From 2007 to 2012, Turkey exported electricity to Syria along a single 117 km, 400 kV transmission line in "islanded" operation mode, meaning the grids were not synchronized (Hafner, Tagliapietra, Andaloussi, & Habib, 2012). Throughout Syria's bloody civil war, Turkey threatened to withhold these electricity exports (Ozerkan, 2011). In 2012, Turkey cut electricity exports to Syria, but they blamed a technical malfunction (Khawaja, 2012). Doubting the veracity of these claims, Syria left the Egypt-Turkey-Jordan power block and began importing from Iran (Haydar, 2012) Iran is skirting international sanctions on its oil indirectly by using the oil to generate electricity and then selling this electricity regionally (Mirsaeedi-Glossner, 2013), illustrating the geopolitics potentially involved in regional power systems (Haydar, 2012) Since the integration between Syria and Turkey was limited and in islanded mode, it was relatively easy for them to extricate their grids. Fully integrated electricity markets and grids would be difficult to separate and would demand better political accord as discussed below.

Strategic geographical reframing, technological integration, and political integration. The original Desertec studies envisioned creating a new geopolitical region, "EU-MENA," requiring the regional negotiation of new laws, subsidies, and regulations to govern this regional, liberalized electricity infrastructure and market. In international relations, the framework of Idealism asserts that economic integration will facilitate peaceful relations between countries (Guzzini, 2013). Likewise regional electricity integration discourses often assume that technological integration will lead to cooperation, dual-sided dependence, and peace. Just as Woodrow Wilson thought the League of Nations would bring peace through the development of international policy, in the Desertec vision, EU-MENA would be economically intertwined through a liberalized energy grid that would bring peaceful political cooperation.

Like Malta, other countries have attempted to strategically redefine their geography to ensure they would play an important role in the new region. Morocco, for example, attempted to frame itself as European by applying for EU membership in 1987. The EU said Morocco was not a European country due to its nine-mile separation from Spain across the Strait of Gibraltar. Morocco now frequently uses its critical location within the Desertec vision to highlight its geopolitical importance in the EU-MENA region. A Moroccan energy official, Abderrahim El Hafidi, stated during the 2012 Dii conference that “Morocco’s special geographical position puts Morocco at an energy crossroads [sic] thanks to its interconnection with Spain and Algeria.” Additionally, Amina Benkhadra, the former Moroccan Energy Minister stated, “due to its geographical position and its interconnections in the east with Algeria and in the north with Spain, Morocco is in a unique position of being a crossroads [sic] for energy.” In another example, Germany, the main proponent of Mediterranean systems integration, is in the awkward position of not being a Mediterranean country. The Union for the Mediterranean, which heads the Mediterranean Solar Plan, includes all of the EU member states including Germany. Without including Germany as a Mediterranean country, France would likely have been unsuccessful in its bid to control the Union for the Mediterranean. For the Desertec vision to work, such political complexities and attempts to secure political power would need to be negotiated across dozens of countries.

In the visioning stage for a regional sociotechnical system, geopolitical boundaries are sometimes redrawn to better accommodate the technological system. Within the Mediterranean electricity systems integration discourse, Southern Europe is often framed as the northern shore of the Mediterranean, while North Africa is the southern shore, or “the sunbelt countries.”[85] In the MedRing study, southern Europe, including Portugal, Spain, France, and Italy, was framed as the “Northwestern Mediterranean.” Part of what is often called the Middle East was called the Eastern Mediterranean encompassing Syria, Lebanon, Israel, the Palestinian Territories, and Jordan. Finally, the South Mediterranean—which could be called North Africa— was framed as Egypt, Libya, Tunisia, Algeria, and Morocco. (Southeastern Europe included

[85] Desertec Red paper

Slovenia, Croatia, BiH, Serbia, Montenegro, FYROM, Bulgaria, Albania, and Greece. Turkey was listed separately.) This framing charts a more unified vision of the Mediterranean by framing the Northern coast of Africa as Mediterranean rather than African.

Instead of removing all nation-state borders from the map, *Figure **34*** from Dii's *Desert Power 2050* report divided up the Mediterranean based on electricity blocks, to emphasize the need to interconnect them and avoiding islanding. For example, "Iberia," which is largely islanded, appeared as one country on the map. Morocco, Algeria, and Tunisia—which currently lack political integration—were drawn as the Maghreb country. These creative reconfigurations of nation-state boundaries are possible in the visioning stage but become problematic as the vision progresses; as I describe in the next chapter, Spain was uninterested in being reframed as a bridge for Moroccan energy to Europe. While maps can be easily redrawn in the visioning phase, during the construction phase the design would be affected by physical and political geography.

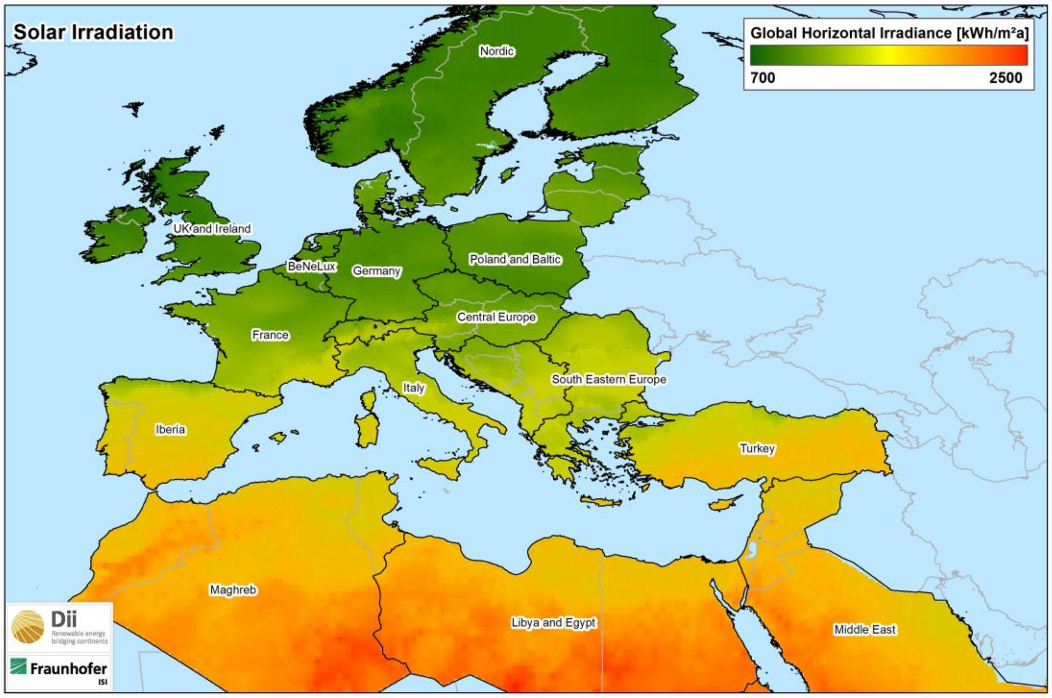


Figure 34. Desert Power 2050 Report, Portrayal of the Region, Source: Dii, Used with Permission.

In Dii's 2013 report, *Desertec: Getting Started,* they recognized that building a new region is a long-term effort.

> In 1950, Robert Schuman [a founding father of the EU and French Minister of Foreign Affairs] said: "Europe will not be made all at once, or according to a single plan. It will be built through concrete achievements which first create a de facto solidarity." This report was researched and written in the spirit of identifying the **concrete achievements** capable of creating the solidarity needed to build a sustainable power system for EU-MENA. And in the same spirit, Dii calls on the stakeholders and decision makers in the ongoing processes **to act now in favor of more renewables and electricity system integration** around the Mediterranean and

> in the Middle East…. A sustainable power system for EU-MENA can only be built in partnership, with mutual respect, curiosity, and open-mindedness towards new solutions. (original emphasis)

EU-MENA will not be made all at once and would require more than metaphorical and cartographic work. According to Dii, building electricity technologies would be the concrete step that would be needed to connect the Mediterranean, just as the European Coal and Steel Community was Schuman's concrete step.

In the discourse on renewable energy integration, MENA's regional coherency often goes unquestioned despite a lack of south-south political integration. In 2013, the Regional Center for Renewable Energy and Energy Efficiency (RCREEE) in Cairo released the first Arab Energy Futures Index, which charted the progress of MENA countries in renewable energy. The *Green Prophet*, an insightful blog on green technology in the MENA region, pointed out that framing MENA as a unified region was problematic.

> One of the challenges that I see in the Arab world and in Arab nations is the notion that Arab-speaking countries should be lumped together while etching out a renewable energy future. And that they should do it collectively. The Arab world is HUGE. Lumping all Arab-speaking nations together could be as helpful as combining America with Mexico, Cuba and Panama — calling these nations the Americas (Kloosterman, 2013).

Typically the focus of electricity integration is on north-south integration problems, but this author raises the important point that MENA itself also lacks integration and that it may not make sense to conceive of the region as a unified whole.

Regional energy system proponents often frame technology as the glue that would unify the vast EU-MENA region, separating technological integration from political integration. The Barcelona process sought to develop a “ring of friends” around the Mediterranean (Del Sarto & Schumacher, 2005). Several years later, the EU funded Medring, which envisioned that technological integration would glue the region together to create this ring of friends. Some system imaginers assume that technological integration will eventually result in political integration. In other cases, the technological system itself is seen as a proxy for cooperation across this diverse region. The *Desert Power 2050* report envisioned a system, not of mutually assured destruction but of mutual reliance, "in which no single country is dependent on another but instead each country is reliant on the system as a whole."

The binary between technological integration and political integration is questionable, as the two are fundamentally intertwined. More recently, common regulatory frameworks at least have been acknowledged as an additional adhesive necessary for energy integration. According to industry experts, “A key unmet need is for the regulatory glue that connects technical standards and the players involved.” (Greacen et al., 2013). In 2009, the EU developed such a regulation—a “cooperation mechanism” called Article 9. Article 9 allows for renewable electricity imports from “third countries” to meet Europe’s 20/20/20 goals. Five years later, no Article 9 projects have been implemented, and the regulatory glue has not interconnected the region due to a lack of political integration that will be further discussed in the next chapter.

The focus on technological integration overlooks the major political development questions at stake in electrical power systems development. One question is whether North Africa countries will pursue the path of electricity liberalization strongly advocated by Desertec proponents, European regulators, and development banks. For example, EU Directive 2009/72/EC allows for free access to the network by producers (i.e., discrimination against suppliers is not allowed), prohibits geographical discrimination for consumers trying to access the network, allows customers to change their supplier, recommends producers make informed choices about electricity generation, and suggests that the market should be liquid. All market players are required to unbundle the Transmission Systems Operator (TSO) and Distribution Systems Operator (DSO) from generation and supply. These principles relate to matters of political development, particularly how much power public and private actors should be apportioned in a society and how much south-south and north-south integration North African countries desire. According to the Medring studies, for a country to connect to ENTSO-E (the Western European grid) it must, in fact, disconnect from other neighboring regions that do not meet ENTSO-E standards. This could impede integration between North Africa and sub-Saharan Africa.

The technological integration and political integration binary also illustrates several challenges with the regionalization and globalization of electricity. I argued in Chapter 1 that the geography of energy, particularly energy siting, is a political development challenge for the West. The regionalism alternative creates new political development challenges as it seeks to develop a regional society (Hettne & Söderbaum, 2000) subject to transnational rules that would facilitate technological development to glue the region together. This would change the region's geopolitics, as is illustrated by oil-poor countries attempting to redefine their place in the region by becoming major renewable energy exporters. Assumptions that increasing technological integration would lead to peace rather than unprecedented challenges for cooperation and security are likely unfounded. The regional vision also poses new challenges for international relations, as well energy justice as described in the next section.

The Spatial Aspects of Energy Justice

Regional geographic depictions omit particular populations and problem framings through methods of mapping, metaphors, and abstraction. This draws attention to the importance of examining multiple scales to perceive what is excluded from the system imaginers' vision. Below, I discuss three energy justice areas implicated in the vision that will be further analyzed in the energy justice framework in Chapter 8. Through a geographical lens, this section helps to answer the question posed in Chapter 1 about what some of the outcomes might be for justice as electricity systems begin crossing nation-state lines, or are even globalized.

Solar sovereignty and recognition justice. The sun may be a free resource, but it is not evenly distributed across the globe. The Desertec dream of exploiting vast energy resources in an empty desert ran aground as some countries questioned who owns the sun, wind, and the land in a desert that is not in fact empty. An interviewee from a Dii shareholder company illustrated that,

> In my own words, Algeria, for example, didn't want [sic] Desertec—they were in the beginning critical—had a critical view on the Desertec things, to give their sun power away to other people. It's our sun, our land, so we use it for ourselves. Morocco was the easiest country and most stable.

Algeria was not alone in their resource sovereignty concerns. Even a Moroccan energy expert explained that they saw the sun and wind as free and belonging to everyone, but not the land and water. An Egyptian engineer I interviewed who supported CSP stated, "we will not give away our land or sell our sand." The broader question is whether North African countries will choose to utilize these resources for export or domestic use. For electricity to be globalized, or even regionalized, numerous countries must decide that electrons are appropriate for export—and along with the electrons, they will virtually export the land, water, and other natural resources that may be used to generate them.

Partha Dasgupta's work on natural capital helps to understand the issues at stake. Dasgupta (2010) argued that environmental resources should be accounted for in economic growth, wealth, and development as natural capital. It is important not to assume that natural capital is fixed, since it can be degraded. Solar heat and light are renewable resources that cannot be degraded. Some actors in the region would argue that they are attached to global property rights—just as the ocean may have global property rights (ibid). However, this solar irradiance is only accessible for harvest via specific parcels of land with private or state property rights. In some cases harvesting sunlight uses water and in all cases it uses other resources like steel to generate this electricity. These resources can be degraded. Dasgupta (2010) refers to these hidden resource uses as "implicit subsidies" on exports that local people affected by the production of the export must pay. Who pays is always a difficult issue (ibid) but it is particularly difficult for solar because solar is rarely economically feasible in traditional electricity markets since it cannot compete with subsidized fossil fuels. This is a dilemma because putting a price on the implicit subsidies would likely jeopardize solar energy development in the current economic climate, but failing to compensate local people for a loss of natural capital would leave marginalized populations to shoulder the burden.[86]

Exporting electricity and other resources versus using them domestically is a matter of the development pathway a country chooses. In order for affected populations to be included in this development, they must first be recognized. The depiction of the Sahara as a vast, empty wasteland ignores complex land and water rights, does not recognize the people living there, and could result in uneven development. Scheele (2012) stated, "If we believe in statistics, the Sahara is perhaps the fastest changing, most dynamic, and wealthiest region of the African continent" with rapid urbanization, population growth, and significant energy resources (p. 7). Conceiving of the Sahara as empty depends upon one's perception of what counts as empty space. Such perceptions have a deep-seated history. As Rabinow (2007) noted, the French colonial experience in North Africa reflected the idea of North Africa as a land without people surrounded by people without land.

[86] See Chapter 7.

During my fieldwork in Egypt, I experienced differences in perspectives of empty landscapes when I visited the Kuraymat ISCCS (Integrated Solar Combined Cycle System, or CSP-natural gas) plant outside of Cairo near Beni Suef with Desertec investors. Prior to the visit, many people informed me that this plant was built on uninhabited lands free of conflict. On the drive to the power plant, I saw empty sandy areas. However, when I scaled the viewing platform over the power plant, I saw neither huts nor nomadic tents but actual apartment buildings (see *Figure **35***). The perception of the landscape as empty contradicted what I saw. What counts as uninhabited land depends on upon the representation of the landscape through maps, metaphors, and the abstraction of specific spaces. The representations of landscapes affect how they are perceived. Chapter 7 will further explore issues of unseen and unrecognized populations living in the vicinity of solar power facilities and address how the trade-off calculus for solar power plant siting decisions is couched in these issues of perspectives. This issue of recognition justice is then included in the framework in Chapter 8.

Figure 35. The Kuraymat Solar Field, with Apartment Buildings in the Background. Photo by Author.

Geographic myths can exclude certain populations and result in overlooking some of the social outcomes of the vision. In Chapter 3, I described how Saharan engineers' incomplete dreams excluded the people living in the desert. This is part of a tendency to define the Sahara by its technological potential and its physical, rather than human, characteristics. Bisson (2003) argued that the boundaries of the Sahara are inappropriately imagined based on geographic determinism rather than human populations and the management of the Sahara by humans, through irrigation for instance. Just as Chicago's growth dramatically reshaped its surrounding hinterland (Cronon, 1992), rapid urbanization shapes the Sahara as Saharans respond to the demand for products, like dates, in nearby cities as well as remote European markets (Bisson, 2003). The Sahara should be defined not only by its physical characteristics but by human and social characteristics including rapid urbanization in coastal regions and in the cities on the outskirts of the Sahara—the "doors" to the Sahara— from which products are shipped through complex transportation and energy networks (Bisson, 2003). Bisson viewed Ouarzazate—a city that will be the focus of Chapter 7— as a key example of such a Saharan city, outside of the geographic boundaries of the Sahara, but indelibly shaped by it.

As the vision progressed, it became apparent that building CSP in the imagined middle of nowhere—in unpopulated, sandy Saharan dunes—would be infeasible. An interviewee from the oil industry explained that they operate natural gas facilities in remote areas of the Sahara Desert only because it is exceptionally profitable. Since electricity from CSP is higher than the grid price, it would not offer sufficient payoff. The first CSP plants are being built instead in the Sahara's "doors," which have at least some of the necessary infrastructure including access to water, transmission, worker populations, supply chain industries, and stable ground.[87] Building solar power plants in the "doors" would have different social implications than building solar power plants in the empty desert. It also suggests that CSP's feasibility depends not only on geographic and technical factors but also upon community acceptance and local socioeconomic development.[88]

By 2013, the Desertec Foundation had come to perceive the North African deserts as populated. An interviewee from the Foundation stated that a demographically young population lives in the deserts of North Africa. Furthermore, the Sahara suffers from water shortages, and people are experiencing salt-water intrusion problems and are

[87] See Chapter 7.
[88] Further detailed in Chapter 7.

consuming fossil water resources. He explained that the Atacama Desert in Chile is unpopulated. For this and other reasons, the Desertec Foundation partly shifted their focus from North Africa to South America.

Energy for African communities. From the 1970s to the mid-2000s, CSP's developers largely assumed that people in the vast, empty sunbelt regions would need little energy in the future.[89] The original vision assumed that electricity from solar energy would need to be transmitted to and consumed in load centers in Europe. On the contrary, electricity demand in the MENA region is projected to reach European levels by 2050 as demand stagnates in Europe and skyrockets in MENA. When it became apparent that MENA would not have surplus electricity for decades, it knocked the Desertec vision off course as people in Europe questioned the idea of importing electricity from energy poor and energy-scarce countries.[90]

Infrastructure in the Western world is characterized by high reliability unlike in the Global South (Edwards, 2004). Desertec is a vision in which the system principle of reliability would stalk new locales for maintaining the reliability and redundancy of premium-networked spaces at unprecedented scales. Many actors saw this vision as an inevitable endpoint within a networking logic that seeks out the cheapest commodity prices and actively works to keep infrastructure invisible for premium-networked spaces. Would the price of this invisibility be that North African populations would shoulder the burdens of electricity generation without having access to premium-networked spaces?

[89] See also Chapter 3.
[90] See Chapter 5.

Perspectives of energy justice and energy poverty shift again when the scale of the African continent is considered. In the second framing of the Mediterranean region, the Sahara is perceived as a boundary between the Mediterranean region and sub-Saharan Africa, and the Desertec system stops at that frontier. Compared to their southern neighbors, North Africans enjoy high rates of electricity access; 75% of sub-Saharan Africans lack access to electricity compared to 1% of North Africans (World Bank, 2011). Desertec's proponents consider it a win-win for all parties, including the energy impoverished, but scholars and media outlets have criticized the Desertec vision for investing in relatively wealthy North Africa while sub-Saharan Africa lies dark to the south (e.g., Simeland & Juma, 2011). The BBC quoted Daniel Ayuk Mbi Egbe, a Desertec critic as stating, "When you go to many African countries there are constant electricity cuts - if you want to help then you need to think not just about exporting to Europe but about supplying Africa as well" (McGrath, 2012).

While the Desertec vision reframes deserts plus technology as connective tissue and the Mediterranean as an electricity hub, the Sahara still functions as a boundary to its southern neighbors. A multi-scalar perspective leads to several questions not often considered in the Mediterranean context. Who should have the right to be linked to premium-networked spaces? What technologies are appropriate in the perceptions of local people? Proximity to regional hegemons like South Africa or Europe spurs the extension of premium-networked spaces, while solar lanterns are viewed as appropriate for the "bottom billion" in more remote African landscapes.

The politics of difference: equality and equity for Mediterranean electricity visions. At the 2013 Dii conference, Bertrand Piccard stated that while in the 20^{th} century pioneers sought to conquer the planet, the 21st century goals of pioneers should be to "conquer quality of life." This reflects, in some sense, the shift in CSP from the domination of nature to the sustainability framing, as people try to place ethical and environmental restraints on technological change. However, the conquering and pioneering metaphors suggest there is a still an envisioned frontier to colonize in order to improve quality of life, which may be antithetical to energy justice. Deserts must be reframed from barriers to connective tissue within the Desertec vision because they are still perceived as empty frontiers to be crossed and conquered, often seen as devoid of people. If quality of life is to be "conquered," will progress be achieved for local populations? Furthermore, when this southern frontier actually is perceived as populated, not all Europeans wish to be integrated with it, as challenges of cultural difference and immigration arise. The geographical construction of the Mediterranean electrical power systems vision reflects sociopolitical controversies related to immigration, connectivity, and barriers between Western and Arab societies.

If the Mediterranean were a boundary between North Africa and Europe, it would be a porous one. Piccard framed himself as an energy refugee from Europe, reversing the typical direction of the journey and portraying himself as immigrating to a more progressive energy policy in Morocco. The Strait of Gibraltar is sometimes termed the Strait of Death because immigrants die trying to cross it to reach Spain. Unfortunately, Morocco has been viewed as the heart of European problems in the Southern Mediterranean, including immigration (Zai, 1997). Spain and Morocco frequently quarrel over border security, as more sub-Saharan Africans attempt to reach Europe via Morocco and its Spanish enclaves (Garcés-Mascareñas, 2012). Cannabis production in the

Moroccan Rif Mountains provides a significant percentage of drug imports to Europe, as well as other contraband goods (ibid). Furthermore, a handful of terrorist bombings in Morocco over the past decade and the participation of Moroccan nationals in the 2004 Madrid train bombings raised fear of Islamic extremism in a country otherwise known for its peaceful and mystical interpretations of Islam (Howe, 2005). More recently, wars in MENA countries including Syria, Libya, and Iraq led more than 45,000 migrants to attempt to cross the Mediterranean in 2013 (Kingsley, 2015). In 2014 and early 2015, large protests were held in Germany against increasing Arab migration and the "Islamization of Europe" despite pleas from Chancellor Merkel to desist so Germany would not be viewed by the rest of the world as xenophobic (Smale, 2015).

Immigration policy reflects the framing of the Mediterranean as a shatterbelt, with little political connectivity and deep cultural divides. Huntington (1996) controversially argued that future world conflicts will involve nine world civilizations, or the highest grouping of people based on cultural identity including language, history, and religion. This "clash of civilizations" discourse was adopted in France after 9/11. The French sought to halt immigration, concerned that an influx of Muslims would impinge upon their culture (Huntington, 2011). The government banned the headscarf in public schools, ID photos, and public buildings (Scott, 2008). Scott (2008) explained that equality in France rests upon sameness, not upon embracing diversity. The French concept of *laïcité*, which refers to the protection of the state from religion, the opposite of the American conception of freedom of religion— was at stake (Scott, 2008). The recent killing of 12 journalists and cartoonists at *Charlie Hebdo* by Islamic extremists has heightened tensions between the north and south of the Mediterranean. Expressions of solidarity in France—voiced online through the *Je suis Charlie* (I am Charlie) hashtag— were rebutted by some young activists in the MENA region with the hashtag *Je ne suis pas Charlie* (I am not Charlie). These activists argued that the media was giving disproportionate attention to the lives of French citizens over the lives of Syrian refugees of war and victims of religious extremism in the Global South. These conflicts are underpinned by cultural differences between Western Europe and North Africa that simply cannot be swept under the rug by uniting transmission lines.

The Desertec vision evolved as Islamophobia surged in France in the 1990s. An interviewee from the Desertec Foundation explained that the Desertec vision could address the immigration and refugee problem, because solar power could improve people's lives domestically so that they are not forced to immigrate. The original Desertec vision stated that "tensions from poverty and immigration" could be reduced through North African development (Wolff, n.d.). In short, by developing the North African nations through solar power and industrialization, immigration to Europe would stop. Considering this, would Desertec replace flows of people across borders with flows of electrons? Or would the Desertec vision connect the Mediterranean in that groups with different interests would negotiate their conjoined futures in an imagined Mediterranean community? Is the goal of energy integration to bind people together equitably or to achieve energy equality for each separate region (EU and MENA)? Is the Medring an "integration miracle" as Dii calls it or a segregation solution? Would Desertec address climate change as a region to avoid addressing adaptation together as a regional or global community later?

The Desertec vision is not intrinsically xenophobic; if the vision further develops, the answer to the above questions will be dependent upon the procedural justice of the political process pursued and the goals of the involved actors. The quote from *Desert Power 2050: Getting Started* discussed above reflects a positive framing on political integration: “A sustainable power system for EU-MENA can only be built in partnership, with mutual respect, curiosity, and open-mindedness towards new solutions.” Scott (2008) argued that instead of focusing on political oneness and unanimity, Mediterranean policymakers should be focusing on how diverse groups of people negotiate their differences based on common ground, rather than trying to eliminate these differences. Ramadan (2008) opposed the “outdated integration discourse” in the Mediterranean because it simply highlights the differences between north and south. South-south conflict is perhaps equally prevalent, including ongoing tensions between Morocco and Algeria discussed in Chapter 6, and north-north politics within the EU have greatly disrupted the Desertec vision, which will be discussed in the next chapter. In contrast to Huntington, Nussbaum (2009), argued that we face “a clash within,” as most conflicts play out within civilizations not across them. In fact, there is less political integration among North African nations than between North Africa and Europe. Awareness of the immigration question and the implicated cultural divides behind it will be important as electricity integration projects are pursued.

Conclusions

This chapter illustrated that Hughes' observation that geography shapes sociotechnical systems should be expanded to encompass constructed geographic representations of the landscapes in question, especially as transmission lines cross nation-state borders and scales with significant implications for energy justice. Visions for a sustainable, modern electricity system in the Mediterranean are couched in complex geographical perceptions and representations of the Mediterranean that date back centuries, such as the Old World framing of the Mediterranean connected by Trans-Saharan trade routes. Sites are framed as appropriate, or even ideal, for CSP using mapping techniques that depict deserts as empty, barren landscapes. Such geographical imaginaries affect how people perceive desert landscapes and who is recognized as part of the vision.

As Laird (2013) argued, energy transformations have significant sociopolitical implications. Examining the spatial aspects of these transformations can help to make visible the political development issues at stake. The Moroccan government supports energy exports, and the European Commission is interested in energy connections with nation-states in the Southern Mediterranean. Despite this support, centrifugal forces pull the region apart. Piccard viewed himself as an energy refugee, not only because of the symbolism of his migration across the Strait of Gibraltar, but also because he fled from European politics to North Africa where the deserts await progressive solar power development.

Regional systems pose unprecedented political development challenges, as a "region-state" with harmonized policies, standards, and rules would have to be established for the system to properly function. In the field of international relations, scholars have observed how regions are being formed and constructed in the era of globalization. New regionalism theory provides a framework for understanding post-Cold War regionalism and evaluating the depth of regional integration (Hettne & Söderbaum, 2000). Regional space has geographic contiguity and is not necessarily respectful of state borders. A regional complex is regional space deepened by increased human contacts and transactions. A regional society is a regional complex subject to transnational rules. A regional community has developed a collective identity and a capacity for collective action. A region-state is a new, multi-layered organization based on voluntary actions by member states that has developed into a novel, heterogeneous form of statehood. One could therefore surmise that a region that is defined based merely on geography, rather than political or social bonds, is indicative of a lack of deep integration. The Desertec vision, through its framing of the "EU-MENA" region, essentially proposed the formation of a region-state. The discourse suggests that technology could be the glue that would hold the region-state together, substituting political cooperation with technological integration. However, it seems unlikely that technological integration could be achieved without political cooperation, and it is even possible that such a model aims to keep people separate more than it does to integrate them.

To emphasize its support of transnational political solutions, the Desertec Foundation developed the cosmopolitan concept of global energy security. The tenets and principles of what constitutes global energy security, and its relationship to energy justice, have not yet been defined. To achieve global energy security based on energy equality, everyone should have the same access to electricity, at least in relative terms. Energy equity and energy justice, which are more complex concepts, require, for example, the fair negotiation of land and water rights, a just process for recognizing and engaging local populations in energy siting, and the negotiation of cultural differences. Chapter 8 further defines global energy security.

If attempts to achieve global energy security developed along with the globalization of electricity, countries would need to decide whether energy exports or the domestic use of energy wealth would be most advantageous to their development and their domestic energy security. Germany is eager to export its energy technologies, but countries in the Global South might prefer to develop their own technologies as part of their industrial policy. In either case, European capital investment may be necessary to expand electricity infrastructure to meet growing electricity demand in MENA countries, and electricity exports from MENA to Europe may be necessary to sweeten the deal for European investment. When OECD countries switch to regional production networks, nearby non-OECD countries typically focus on export-oriented industrialization to bring investment from OECD countries (Panebianco, 2003). Developing countries can benefit from know-how, technology, jobs, and capital, but in reality they often reap few benefits (ibid). Ensuring these benefits may be a tenet of global energy justice.

It would be easy to conclude from the challenges of regional political integration that the Desertec dream is infeasible and socio-politically untenable. However, if the Europeans decide to pursue energy independence, they will either have to abandon the dream of climate-friendly energy or to address significant systems-level issues to integrate large amounts of fluctuating renewable energy into networks. Given the goals of European energy policy, business-as-usual seems unlikely. Put differently, if the Desertec dream is again deferred, Europe will have to make other, major system-level electricity transformations. The next chapter will illustrate these system-level challenges and address the temporal aspects of energy transformations in addition to the spatial.

CHAPTER 5

EVOLVING SOCIOTECHNICAL VISIONS AND DEFERRED DESERTEC DREAMS?

In his speech at Dii's 2013 conference, Solar Impulse pilot Bertrand Piccard asked, "What is pioneering spirit? What is exploration?" Piccard was not pioneering discovery and innovation in the traditional sense. According to him, the pioneering spirit does not have to do with new ideas but with belief; for example, humans went to the moon because they believed they could. He said that humans are desperate to find the best tools to help them in society. Most of these tools are about power, speed, and control, but he encouraged Dii investors to embrace the unknown, comparing life and investment to being in a hot air balloon in which one has no power, speed, or control. One must then metaphorically drop ballast, not in the form of new technologies, but in the form of one's certitudes, or deep beliefs, or paradigms. Piccard stated,

> Innovation is not a new idea—it's an old certitude you throw overboard… People who are here [at the Dii conference] believe in the power of dreams, innovation, creativity. This is the reason for Solar Impulse. If you want to fly day and night without fuel, it shows that dreams can happen with some human power.[91]

Innovation in the Desertec vision is conceived of as the achievement of a deferred dream— a dream for a system based on large amounts of renewable energy dating back to the early 1900s that could reemerge and be achieved in the present once the various

[91] From my field notes from the conference.

factors that have impeded the dream are shed. From this perspective, modern energy systems are not necessarily innovative ones, but visions whose time has come. Al Gore's famous quote, which has been widely circulated in the policy domain, reflects this mentality: "we have all the technologies we need, more are being developed…but we should not wait, we cannot wait, we must not wait." This perspective is further reflected in the popular climate change stabilization wedges scenario, which focuses first on picking the "low hanging fruit" of climate change mitigation, such as greater energy efficiency. The job of today's innovators is then to carve out a niche in the future in which the deferred dream will be realized and then to speed up progress toward this end goal.

What this perspective on innovation downplays are the significant systems-level reorganizations involved in scaling up these existing technologies. This chapter lays out the systems-level challenges posed by energy transformations of the 21st century by illustrating the significance even of those transformations that generally leave the centralized electricity system configuration in place.[92] Since electrical power systems already have over a century-long history, these systems are not being built from scratch, rather the old system is being refurbished and rearranged and new infrastructure grafted onto the old. This complicates the process of dropping ballast because there is a complex, existing sociotechnical and sociopolitical landscape in which "old certitudes" are cemented on top of which the system must be built. The Desertec vision seeks to extend the centralized systems logic across an entire region to build an integrated system based almost entirely on renewable energy, which is a much different system to manage than a

[92] See Chapter 1.

power system bounded by a nation-state. The innovation involved is in massive systems integration across nation-state borders and its management, more so than in the renewable energy technologies. By comparison, groups like Eurosolar envision a more radical systems reconfiguration in which electrical power systems would shift to a distributed, point-of-use arrangement in which power is generated largely on rooftops and in backyards.[93] Whether extending the centralized configuration across a continent or completely uprooting the centralized infrastructure and switching to distributed generation—or perhaps another scenario yet to be envisioned— scaling up renewable energy would require significant changes. Unlike the distributed alternative, growing complex centralized renewable energy-based systems will require centralized management, which presents new risks even as it addresses other problems like climate change mitigation.

Part of the significance of system-level energy transformations are the broad-reaching goals the system seeks to address—as Piccard put it, renewable energy innovation is meant to “conquer quality of life” in the 21st century. While the electrical power systems of a century ago sought to bring light and heat to cities and remote areas, rebuilding electrical power systems to meet sustainability goals brings with it broader challenges. My analysis of the Desertec vision illustrates that energy transformations relate not only to powering communities but also to addressing integrated challenges related to water, poverty, food, and development. It might not only be desirable to address these challenges in tandem but also necessary. For example, the energy-water nexus is addressed in the first system design of the Desertec vision, but not in the second

---

93 See Chapter 1 for further explanation.

This creates problems as the first CSP plant in Morocco is being built in a water-scarce region, as will be discussed in Chapter 7. Some of the most interesting questions of energy justice and politics lie in these intersecting domains and their trade-offs. Although the system imaginers seek to address multiple challenges at once, no system is a win-win; there will always be trade-offs at different scales. If innovation relates to shedding deep beliefs, what values and beliefs do underpin these long-term dreams and what makes them stick? This chapter shows that the vision's principles are not cemented in the design stage; they are still up for negotiation as the actors work to accelerate the vision from design to construction.

In part, this chapter picks up CSP's history when I left it in Chapter 3, exploring its reemergence as part of visions for sustainable energy systems for Europe and North Africa. However, it does so by understanding CSP in the context of a broader and much more developed vision for a system than existed when Frank Shuman envisioned building 270 million horsepower of CSP troughs in the Sahara Desert. This chapter explores CSP in the context of an ensemble of technologies in the Desertec vision, including high voltage direct current transmission lines, solar PV, wind, geothermal energy, and fossil fuels. In 1850, CSP was a dream for a technology; by 2006, it was subsumed under a broader vision for a system and prioritized for its system-specific benefits. When the envisioned system properties change in the second system design, CSP plays a less significant role in the system design.

In Chapter 1 I asked: How are the windows of opportunity that allow a technology to form a niche that breaks into a system imagined, what problems do they create in the system, and how are these problems addressed? This chapter analyzes the framings of ensembles of technologies, including CSP, within a systems context, considering what benefits they provide the overall system. It combines a SCOT microscale analysis of technologies with a mesoscale understanding of the systems-level challenges to better understand modernity and technology. It emphasizes that renewable energy technologies evolve within system contexts, and systems are shaped by the context of available technologies and the benefits or drawbacks they offer the system. The politics of the technologies within the vision are then dependent upon the politics of the overall system. This analysis provides more feedback between the SCOT approach, which is typically not studied in a systems-level context, and the systems-level approach, which often overlooks how microscale framings of technologies affect the shaping of the visions for a system. Understanding this interplay between the technology and the system provides a more nuanced understanding of why it has been seemingly impossible to scale up renewable energy.

This chapter explores these envisioned system-level transformations, the technologies they include, and their sociopolitical stakes by analyzing how visions for a Mediterranean sociotechnical electricity system were developed and negotiated over time and how regional politics and other intervening factors affect the vision and whether or not it will be deferred. I identify and analyze three different system designs within the broader umbrella of the Desertec vision. I explore how these designs developed over eight years and how characteristics of the visions such as feasibility, societal benefits, and sustainability are constructed and reframed within new versions of an old dream. Comparing and contrasting these visions illuminates the system-level and technology-level changes the actors are proposing, the principles underpinning them, and their promises for societal benefit, as well as the factors that shaped the visions. It also illustrates the politics involved in envisioning a regional sociotechnical system, which were not explored in Hughes' account. What processes would allow electrons to flow unimpeded across borders and what stops them? In an energy system encompassing dozens of countries whose vision wins out?

Analyzing these visions also illustrates the temporal significance of energy transformations and how they relate to technology and modernity. In Chapter 1 I argued that the temporal aspects of energy transitions are as challenging as their geographical aspects. Keeping the centralized system configuration in place with large amounts of renewable energy is a highly temporally dependent challenge. In Desertec Design II, renewable energy's intermittency would be evened out through "perfect foresight" that predicts the weather and the electricity demand at each second to make electricity immediately available at any point in the system across an entire region. Even though Desertec is an old dream, to revert to sun and wind power while managing their natural, intermittent cycles would perhaps be the ultimate project of technology and modernity. Again, a modern energy system is not envisioned as one with radically innovative technologies but a somewhat different system configuration and different management, especially relating to the temporal aspects of the system.

A new model of a vision. Below I present three system designs under the aegis of the Desertec vision and the factors that shaped them. I identified these system concepts through the analysis; they are not actor categories. I call Design I "a system for integrated solutions on a crowded planet" to reflect the Limits to Growth philosophy underpinning it. Design II I call "the integration miracle," which emphasizes the benefits stemming from extensive large-scale electricity systems and market integration, and Design III I call "virtual exports," which would avoid building cross-continental transmission infrastructure and instead develop a virtual carbon market. The first design valued certain system properties and goals and then advocated for particular technologies framed as fitting these system properties. The second design prioritized different system properties—primarily low cost— and was ambivalent about which technologies would be used to meet these goals. The third design was a form of what Graham (2000) calls "infrastructural consumerism," to form a niche market for renewable energy in North Africa supported by green consumers in Europe. For each design, I compare the stakeholders' overall goals, their implied or explicit definition of sustainability, the technologies used, the properties and values imbued in the various renewable and non-renewable technologies in the energy mix, the principles prioritized in the system (e.g., reliability, affordability, dispatchability), and the expected social benefits. I illustrate how the Desertec vision has been shaped by public criticism and the changing constellation of actors advocating for it.

Table 2 presents an updated version of the generalizable model of a vision developed from the literature in Chapter 1, improved upon by the empirical study. These categories are important in developing, constructing, and negotiating a vision. The first part of the table describes the components of a vision for a sociotechnical system (i.e., technologies, geographic construction, system properties, depiction of modernity, managing organization, shared social problems, construction of feasibility). The second part of the table describes the forces and processes that shape the vision (i.e., system imaginers, sociopolitical context, timescale, wildcards, philosophy underpinning the vision, media response). This aids in understanding how the vision has been constructed and negotiated over time and what processes have affected whether it will be realized in the future or deferred.

This model of a vision and the comparison across concepts illustrate how the dream for renewable energy in the Sahara moved back and forth across a continuum from being a dream, to a vision, to a design (or a variety of designs), to a constructed system. This chapter specifically explores the visioning and design process. As I asked in Chapter 1: What happens to the network of supporters when a vision must conform to the realities of media backlash, financing problems, and disruptive events, which could result in certain expectations not being met? These system imaginers are not inventor-entrepreneurs but act as project "accelerators" to "speed up" the vision to realize the deferred dream, prioritizing the urgency in Gore's plea over technological innovation. The term "innovation" is therefore almost completely absent from the Desertec discourse. Given the vision's ambition and scale, actors must depict it as feasible to propel it to the construction phase. Proving feasibility is an operationalizable form of what Piccard called dropping ballast—convincing people that a crazy idea will fly. Means of proving feasibility include framing the end goal as an inevitable and proximal future, framing the technologies to be deployed in the vision as mature, and framing the system imaginers as credible and objective. Through temporal tactics, the actors construct their envisioned future as feasible, catapulting it from the design to the groundbreaking stage. Additionally, three methods of proof-of-concept emerged throughout the vision's lifecycle and were contested by the involved actors: building a reference transmission line, building a reference project, or lobbying for better regulations and policies to pave the way for the eventual implementation of the vision. Proving feasibility is the force needed to propel a vision from a dream to a constructed reality. However, Desertec's promoters disagreed on the means of proof-of-concept, unmasking a substantial value conflict and pushing the vision backwards to the dreaming stage.

Table 2.

Updated Model of a Vision for a Sociotechnical System

VISION			**EXAMPLES…**		
Technology	Technological mix (e.g., PV, CSP, wind, HVDC)	System properties the technologies fulfill, e.g., dispatchability	Construction of technological maturity	Technological neutrality vs. technological advocacy	Framing of innovation
Geographic Construction (described in Chapter 4)	Constructing a shared region	Geopolitical reconfiguration of countries	Boundaries, barriers, connectivity	Abstraction, visualization methods	Whether populations are written out of the landscape
System properties	Dispatchability	Associated system benefits e.g., water provision	Temporal dependency	Mutual reliance	Baseload & peak power
Depiction of modernity	Energy farming	Temporal control	Infrastructural consumerism	Balancing the present and future (Chapter 6)	
Managing organization	Mediterranean TSO	RWE utility company	ENTSO-E		
Characterization of shared social problems and societal benefits	Mediterranean emigration/ immigration	Meet rising energy demand in the MENA region	Prevent curtailment	Improve or maintain system reliability while integrating intermittent renewable energy	Sustainability and climate change
The construction of feasibility	Methods of proof-of-concept	Feasibility studies	Technological maturity or neutrality	Political feasibility	
DRIVERS			**EXAMPLES…**		
System imaginers	Companies and consortiums	Mergers, MOUs (e.g., Dii and	Staffing at the Dii & Desertec Foundation.	Participating governments	Funders

	involved & how they frame their identities. Accelerators vs. developers	MASEN)	Cosmopolitan agents.		
Sociopolitical context	Regional political process on energy (e.g., Euro-Med Partnership, Union for the Med)	EU electricity policy developments (e.g., Article 9)	National renewable energy developments	Foreign policy, region building	Energy security framings
Timescale	Future as proximal or distant	Temporal dependency of the system	Grappling with vast timescales		
Wildcards	Arab Spring	Eurozone crisis	Falling price of PV	Events that disrupt the vision's feasibility e.g., BP Algeria hostage crisis	
Philosophy underpinning the vision	Limits to growth	Culturally situated framings of sustainability	Neoliberalism		
Media Response	Neo-colonialism	Public commu-nication of science	Mis-understandings	Depictions of Dii	

A Tale of Three System Designs

Design I: "solar power for Europe; water and development for MENA": a system for integrated solutions on a crowded planet. The Limits to Growth philosophy provided the paradigms and values underpinning Design I. The Club of Rome's *Limits to Growth* report from 1972 defined the "world problematique" facing all nations as, "poverty in the midst of plenty; degradation of the environment; loss of faith in institutions; uncontrolled urban spread; insecurity of employment; alienation of youth; rejection of traditional values; and inflation and other monetary and economic disruptions" (p. 10). It framed the world population as overshooting the carrying capacity of the available resources on the planet, and Desertec was later offered as a solution. In 2003, the Club of Rome and the Hamburg Climate Protection Fund, which were interested in addressing population growth on a crowded planet, founded the Trans-Mediterranean Renewable Energy Cooperation (TREC) to promote the Desertec vision.

In 2006, the German government commissioned the Systems Analysis and Technology Assessment (SATA) division of the German Aerospace Center (DLR) to conduct feasibility studies of the Desertec vision to showcase Germany's commitment to renewable energy at an international conference to be held in Germany. SATA had been involved in CSP analysis since DLR's involvement in the Solar Plataforma in Spain. The greater focus on electricity for Europe than for MENA in the report is partly the footprint of the interests of the client and the event for which the report was written. The studies included Med-CSP, which considered the potential for renewable energy around the Mediterranean Sea; Trans-CSP, which evaluated the south-north export of renewables to complement the European electricity mix; and AQUA-CSP, which explored the feasibility of solar water desalination. DLR considered whether it would be feasible to provide an 80% renewable energy future for the EU-MENA region, to provide 15% of the EU's power from MENA by 2050, and to foster a positive energy partnership between the EU and MENA regions. The scientist who headed the project said, "we got an order from the German Ministry of the Environment to check this idea for plausibility… then we sat down with our partners, and we tried to kill this concept but we did not succeed in killing it." The rest of this section explores how DLR constructed the vision as feasible—by ascribing advantageous traits to technologies framed as mature, or technologies whose time had come that would provide important benefits to the overall envisioned system.

HVDC grid. A technology's maturity is a key factor in whether it is perceived as feasible. Mature technologies can be implemented quickly to speed up progress toward realizing the vision. DLR framed HVDC as a *mature* technology, as opposed to an innovative technology. As evidence they stated that—strung together— all of the current HVDC lines could wrap around the globe. Furthermore, a total of 75 GW of capacity in over 90 projects worldwide have been developed, and the first line was built as early as 1954 from Sweden to the island of Gotland. They also referenced the existing DC submarine cable between Italy and Greece. This mature technology would form the "backbone" of the vision, or "highway" connecting the region. Each country would maintain its own AC grid, analogous to country roads and city streets. The design included 20 power lines of 5 GW capacity each built by 2050.

In addition to HVDC's maturity, DLR valued it for numerous other traits making it advantageous for building the backbone of the system. They illustrated this through a comparison to AC transmission. The battle of the currents between AC and DC that Hughes (1983) thought had been put to rest has been reopened. First, HVDC is *efficient* because it has half the long-distance transmission losses than HVAC, and higher-capacity longer lines can be built. Second, while AC transmission was framed as safe in the 1900s, DLR framed HVDC as *safer* because AC requires more transformers to maintain the voltage on the line and if one AC transformer gets out of sync the entire circuit will be short-circuited. With HVDC, if something goes wrong on one end, it grounds to the ground rather than short-circuiting. An HVDC grid would also provide the system with the traits of *stability* and *redundancy* through the “n-1 criteria” in which a broken power plant in one country can be substituted for an operational one in another country during an emergency. For example, in 2008, several of the steam turbines at Morocco’s Jorf Lasfar coal-fired power plant (300 MW capacity each) unexpectedly shut down. Importing electricity from Spain and Algeria allowed Morocco to avoid load shedding (Fairley, 2008). HVDC also would provide for *connectivity* by linking the best sites for solar energy in North Africa to Europe.[94] Additionally, HVAC transmission lines cannot be buried, while HVDC can. Since the HVDC cables would be buried underneath the Mediterranean and throughout the EU countries, HVDC has the property of *invisibility* for premium-networked spaces in Europe. It would also allow the generation facilities to be placed out of sight— on a different continent.[95]

Because of all of these advantages, DLR concluded that an HVDC backbone grid “will probably be implemented in Europe within this century to enhance security and stability.” By framing HVDC as a mature, efficient, stable, safe, redundant, connective, and invisible technology, its implementation appeared to be nearly inevitable, or part of a networking logic. Therefore, HVDC was not necessarily perceived as an innovative technology, but a technology whose time had come.

Dispatchability. The value of *dispatchability* underpinned Design I’s logic for integrating a power system across dozens of countries, illustrating the importance of system-level considerations in energy transformations. Dispatchability means that an energy source can be controlled on demand—turned on or off or ramped up or down as

[94] See Chapter 4 for a discussion on why connectivity is important.
[95] See Chapter 4 on the justice aspects of extending premium-networked spaces.

needed by utility company operators (Greacen et al., 2013).[96] DLR analyzed 50 countries in the region and found that each country could reach an 80% renewable energy future in terms of resources but not in terms of its system being able to function. Not every country has the right kind of renewable energy to independently maintain a *reliable* renewable energy system, which is generally the trait valued most highly by electricity system builders. Some in the power sector see renewables as fundamentally untenable because they are intermittent and are not dispatchable. Incorporating large amounts of fluctuating renewable energy resources into the grid can make it unstable and unreliable (ibid).

Design I posited that integration across countries could provide dispatchability in the system in order to *stabilize* it. While European countries could generate their own fluctuating (intermittent) renewable energy from sources like wind and PV, at a system-level, they require a replacement for the baseload power provided by coal and nuclear power plants that produce a constant flow of electricity 24 hours per day. A DLR scientist explained, "In some countries [they] needed this import of solar electricity from the south to the north because they had a lack of flexible renewable energy…and this high quality of energy, this is only available in North Africa." Intermittent wind and hydropower in the north could be combined with dispatchable electricity from CSP from the south. A CSP plant sited in North Africa would be operated as a virtual power plant for Germany, replacing baseload power from coal. Unlike in Design II, cost was not the first priority for generating dispatchable power; DLR hoped Germany would be willing to pay more for this dispatchable power to avoid using fossil fuels or nuclear as baseload power plants.

[96] See also the electricity primer in Chapter 1.

CSP. While some interviewees asserted that Design I focused on CSP merely because of SATA's experience with it, CSP was advocated for in Design I specifically for the system trait of dispatchability. Technological advocates focus on particular technologies, but they do so based on their system principles. CSP had an air of inevitability at the time; according to the father of Desertec, it appeared to be "only a matter of time" before this mature technology was developed because of the important role it could play in the electricity system. Unlike in 1880, CSP in Design I was envisioned as an important part of the overall electricity system.[97] Combined with cheap thermal storage,[98] CSP could compensate for fluctuations and nighttime to generate dispatchable electricity about 20 hours per day. It is difficult and costly to reduce generation from conventional baseload power plants when the generation spikes from fluctuating renewable electricity, and it can take 20 hours or more to restart a nuclear power plant. In contrast, it is easy to shut down CSP by simply moving the mirrors to the stow position.

Conforming to the Limits to Growth philosophy, Design I also valued CSP plants for their ability to address integrated challenges, illustrating that the challenge of building electrical power systems in the 21st century goes well beyond providing heat and light. DLR framed CSP power plants as *multipurpose* power plants providing integrated solutions. The report stated "In the world's arid regions, such plants could become the nucleus of a totally new social paradigm: like the conservation and recuperation of land flooded by the sea in the Netherlands." DLR argued that building multipurpose plants in

---

[97] See Chapter 3.
[98] Developed at the PSA in the 1980s as described in Chapter 3.

the margins of the desert could *prevent desertification*, *desalinate* ocean water, provide *food* by sheltering plants in the shadow of the mirrors, and facilitate *foreign cooperation* (see *Figure **36***). In the loftiest of CSP's promises, a solar power and water project for Gaza sited in Egypt was envisioned to bring peace to this tumultuous area.

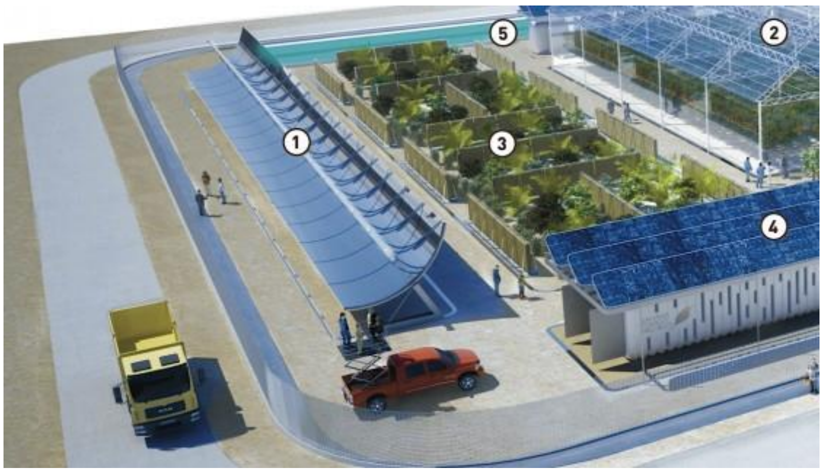


Figure 36. Integrated Solar Energy Solutions, Source: Aqua-CSP, German Aerospace Center (DLR) Feasibility Studies

PV & wind. In this design, solar photovoltaics and wind were seen as *expensive, fluctuating* sources of electricity that DLR expected to be built in a distributed configuration in Germany and other Europe countries. The fluctuations from wind balance each other out in the system to a certain extent, but overall fluctuating energy would need to be balanced out by dispatchable, firm power on demand from CSP in deserts. This would change dramatically in Design II.

Fossil fuels. Like HVDC and CSP, DLR framed fossil fuels as mature technologies that provided important advantages despite being non-renewable. They improve system *reliability* by ensuring a 25% spinning reserve capacity (i.e., generation that can come online within 10 minutes to ensure the system's frequency is maintained). Fossil fuels would also provide for peak power demand. The studies criticized humanity for squandering fossil fuels when other resources are available to meet baseload demand (the opposite of today's system). They stated that humans are "like squirrels eating the nuts we should be saving for wintertime." As discussed in Chapter 4, Design I depicted farming energy as more modern and sustainable than generating energy from fossil fuels gathered "like our ancestors collected berries and hunted animals." Using CSP to harvest energy from the sun then was viewed as part of natural, global technological progress. While DLR framed this system as modern, it was also based upon an old dream for CSP seeking to become a reality, providing further evidence that new system configurations in the power sector are viewed as more innovative than new technologies.

Sustainability. How the system imaginers defined sustainability shaped the vision and its design. Sustainability is an ambiguous term that is defined differently in different cultures. Sometimes it functions as an ideograph, or an empty term that is flexibly interpreted and often evokes an emotional, rather than intellectual, response (Van Lente, 2000). Ideographs legitimate expectations for future social benefits from the envisioned technology or technological system (ibid). In other cases, sustainability adopts substantive cultural connotations. For example, we found during our study abroad trips in Spain that sustainability has been associated with opposing government corruption following the Eurozone crisis.

In Design I, the definition of sustainability was based upon an alternate interpretation of the triple bottom line. DLR conceptualized the economic pillar as the affordability of electricity and the internalization of the externalities of fossil fuel generation. The second pillar was conceptualized as "compatibility with society and the environment." The final pillar was security, which was conceived of as security of supply and security gained through international cooperation. Sustainability was also framed as using the least materials possible. DLR's Med-CSP report included a lifecycle analysis of the technologies to consider whether there were sufficient materials available to build all of the technologies in the system design. These aspects placed a greater focus on integrated solutions and were lost in Design II.

Societal benefits. Van Lente & Rip (1998) argued that promises for the societal benefit of new technologies established expectations for outcomes. These expectations become promises and lead to problems for the technology when it is built. In addition to setting expectations, the framing of the system-level societal benefits is important to establishing the feasibility of the system—not just from the perspective of whether it can be achieved technologically but whether it should be built in terms of societal value added. The expected societal benefits of Design I included the expansion of premium-networked spaces, energy interdependence, and win-win cooperation. DLR asked the following three questions: Could the common goals overcome frictions and suspicions based on cultural differences (which was problematized in the immigration discussion discussed in Chapter 4)? Can these regions cooperate without endangering their cultural identities? Can all countries become winners through cooperation?

While promoting societal benefits is essential for establishing feasibility, the societal benefits were framed through a promise that the system would not have drawbacks, which became problematic in reality. In contrast to the *Limits to Growth* report, which acknowledged the trade-offs inherent in the development of technologies, the Desertec vision was framed as a win-win solution from its inception. DLR also argued that the vision would result in a win-win outcome for all countries. For example, since there are surpluses in Europe of oranges and tomatoes, European farmers would lose from imports, whereas importing electricity could be a win-win. DLR stated, "proper general conditions could generate considerable economic and ecological win-win configurations for all countries of EUMENA" including to

1. “enable *feasibility* and enhance *productivity* of the cooperation
2. ensure *advantages* for all sides
3. support *stability* of the interregional relations
4. bar the *abuse* for hegemony and cultural domination” (Trieb, 2006, p. 98).

I describe later that system imaginers struggled to convince all parties that the vision would be a win-win, and Spain failed to sign a transmission agreement, which disrupted the vision’s feasibility. The win-win concept is further explored in Chapter 6 by examining the perceived benefits of integration for Morocco and in Chapter 8 as part of energy justice.

I argued in Chapter 4 that expanding premium-networked spaces could be a tenet of energy justice. This was another of Design I’s proposed benefits. An interviewee pointed out that 25% of Mexico’s population lives in Mexico City because of limited access to electricity in the rest of Mexico, while even the Black Forest in Germany is a premium-networked space. In this sense, a lack of centralized, interconnected power systems centralizes people. DLR argued that energy autonomy and independence goals conflicted with Europe’s obligation to be good neighbors. They stated,

> In fact the autonomy goal, and its proposed solutions, is rather questionable in terms of ethics and sustainability: it propagates a Europe unaffected by the future misery of its neighbors, and fosters the illusion of independency on a rather small and crowded planet. (p. 33)

Design I sought to build an energy system for the Mediterranean in which everyone would be equally networked. The *Limits to Growth* framing underpins the global conception of energy security discussed in Chapter 4, in which energy sustainability and energy access for a growing population must be addressed at a regional, if not planetary, scale due to earth's limited resources.

Security. Aside from the global equality framing of security, Design I framed energy security chiefly as the *diversification* of Europe's energy portfolio. The report envisioned that electricity could come from ten sources in 2060, as opposed to the five fuels sourced at the time of the report's publication. They described the current energy path as based on high risk, short-term policy decisions, while Design I with renewable energy and fossil fuel backup would be "low risk". DLR also framed *network stability,* which HVDC would provide, as a tenet of security. Finally, Design I partly conceived of security as building renewable energy in MENA to relieve pressure on the fossil fuel supply for Europe. The framing of energy security changed significantly in Design II as will be described later.

In 2007, TREC published the *Desertec White Book*, which reflected Design I. The *White Book* was qualitative and included voices from MENA, lending legitimacy to the vision from the south of the Mediterranean. Prince Hassan of Jordan, also the president of the Club of Rome, wrote the introduction, which presented Desertec as a solution to power *and* water for a growing population. It also emphasized the vision's global security and interdependence benefits. First, it framed global climate change as the central challenge the Desertec vision was seeking to solve. Second, it framed energy poverty as the central type of poverty in the world and proposed to fuel economic development with energy. Third, it focused on North-South cooperation between the "sunbelt and the technology belt." TREC still saw CSP as the leading technology in the system, and the Algerian Hassi R'Mel ISCCS plant was offered as proof-of-concept and evidence of technological maturity. Prof. Bennouna from Morocco argued that Europeans could make up for the wrongs committed during the colonial era by helping Morocco with its industrial development. He argued that Morocco should better negotiate with the EU to use renewable energy to fight common challenges of poverty, climate change, and South-North discrimination. He predicted that "Morocco is on its way to [becoming] an energy exporting country." (In contrast, the European media responded in part to Design I by predicting that this scale of cooperation would result in neocolonial relationships.) Finally, the report recommended an Apollo-like EU-MENA Desertec Program, which is an unfortunate metaphor since Apollo focused on international competition instead of collaboration.

In summary, Design I would maintain individual country-level energy markets, CSP would provide the essential service of firm power on demand (dispatchability), and fossil fuels would play an important, albeit much smaller, role. The system design addressed integrated solutions, to provide solar power for Europe and energy and development for MENA.

System Drivers: Forces that Shaped the Desertec Vision and its Design from 2007-2011

This section explores the forces and processes that shaped the vision and its design until Design II was published in 2011, in order to illustrate how visions are developed and negotiated over time and framed as feasible. These forces and processes included the creation of the Desertec Industrial Initiative (Dii); the neocolonial critique; differing energy security framings; long timescales; and what scenario planners call wildcards, including the drop in the price of PV and the Arab Spring. These represent the system drivers in the model of a vision in Table 2. In order for the vision to be perceived as feasible from a sociopolitical standpoint, these forces and processes had to be addressed within Design II. There are many moving parts to this story, yet it only scratches the surface of the complexity of the factors that shape sociotechnical systems in a transnational world. In this section, I describe the new institutions and the processes that shaped the vision and its design, and in the following section I describe how Design II differed from Design I as a result. These processes affect whether the dream will become a reality in the future or be deferred. However, Design II did not replace Design I but eventually came into conflict with it, as will be described in the end of the chapter.

Mediterranean system imaginers & the Dii. In 2009, the constellation of actors advocating for the Desertec vision changed, which shaped the vision through new stakeholder agendas. Euro-Medness infected the energy sector as complementary organizations sprang up, including the Union for the Mediterranean's Mediterranean Solar Plan, a political process to promote renewable energy integration in the Mediterranean; Medgrid, the French run equivalent to Dii; and Res4Med, Dii's Italian equivalent. In 2010, Friends of the Supergrid was founded, which is a coalition of companies advocating for an EU supergrid. TREC was disbanded, and the Desertec Foundation was founded to protect the Desertec brand and spread it to other parts of the globe. The development of these new institutions shaped the vision and its design.

Most significantly, in October 2009, a "unique industrial initiative" was founded during the largest press conference in Munich Re's history. There, twelve shareholder companies convened to sign a memorandum of understanding (MOU) to implement the Desertec vision in the EU-MENA region. The MOU for the Desertec Industrial Initiative (Dii) stated, "it is the intent of the companies…to establish a planning entity in the form of an incorporated company," (a limited liability corporation). Over three years, Dii was to create a legislative framework to develop projects faster, to facilitate the construction of a reference project for proof-of-concept, and to conduct a study with a proposed design for the power system of 2050 (i.e., Design II). These steps sought to prove the vision was feasible and to carve out a space in the future for it. Dii's complexity rivals the complexity of the vision and requires further explanation to illustrate how its creation shaped the vision and its design.

Dii included a diverse group of stakeholders and was highly complex, shaping Design II. The initiative represented an unprecedented effort to convene companies from the core value chain and associated chains that would be needed to develop the Desertec vision—banks, utility companies, solar PV manufacturers, CSP developers, TSOs, insurance companies, energy companies, and project developers. It included one of the world's largest reinsurance companies (Munich Re), major banks such as Deutsche Bank, and large energy and utility companies such as Siemens and RWE. Associated companies included those who wanted to carve out a niche within the energy transformation, such as IBM, which is working on smart grid software and software to manage wind parks.[99] An interviewee described that as Dii grew, it became an extremely complex, intercontinental public-private partnership with 50 companies, each with a different agenda (see Table 3). S/he stated, "It was a great learning experience for me as well because I never had seen such a big level of complexity." Several representatives expressed that working across different industry and company cultures was a challenge. For example, some companies in the consortium were more "cosmopolitan" with greater international experience, while others were more focused on domestic business.[100] Finally, they described themselves as balancing complex and sometimes conflicting goals to improve society and the standard of living in North Africa versus their business intent. The table below summarizes the Dii shareholder companies.

[99] The Dii recruited these companies at conferences. Each shareholder signed a three-year contract and paid 1 million euros per year; associated partners paid 75,000 euros per year. Dii was headquartered in Munich, Germany and employed about 30 staff members, seven of which were "secondees," or employees of shareholder companies who worked for Dii temporarily while the shareholder company paid their salary. Dii had a shareholder committee group formed of five or six key individuals nominated by the shareholders who met once a month in person. They split into technical working groups including PV, CSP, networks, power transfer, storage, local context, and political frameworks.

[100] Furthermore, I noted that there were particular actors within these companies who were selected as cosmopolitan agents of cooperation to make these connections. I heard many stories of people who had family connections to the MENA region or previous work experience there and had an appreciation for the culture. On the North African side, many of those involved in energy cooperation had lived in Europe or the United States for much of their lives and returned to Morocco to work across the aisle on renewable energy projects.

Table 3.

Summary of the Dii Shareholders

Shareholder	Description	Reason for joining
Schott Solar	A German manufacturer of glass products.	The CEO of Schott Solar is part of the Club of Rome. Involved because they developed solar projects and supply products to these projects.
Munich Re	The world's largest insurer, with 250 billion euros invested in renewable energy assets. They seek to invest 1 billion euros in renewable energy as a stable asset and as a climate mitigation measure.	Munich Re has a small scientific unit that studies the future risks of climate change on a massive data-gathering mission to track climate activity. A project like Dii could mitigate future climate change insurance risks. Many people on the Dii shareholder committee identified Munich Re as the most important member of Dii.
Red Electrica	The Spanish Transmission Systems Operator (TSO), which is 20% state-owned with 25 private distributors.	They wanted to ensure they were part of the project if it moved forward, but their enthusiasm fell because they do not see who will pay the price gap for renewables especially when there is no significant price for carbon dioxide emissions.
ABB	A high-tech engineering company focused on the power, robotics, and automation sector headquartered in Switzerland. Its precursor company was founded in 1883 and played an important role in electrification.	ABB may have first developed the Desertec vision independently. They were motivated to join Dii not just because they make HVDC technology but because they are used to "shaping the world" of electricity. They believe the system is undergoing its first fundamental transformation since the 1880s, and they want to continue to be a significant systems builder.
Deutsche Bank	Deutsche Bank's slogan is "banking on green," and they run the "Get Fit" (feed-in tariff) program	According to Caio KochWeser, vice chairman, at the 2011 Dii conference, they became involved to make productive use of resources and to realize the green growth paradigm, to find a way out of poverty for millions in Africa without energy, to bring the costs of renewable energy down, and to be part of a bottom-up coalition of businesses partnering across the region to develop the Desertec vision. Many of the shareholders of Dii are their clients, so they became involved to give project finance expertise. They believed Dii would develop a market for renewables in MENA.
RWE	A major utility company that does half of its business in Germany and half elsewhere. They are the largest mining company in Europe (lignite coal) and Europe's biggest carbon dioxide emitter.	RWE heads Dii's shareholder committee. According to Frank-Detlef Drake, chairman of Dii and shareholder from RWE, they joined Dii to improve their understanding of renewable energy supply,

	They are also one operator of the Andasol III CSP plant in Spain. The company is currently not profitable because it is paying a high feed-in-tariff to the owners of rooftop PV panels in Germany. Their business model is in turmoil.	to understand how to balance Germany's focus on rooftop PV with CSP in sunny areas. They expect their membership in Dii will pay off in 10-20 years.
HSH Nordbank	A bank headquartered in Hamburg, Germany	They were approached by the Club of Rome to join the consortium (both are headquartered in Hamburg). They were interested in the Dii as the biggest renewable energy project in Europe because they had a new business unit on renewable energy in 2008. In 2011, after the Eurozone crisis bankrupted the company, they moved their focus back to Europe and did not intend to pursue North African projects. They do not focus on grid interconnection but on financing individual renewable energy projects. Therefore, they withdrew from Dii in late 2013.
M+W Group	Engineering, procurement, and construction company headquartered in Stuttgart, Germany.	They became involved through a personal connection with Gerhard Knies. They helped fund the printing of the *White Book*. They joined Dii to become involved in project development; they have a focus on developing a pipeline of projects on North Africa and the Middle East. They dropped out when they determined they had made their technical contribution to Dii and no projects were yet available on which to bid.
First Solar	A U.S. PV manufacturing company, focused on large-scale PV rather than rooftop.	To sell cost competitive PV panels in the MENA region.
Cevital	A large Algerian food manufacturer	No data
Abengoa	A Spanish engineering firm, which was one of the initial developers of CSP technology. It is one of the only successful CSP firms in the world currently.	No data
Acwa Power	A Saudi power and water utility company.	No data
Enel Green Power	Italian multinational renewable energy corporation	No data
Flagsol	A German CSP developer	No data
Siemens	The largest engineering company in Europe and a formative player in the first electrical power systems and steam turbines.	Siemens withdrew from Dii when they closed their CSP operations.

I call Dii and related organizations "system imaginers." They differ greatly from the inventor entrepreneurs that Hughes described as the system builders of the original electrical power systems. These organizations describe themselves as accelerators, enablers, catalyzers, facilitators, coordinators, and conveners rather than inventors or innovators. They seek to become the catalysts that shift the vision from imagined to designed to constructed. Dii uses temporal tactics to attempt to speed up progress toward its envisioned system. As Al Gore expressed, energy transformations are a matter of addressing urgency rather than technological innovation. These organizations frame, colonize, and control the future but not by physically building it or inventing new technologies but by convening powerful groups, constructing knowledge, and constructing markets. Large energy companies and visionaries do not co-design these systems and the technologies as, for example, Thomas Edison did. Dii's CEO Paul van Son, for example, is an effective builder of networks of people, but he does not invent technologies or build projects but instead advocates for certain system configurations. These large organizations and companies are vested in a particular systems configuration, whereas in the early 1900s they were interested in building up a system around the technology they invented.

Utility companies were motivated to join Dii to ensure that their business model would still be relevant as energy systems are reconfigured in the future. One shareholder representative articulated the importance of maintaining system-level leadership in the power sector,

> If we believe that the world of electricity is developing in that direction [toward systems integration], then we want to be among those that shape this again, also to be a dominant player in that again.

These companies realize that, while electricity systems have gained significant momentum, they are not maintained without continual effort, and that if disruptive innovation were to occur that completely changed the system configuration their business model could become obsolete. These electrical power systems are being constructed in a complex and changing landscape of existing infrastructure and institutions that will work to maintain their relevance. Hughes (1983) described the centralized system configuration and the education of electrical engineers in a particular form of grid management as indicative of the final stage of momentum in electrical power systems. Renewable energy advocates in the United States deride the managers of today's systems as DOUGs (dumb old utility guys) who fail to imagine new ways of managing electrical power systems. ABB is one of a handful of major companies still in existence involved since the inception of electrical power systems, and its aim is to avoid succumbing to stagnant thinking. An interviewee from ABB stated "it's a problem of knowledge, achieved knowledge, which unfortunately doesn't cover all questions, and as you may know it's much more difficult to forget what you know than to learn new things." Although ABB is an old incumbent, it is committed to looking at the energy system in a new way.

Because of Dii's complexity—with numerous stakeholders with many agendas, working across company cultures and balancing business intent and social goals— it struggled to project a coherent identity, especially one that would provide it with the credibility to shape the future of the power sector. At Dii's 3rd Annual Conference in Berlin in 2013, Aglaia Wieland, Chief Strategy Officer, articulated that Dii is a think tank, an industrial platform to facilitate unprecedented collaboration between companies, and a trusted political organization. The multiple identities of the system imaginers affect the sociology of expectations. Expectations play an important role in shaping new technologies at both the level of systems and individual technologies (Borup et al., 2006). As Van Lente (2000) observed, expectations become requirements for the technology and— I would add— the system and the system imaginers. For example, if Dii is a project accelerator, then people expect the project pipeline will grow faster than it would otherwise. If Dii is a trusted advisor, then people expect that the leaders will not air their disagreements in the media. When these identities came into conflict it, in part, led to the deferral of the dream. Below I explain Dii's five identities and how they relate to its credibility, ultimately to describe how Dii's identities shaped Design II. This also provides a better understanding of today's system imaginers and the role they play in developing tomorrow's electrical power systems.

A project accelerator. Dii acted as an accelerator to speed up the process of helping a deferred dream find its place in the future. Selin (2006) stated, "there is a pioneer quality to these visions: they colonize the future and latch on to new spaces, staking out unusual territories." Adam (2003) pointed out that time is colonized through a capitalist market, as financial and insurance markets predict the future based upon the past and make promises to compensate people in the future. This is "based on the belief that the future is amenable to human regulation and design in the present." (p. 73). Dii framed the Desertec vision as the inevitable end of a fixed trajectory in order to carve out a future space for the dream and to accelerate development toward that future. They framed the end goal of market integration as an inevitable future based on market logic while in the present constructing the markets that would be needed to reach this end goal. An interviewee from a shareholder company illustrated this perspective,

> it's like water pouring down a river—you can be sure it will go down—but sometimes you can accelerate the development. It's not a question of whether Desertec comes at the end of the day, but it's a question of time and whether you can speed up the process.

This temporal tactic attempted to throw assumptions about the infeasibility of renewable energy overboard in order to accelerate the vision into an inevitable future.

Not all shareholder companies agreed on the timescale required to reach this end goal, which resulted in disappointed expectations. One interviewee from a shareholder company longed for a Desert Power 2020 report, instead of Desert Power 2050. Another shareholder interviewee emphasized the uncertainty involved in the process of integration but the likelihood of reaching the end goal: "I would say if you try to describe something that will happen—that is expected to happen—in 40 years most likely it is wrong. But there are good arguments for integration, and I think we will move in that direction." Dii opened up possible imagined systems based on renewable energy integration and worked to make the case that they are feasible to project the overall vision as feasible. Disagreement about how quickly this could be achieved ultimately created conflict for the organization, and failure to achieve results conflicted with its identity as a project accelerator (described later in the chapter).

Creator of markets. Ironically, Dii exists because the vision is not, in fact, inevitable, rather the necessary markets must be constructed in the present in order to shape the future. Dii was created to open up markets for renewable energy between the EU and North Africa. This private association of industry actors interested in a market-based approach shaped Design II, whereas Design I was shaped by a government-funded research consortium and envisioned power markets bounded by nation-states. As the Dii grew, its goal became more explicitly to create a single market for electricity in the MENA region, which Europe could benefit from if the grids between the regions were integrated. Therefore, the creator of markets identity became increasingly important as described later in the chapter.

A think tank and lobbying organization. Miller, Iles, & Jones (2013) identified energy epistemics as a key issue in energy transitions: "who knows about energy systems, what and how do they know, and whose knowledge counts in governing and reshaping energy futures?" (p. 137). Dii tried to spread its energy epistemics, or new ways about thinking about electricity systems integration, in order to make its envisioned future more viable. These ideas were also exported to MENA countries as part of Germany's broader foreign policy and industrial policy goals.[101]

Dii was founded amidst significant public confusion about whether it would construct the Desertec system itself. The shareholders decided in 2010 that Dii would not build projects itself because they did not want to create a competitor for the shareholder companies. Instead, Dii would use its know-how to gain traction in public policy debates to construct a particular future with a regulatory environment advantageous to the

[101] See Chapter 4.

companies. An interviewee from Munich Re stated, "it's more a know-how company, where the knowledge is bundled, not a company realizing new power plants directly…"

Dii used this identity as a think tank to frame itself as a credible advisor providing know-how and policy advice. Its analysts sought to be "fact based," and the managing director shielded the analysts from politics. Dii described itself as providing business plans that its partners can trust. At the 2013 conference, a shareholder company representative explained that Dii needed to "step on the toes" of their clients, as a credible party and well-respected advisor without a direct financial interest.

Industrial platform and convener. Dii has taken unprecedented strides in convening a large number of companies and stakeholders at conferences that spread their energy epistemics to the broader energy policy community in EU-MENA. This helped Dii to control the conversation and the knowledge created about future power sectors. It also aimed to develop the network of "human power" that Piccard said is necessary to make dreams happen. This role is also contested in terms of procedural justice, as some people in the region saw Dii as a gatekeeper that limited the conversation on energy integration to powerful actors who could pay for the conferences. For example, a Moroccan wind energy developer complained that Dii provided neither a venue for dissenting views and critique nor a focus on improving energy access.

Technology neutral advisor. Dii argued that it is a neutral, independent actor because it does not represent the interests of one particular group but a wide range of industrial partners. Dii's identity as a technology neutral advisor is important for understanding how systems and technologies are co-shaped and why CSP played a less prominent role in Design II.

In the first year, Dii struggled to negotiate the needs of its CSP-focused shareholders versus its shareholders who did not have a stake in a particular renewable energy technology. For example, Munich Re, identified in many interviews as the most important company in the consortium, is interested in climate change mitigation to reduce natural disaster risk and does not have a stake in a particular technology. Other companies, like the utility companies, are interested in the cheapest technologies. A representative from a shareholder company stated, “we tried not to [focus on CSP] because we wouldn’t want to be stamped as a German CSP Club jah.” Therefore, Design II focused on developing the lowest cost mix of technologies in the system, rather than focusing chiefly on CSP.

This technology neutrality had boundaries as Dii decided only to consider feasible, “industrially stable” technologies. As such, the Desertec vision came to be pioneering but not innovative. In other words, they were staking out new territory in terms of system integration and scaling up renewable energy, but they focused only on existing, mature technologies. Technology neutrality reflects the idea that the necessary technologies exist but system imaginers need to throw old certitudes overboard to realize them. The vision is therefore visionary only within boundaries and constrained futures. I describe in the next section how this focus on technology neutrality had a significant effect on Design II.

The technology neutral identity was based not only on economic principles but also on Dii’s construction of its credibility. At Dii’s 2012 conference, a shareholder representative explained that Dii had generated significant credibility due to its technology neutrality and the fact that it is one step removed from profit. A Dii employee explained their broad appeal stating,

> It's the association logic. I mean, the UfM and the Mediterranean Solar Plan doesn't care what ABB thinks but they do care what a broad spectrum of industry thinks. And they care about a broad spectrum of industry far more than they would a narrower sector, so that's in a way why Dii is a more attractive forum than, for example, the European Photovoltaic Industry Association… that's photovoltaic companies and we're banks, insurance, utilities, renewables producers, more on the generation side, more on the transmission side.

Being technology neutral became a desired state, analogous to being unbiased and objective.

Public perceptions of Dii and temporal complexity. Given its five identities, Dii suffered from multiple personality disorder in the media. The media's response to the Desertec vision, as well as the perception of Dii by other Mediterranean stakeholders, shaped the Desertec vision and its design. Common, often contradictory, media framings of Dii include that of

- a powerful German consortium seeking to supply 15% of the EU's energy needs by 2050. This was DLR's assessment of the percentage of energy imports that would be feasible, which the media and Dii later reified as a goal. The target caused problems for Dii because it appeared as though they were uninterested in providing power in MENA where demand is skyrocketing.

- a consortium seeking to supply local needs and 15% of EU's energy needs
- a single project with significant cost, scale, and ambition. Sometimes this was framed in a positive light; other times it was used to portray Dii's vision as risky because no one has attempted to deploy renewable energy at this scale. It also set the expectation that there was sufficient capital available, when in reality Dii was only funded at one million euros per shareholder company, far short of the half a trillion dollars DLR projected was necessary to build the system. As described in Chapter 4, Dii came to emphasize that it was a grouping of distributed, although large-scale, projects in the region not a single project.
- a project portrayed by the media as merely an idea, fantasy, dream, mirage, or white elephant in the desert, which set the Desertec vision a step back in its appearance as a feasible plan.

In the EU-MENA power sector, Dii was often viewed as a private, German consortium focused more on profit than on societal benefit. An official from the Union for the Mediterranean described the Desertec vision as "a private industry joint venture to…accelerate the implementation of the Desertec vision in EU-MENA…it's about making money, at the end of the day how will they make money?" Similarly, a World Bank official explained that they did not work with Dii because they work only with governments, not private companies. Furthermore, s/he stated it's about "let's play

German," meaning that the project was about promoting German renewable energy technologies in other countries.

The vast timescale and temporal complexity involved in the project also posed challenges for communicating it to the media. These lengthy timescales are fundamental to electricity planning; 50 years is one, or at most two, investment cycles in the power sector, including planning, permitting, construction, operation, and decommissioning. A public relations director for a major Dii shareholder company explained that at a 2009 press conference, they showed pictures of CSP plants in Spain and reporters had the impression that the first power plants had already been built in North Africa to deliver power to Europe. He reflected upon this stating,

> It was totally strange…we said, hey wait, this is a group of shareholders, we will make this happen in the next *forty* years, until 2050…[but] journalists just did a journey to Northern Africa and looked for the first spots. This was just…it was strange. It was only the German side…and it was all about these rumors and we don't need nuclear energy and all about that. The fight was done. You know the war was over. Yeah. Because the future is today, and the future is in Northern Africa…It was something like a surreal experiment. It was only a dream yeah. A vision. And they thought it was real. And so therefore…we did a lot of talks in the background…and explained to [sic] everybody [that] this is a vision. We're proud to be part of it, but it's [got] a long way to go. We're talking about realization in 2050. Not yet, not 2040, not 2015, two thousand *fifty*. Five. Zero. Yeah. And it really it seems like something that won't work. Now, four years later…they said,

> hey, Desertec is dead. Nothing happened. No, you can't realize this vision because you don't believe it yourself, and you've only been part of the shareholders [group] to bury this project. We said -'what?!' [They said] yeah, it's a plan from the energy industry, you don't want renewables, therefore you built up this group.

He said the media assumed that Dii played a role analogous to GM in intentionally sabotaging electric car technology. Dii was launched with high expectations for what they could accomplish. When goals were not met on a much shorter timescale than Dii had promised, expectations were disappointed. Several interviewees explained that they thought the journalists were too optimistic when Dii was founded and then later became critical of the vision because they regretted their lack of skepticism. One stated,

> The first step is [the journalists] are getting a little bit enthusiastic too. Second step is you are asking yourself, [wait a] moment. Nothing in history has been only historic, Hercules, [the] biggest, superlative, there must be some problem. Let's wait. And if you have been part of the mass media hype there is a certain form of being ashamed of having been too enthusiastic about something as a journalist because you have to stay skeptical, [sic] distant. That is what we are seeing now in the mass media— this is a form of backlash because of their being ashamed a little bit, having been part of the enthusiastic hype.

Especially in light of media skepticism, Dii would need to catapult the vision from designed to constructed through temporal tactics that make the dream a feasible reality. These tactics are part of the process of negotiating a vision. In order to gain leverage for breaking ground on the envisioned Desertec system, Dii must frame 2050 as proximal, which as Michael (2000) pointed out, does work. In one of many examples, the Desertec Foundation posted a picture on Facebook of the first CSP plant under construction in Morocco stating,

> The future has begun. Germanwatch e.V. employee sends us this picture from Ouarzazate (Morocco) where he evaluates the realisation of the biggest solar power plant of the world in terms of sustainability and socio-economic development. Help to spread the word: Energy Transition is possible!

The framing that the future is here works to frame CSP as a reality in the present. I will return to this quote in Chapter 7 as I explore the challenges of constructing the first CSP plant in Ouarzazate. System imaginers also framed the vision as inevitable to make any advances appear as steps toward an end goal made certain by market logic; market integration therefore became a new, feasible certitude. An official from the World Bank framed the export of renewable energy to Europe as inevitable as a matter of cost, supply, and demand

> There is a communication under preparation in Brussels and maybe that would develop a better framework for meeting the objectives of Europe for the

> imports… but at the moment it is fairly complicated. *But I'm pretty sure it will happen at some point, the question is when…* Because Europe has made a commitment to 85-90% reduction in CO_2 emissions by 2050, which requires a full decarbonization of the power sector. *At some point* it would be cheaper to tap into the solar resources of the Middle East-North Africa than putting more wind farms offshore or anything like that, so clearly *if you look at the supply-demand curve there is a point at which basically [it] points to imports anyway*, so just it kind of makes sense… (emphasis added)

S/he added that this would not be a linear path but that it was likely the endpoint would be reached. Market innovation is therefore not about implementing novel technologies but about speeding progress toward an inevitable future.

Officials I interviewed from the Moroccan Agency for Solar Energy (MASEN), which is developing 2 GW of CSP in Morocco, saw the vision as desirable but situated it in the distant future, which could defer it. When I asked about the feasibility of the Desertec vision, a MASEN interviewee stated

> I think you are one of [sic] the rare persons who [sic] uses the correct words. You know what, because Desertec is a concept and it's not a project… they cannot build, and they're not aiming to build… And [there is] very, very huge work to do. And it will not be done in [sic] one day. Because energy is a very specific sector. Each country has its own legislation… And that's why the Desertec concept is still a good concept…but this is a long [sic] trip.

Another official from MASEN stated that Desertec is a good idea, but the end goal is distant due to complexity,

> Desertec is an idea, is a concept, is a nice concept. Produce electricity where it is cheapest and transmit over HVDC where it's needed. Simple idea. But the interconnections and political will are very complex. Multinational projects take a lot of political will and leadership and we're working on that (not verbatim).

The interviewees expressed two different framings: that the vision is far-off in the future so it does not need to be enacted now, or that it is urgent but takes a long time to build so progress must be accelerated. Framing the future as proximal raises expectations that progress will be made soon and along with it risks that expectations will be disappointed.

Neocolonial Critique. Dii's most significant public perception issue when it formed in 2009 was that the vision was fundamentally neocolonial. For critics of the Desertec vision, CSP had not shed its colonial politics.102 They framed the Desertec vision as a neocolonial European scheme to exploit North Africa's natural resources. Critics often describe Dii as a German initiative to export North African solar power to meet 15% of Europe's energy needs by 2050, and they do not mention local renewable energy use. Daniel Ayuk Mbi Egbe, the head of the African Network for Solar Energy, which focuses on distributed PV installations to alleviate energy poverty stated (as quoted by The Guardian)

---

[102] See Chapter 3.

> Many Africans are sceptical [about Desertec]," he said. "[Europeans] make promises, but at the end of the day, they bring their engineers, they bring their equipment, and they go. It's a new form of resource exploitation, just like in the past (Hickman, 2011).

The media also circulated a comment made by a graduate student in Arabic and Islamic Studies living in Morocco on a *New York Times* blog. She said “Haven’t we already been here before? "Europeans covet Africa's wealth of natural resources," she continued, "so they make economic investments for the benefit of Europeans and the detriment of Africans” (Zeller, 2009). She explained in an interview with me that she was unfamiliar with the project’s details but wanted to provide the historical context related to it.

In contrast, the paradigms espoused by many Desertec advocates assume that the concepts of sovereignty and the nation-state are outdated. They assume the nation-state is obsolete and that politics impedes building rational, modern infrastructure. Sovereignty is isolationism. They perceive the history of the colonial empire, followed by former colonies reclaiming their sovereignty, as being in the distant past.

These are two different worldviews, one seeing the region as a shatterbelt with a complex and divisive history[103] and the other viewing it as a post-colonial, globalized region in which nation-state boundaries are obsolete. The first point of view risks dwelling on the past and assuming that all collaboration between Europe and North Africa is neocolonial. The second risks ignoring histories that are still important to

[103] See Chapter 4.

citizens living in the region and even shape today's electricity system, as illustrated by the history of Moroccan electricity systems in Chapter 6. Just as I argued in Chapter 4 that there is nothing intrinsically xenophobic about the vision, there is also nothing intrinsically neocolonial about the vision. The possible neocolonial outcomes depend upon how the process plays out, as Chapter 6 will illustrate. The neocolonial critique shaped Design II, which did not envision building single south-north HVDC transmission corridors that could be perceived as draining energy out of North Africa.

Wildcards. Another challenge for a vision with a long timescale is that numerous circumstantial, unforeseen events—which scenario planners call wildcards— occur in the visioning process that the media and skeptics can then use as evidence that the vision is not feasible. The actors must concretely design the vision within the region in order for it to be seen as feasible, but in doing so they expose numerous potential problems in a large and complex region. Random circumstances in the region therefore disrupted the vision's feasibility. For example, in February 2012, a Siemens executive was murdered in Cairo. Later that year, Siemens withdrew from the CSP business altogether, closing their CSP office in Germany and withdrawing from Dii as well. While its withdrawal was a reflection on the CSP sector as a whole and the fact that Siemens expects a higher return on its investment than smaller, less reputable companies would, this reflected poorly on Dii and the vision as a whole. In another example of a wildcard, in January 2013, a bloody hostage crisis at a BP natural gas plant in the Algerian Sahara made headlines throughout Europe. Dii issued a statement emphasizing how important it would be for their work to continue. In third example, in 2011, Turkey threatened to withhold electricity and water exports from Syria because of the government's harsh repression of protestors, illustrating that electricity could be withheld for political reasons.[104] Dii responded to these events by stating that instability in the region increased the importance and urgency of their work.

In 2010-2011 uprisings in Tunisia and Egypt spread across the region in what has been called the Arab Spring, which also disrupted the vision's feasibility. On March 4, 2011 and on March 23, 2011, Dii released statements emphasizing the importance of continuing their work despite and because of the Arab Spring. Their 2011 promotional brochure stated,

> political transitions in North Africa and Middle East plus a worldwide reevaluation of our energy supply give greater *urgency* to the questions of where are the large-scale sustainable energy resources of the future (emphasis added).

Here they use temporal techniques to suggest that the vision should be accelerated rather than slowed by the tumultuous events in the region.

Dii attempted to reframe the Arab Spring as a social justification for the vision. They suggested that the countries that are becoming more democratic are those interested in large-scale wind and solar and that the Desertec vision will have positive socioeconomic effects and therefore contribute to overall political stability. (In Chapter 3, I illustrated that CSP took hold in Spain during its transition to democracy. CSP often gains traction during crises.) Dii presented the vision as a solution to political instability by giving people local value added through the energy industry to improve quality of life.

[104] See also Chapter 4.

Michael Köhler, head of the cabinet for EU Energy Commissioner Oettinger, articulated this view,

> we will pursue this because our objective— even more so after the Arab Spring— is to create a shared zone, not only of democracy, but of shared prosperity in the Mediterranean between Europe and the Mediterranean, and we see energy cooperation as one of the key elements in this regard.

Dii demonstrated its commitment to the region by hosting its conference in Cairo after the January 2011 revolution. The conference was held just a week before another wave of massive street protests in November 2011 in Tahrir Square, which called for an end to military rule. In one protest, mobs stormed the Semiramis Intercontinental Hotel in Tahrir Square where the conference had been held, and the staff had to beat them back with pots and pans (Lynch, 2013). Simultaneously, money poured into Egypt for development, which the Desertec Foundation termed the green Marshall Plan. Egypt did not have the robust private sector to absorb this funding, which increased interest in foreign investment there. Despite the turmoil, Dii saw the possibility of playing a central role in the transition toward liberal democracy in the MENA region. However, the Arab Spring disrupted the search for a pilot project for proof-of-concept as investors turned away from Egypt and focused on Morocco due to political stability.

Government instability is a significant risk factor for investors, and integrating the European grid with grids in unstable countries to increase grid stability to be a shaky proposition at best. The Arab Spring increased the perceived risk of project development in these countries due, in part, to unstable governments and regulatory environments. Solar investors see the biggest risks in investing in solar in MENA as: regulatory, political, and force majeure (including terrorism) (Komendantova, Patt, Barras, & Battaglini, 2012). Design I argued that risk relates to short-term policy decisions and wasting fossil fuels. In contrast, Design II framed risk based upon investor perception of risk in investment in North African countries. Even so, certain Dii investors renewed their confidence in North Africa. The CEO of Acwa Power said at the 2013 Dii conference “the proof is in the pudding. Our independent power producers in Egypt are still being paid regularly for supplying electricity in Egypt.” Shortly thereafter, the CEO of E.On Climate and Renewables (part of the German utility company E.On) exclaimed, to a round of applause, that he was not worried about the political situation in North Africa, he was worried about the political situation in Europe.

Energy security. As discussed in Chapter 4, countries in the region do not frame energy security congruently. Design I framed energy security as diversifying the energy portfolio, not as energy independence, because they viewed energy integration as advantageous for numerous reasons. One response to Desertec was that by 2050 Europe would become beholden to the sun kings of MENA, who could form a solar cartel and withhold electricity from Europe for political reasons. The Desertec Foundation countered that economic integration would provide sufficient incentive to prevent the political withholding of electricity, which conformed to the Foundation’s idea that there could be such a thing as global energy security. According to the FAQ on the Desertec Foundation website

> The big difference with regard to the dependency on fossil fuels lies here: Renewable power can be produced just as well in Europe, albeit at higher costs and requiring more input. It is hence in the interest of the power-exporting countries to offer an economical and reliable product; otherwise the demand would decrease and a drop in investments, export revenues and employment could be expected. In this sense, an energy cartel much like the model of OPEC tends to be self-destructive and makes little sense. Solar power that is not delivered is thus lost and may not be sold later at a higher price as with oil or gas.

This illustrates a key difference between electricity and oil markets i.e., electricity markets are highly temporally dependent. Generation that is withheld would be curtailed, or lost; it could not be stored and sold later on. Design II is a highly temporally dependent system, shaped by this energy security concern. However, countries are not entirely rational economic actors and could withhold electricity for political reasons despite the economic disadvantages.

Price of PV. Based on its technology neutral framing, Dii focused on scaling up the cheapest renewable energy technologies. In 2011, there was a surplus of PV panels on the global market due to Chinese industrial policy, which resulted in a dramatic price decrease, from 2 euros per watt to 50 cents per watt. PV is the only energy technology that achieves economies of scale from the size of factory production, rather than from building large power plants. Therefore, project developers, such as the Dii's founding shareholders, had little influence on this development. As one shareholder representative put it, "no one anticipated this." Another stated, "everybody said, oh we will get there with CSP because we can generate electricity for 17-20 hours [per day]…and during that time the price for PV modules just fell down. Wow!! This was an effect! And this changed the discussion in [sic] the group.” A representative from Dii also described this shift, which was magnified by PV companies joining Dii

> …Desertec, was actually CSP focused. So that definitely changed and this is of course also due to the fact that PV prices dropped dramatically, so PV became... much more attractive...than CSP on a relative basis. But also due to the fact that the PV companies who joined as associated partners started to lobby more for their interests. And what happened is that, for example, First Solar, managed to apply successfully for an upgrade to shareholder at the start of this year [2013]. So this has been also a milestone getting one of the leaders worldwide in photovoltaics on board as a shareholder.

Dii expressed that it cannot predict the future and know what the next technological breakthrough will be. Therefore, it focused not on energy innovation but on projects developed with the best available, most mature technology. The focus on PV, as well as wind energy reaching grid party, shaped Design II significantly.

Eurozone crisis. These European political challenges relate partly to the fact that Dii was founded just before the Eurozone crisis. When Dii was formed, European companies saw that MENA countries were experiencing 7-9% GDP growth per year, plus skyrocketing energy demand, while Europe’s economy was stagnating. They had surplus capital to spend, and North Africa appeared to be an attractive place. After 2011, Dii had a difficult time recruiting new partners and lost members as companies like Siemens fled the solar power sector during the economic crisis. European economic development no longer appeared to reflect linear progress. For instance, in 2013, the Moroccan GDP gained 5%, while the Spanish GDP lost 5%. Electricity demand grew rapidly in Morocco while falling short of projections in Spain. As such, the presumed mismatch in demand between the load centers in Europe and the empty deserts of North Africa was in fact reversed. This left the vision in turmoil, as it became even clearer that exporting electricity to Europe would be possible only in the distant future. In the short term, Europe might export to North Africa, rather than the reverse, just as Spain currently exports to Morocco.

Design II: The Integration Miracle

In its first report, *Desert Power 2050*, published in 2011, Dii (and its contractor the Fraunhofer Institute for Systems and Innovation Research) depicted not only a fully interconnected grid for EU-MENA but also a single regional electricity market. They designed the system to prioritize the lowest cost electricity, which was the most highly valued trait of the system in Design II, to supply the commodity of "desert power." The system design no longer prioritized dispatchable electricity from CSP, rather it sought to address the intermittency of renewable energy through "the integration miracle," in which massive systems integration would complement peak loads in different parts of the region allowing electrons to flow where they are needed, when they are needed.[105]

In this integrated power market, Dii imagined three categories of countries: super producers (e.g., Morocco and Norway), whose renewable energy resources far outstrip demand, leaving electricity available for export; importers (e.g., Germany and Turkey), whose renewable energy resources are smaller than demand requiring imports; and balancers, whose resources and demand are well matched (e.g., Saudi Arabia and Egypt). Surplus solar electricity produced in Morocco in the middle of the day when North African demand is low could be sent to power Europe's industrial center, while surplus wind in Spain could cover Morocco's peak demand from 6-9:00pm. People in the Mediterranean power sector sometimes referred to this envisioned transmission system a "copper plate," because copper is an excellent conductor, and electrical charge is instantly available on any part of a copper plate.

Cost. Since a private industrial consortium had taken over the vision, its first priority became cost and creating a pipeline of renewable energy projects on which the shareholder companies could bid. Dii based Design II on a cost optimization model. A DLR expert stated that Dii's study was "driven by the question whether the economy under the right boundary conditions may find the best solution by itself," rather than Design I's "heuristic" approach of integrating fluctuating capacity with baseload power and finding the best place to site transmission cables. While Design I focused on demonstrating that renewable energy export is a feasible option, Design II focused on deploying the cheapest renewable energy possible and integrating markets to allow

[105] This is a similar discourse to natural gas integration, described in Chapter 4.

electricity to flow based on market logic. Dii argued that an integrated EU-MENA power system would be worth more than the sum of the two parts, because the interconnected system would supply cheaper renewable electricity than the two separated systems.

Markets, HVDC & Neocolonialism. Design II used the same transmission line technology as Design I—HVDC—but Design II imagined a single electricity market in MENA, rather than transmission corridors that would take electricity from a power plant in the Sahara acting as a virtual power plant for Germany to the north. This reflected Dii's private industry neoliberal view on power markets. It also indirectly addressed the neocolonial critique because it would avoid a situation in which a country would export electricity to Europe when it could not meet its domestic demand. Instead of focusing on exports to meet a missing piece of the European system, it focused on building a fully integrated reliable, affordable, and renewable electricity system for the entire region.

Dispatchability & technology neutrality. The key challenge in managing electrical power systems is to ensure that generation matches the load curve (or, rather, meets demand), and renewable energy makes this more challenging.[106] Due to an increase in fluctuating renewable energy production in Europe, the part of demand covered by constantly running power plants (baseload power) is decreasing. Again, this illustrates how important a system-level view is for scaling up renewable energy. Dii's identity as a technology neutral, private industry consortium shaped the energy mix in the system, as well as the system properties. Dii system imaginers prioritized low cost renewable energy and systems integration but were ambivalent about which renewable energy technologies should be used to meet these goals. A Dii shareholder interviewee from ABB explained

[106] See also the electricity primer in Chapter 1.

that CSP offers the benefit of dispatchability, but although dispatchability is a system benefit, there is not a sufficient market for it in many cases. Furthermore, even though CSP's thermal storage is cheaper than electrical storage from distributed PV, it is still an additional cost compared to having no storage at all. The economic optimization model for Design II suggested that it is cheaper to have excess capacity in the system to meet demand than it is to store electricity. The model accounted for CSP's dispatchability, but wind and PV, which are not dispatchable, were the winning technologies of the report nevertheless. Wind power is the cheapest form of renewable energy, and the wind peaks in Northern Europe and North Africa are at complementary times of day. In Design II, Dii concluded that is it cheaper to deploy wind and PV in a regionally integrated system than to pay for storage from CSP. ABB was convinced that supply and demand could be effectively and reliably met in a regional power system like the one outlined in the *Desert Power 2050* report, even though it differs somewhat from today's electrical power system configuration.

At the 2013 Dii conference, a group of panelists argued that both baseload power and dispatchability were antiquated constructs. An official from MASEN questioned who would let the utility companies know that era of dispatchability is over. He bemoaned that thinking of backup, conventional power is "bringing us to the wall." One interviewee stated, "We have to change the idea of baseload power…night, no sun, or no wind…we just have to equalize those differences." In contrast, a manager from the Moroccan utility company at the Dii conference articulated the traditional view that the network is a public service that needs to provide 10% backup to ensure the security of system.

An expert from DLR argued that the vision's most important goal—which in Design I was not generating desert power but firm power on demand—was lost due to the shift to technology neutrality. It was clear to DLR that their design had undergone a profound shift from "firm power on demand to fluctuating supply for export." An interviewee pointed out that Spain currently has a surplus of electricity, while Morocco will not have a surplus for decades to come. So, according to him, trading surpluses of renewable energy among countries does not make sense and puts Dii "up against a wall." The head of the DLR feasibility studies for Design I stated, "At DLR, we opened the door with our studies. And since 2006 we are standing here and keeping the door open. And everybody's busy in running against the wall beside. Yeah. Nobody goes through that door."

The energy mix & technology neutrality. Dii's shift to technology neutrality, its focus on low cost, and its decreased focus on dispatchability led CSP to be framed as expensive and immature. The focus on desalination and integrated power plants for integrated solutions was excluded from Design II. Wind was the winning technology of the report, which was framed as mature, cheap, and less dependent upon geographical conditions. Also, it could be sited where there is not competition with value-added sectors. East-West interconnection would balance out solar power between day and night, while wind is complementary in north-south integration between North Africa and Europe.

PV was the second most important technology in Design II. The drop in the price of utility-scale PV was a wildcard in the vision's development. Design II framed PV as quickly scalable. Furthermore, since Design I had been developed, Germany had begun meeting part of the day peak demand with rooftop PV. This would have been the part of Europe's day peak met by CSP from MENA, where the peak load is in the evening. As one of the Dii shareholders explained,

> the German industry partners hoped [to give] CSP [a chance because of] baseload power. And there was a big discussion in Desertec if we needed baseload or if we needed peak. And since the European countries have day peak and not so much the evening peak like other countries in the Gulf or in the Mediterranean regions, a day peak would have helped a lot, just to shave the peaks and let's say benefit from ... cheap power…compared to the former German peak prices. They [the peak prices] disappeared anyway, but not because of Desertec; they disappeared because of the German-based renewables with wind and photovoltaics.

This is also quite different from what Design I proposed, which was not to shave the day peak but to provide something approximating baseload power. The quote illustrates that even subtle changes in the existing energy landscape affect designs for future systems; they are not developed a blank slate (or plate).

Sustainability. Dii conceived of sustainability in Design II as achieving the lowest system cost and reaching a 90% clean energy system, above Design I's 80% target. While the percentage of renewable energy would be higher, the lifecycle analysis approach from Design I was lost. There was no longer a focus on integrated solutions, and water was not discussed. The vision's paradigm shifted from limits to growth to no limits to what systems integration could provide. Integrated is beautiful, rather than small is beautiful. Dii framed extensive systems integration as more flexible and efficient than distributed energy systems, which were deemed to be out of the scope of the study. This represented a major shift away from the limits to growth framing and reflected Dii's narrower focus on developing a feasible system at the lowest cost possible.

Social benefits. The win-win framing was retained in Design II, but the foci on the ethics of integration for a crowded planet, development, and integrated solutions were lost. Dii saw the social benefit of Design II as threefold: "all countries benefit from access to affordable renewable energy, and reduced cost of decarbonization, all three types of countries benefit in a different way leading to mutual reliance, providing sustainable and affordable power for future generations." At the 2011 conference, Dii's CEO framed Europeans as "unlucky" to not have as much sun as MENA. By bridging continents and connecting people, Dii could create "win-win" situations. One Dii shareholder representative said that "the impact on the society is really perfect." An official from MASEN stated, "it won't happen unless it's a win-win."

The win-win framing refers to wins at a broad and abstract scale—national energy policy, security, regional stability, peace, and development—rather than referring to which social strata of the population would benefit. In my interviews I uncovered few predictions of the social impacts. Many stakeholders, perhaps contradictorily, saw the vision as a win-win but the social impacts as unknowable due to the uncertainty involved in planning over such lengthy timescales. (See Appendix A for a complete list of benefits and drawbacks identified by the interviewees). When I asked an official from MASEN who would lose from the vision, he stated

> there are [sic] no losers in this situation. When you [sic] implement the good conditions where everyone can find a situation where he is a winner, he will win something. So things uh – I, I don't answer this kind of – I don't have any answers for this kind of question [sic] but you make sure if you develop something all the region will gain in it and much more than perhaps anticipated.

This question also caught a Dii stakeholder representative, who had never considered whether there would be any losers from the Desertec vision, off guard. He had received a phone call from some Toureg people from the desert who wanted to be sure that Dii would not take their land for solar power. Many interviewees referenced losers in the private sector, such as the "old incumbents," including oil companies and state-run utility companies, but they qualified this by explaining that if these companies continue to be system imaginers and adapt they would not lose either. An executive I interviewed from BP indicated that they were not concerned about the security of demand for oil; even if the Desertec vision were developed there would be plenty of uses for oil and natural gas in the transportation sector. Generally, the interviews yielded few findings of projected social drawbacks, and system imaginers genuinely believed that the system would be a win-win or it would not be feasible.

Energy security and the solar cartel. Unlike in Design I, in which Europe would pay more to diversify its energy portfolio, Design II framed energy security partly as a matter of *cost* because the integrated system would be cheaper than separate EU and

MENA systems. The framing of energy security in Design II responded indirectly to public concerns discussed above that renewable energy exports could be withheld for political reasons or through a solar cartel. Security of supply was not seen as adding more fuel sources (as it was in Design I) but as increasing the number of countries that provide each country with electricity. No single exporter would provide more than 10% of Europe's electricity supply, which placed constraints on energy dependence. Coupled with this, the new role of fossil fuels in the system would be to provide 10% backup power for Europe as its "insurance policy," ensuring that if a country withheld electricity exports, Europe's grid would remain reliable. Security of supply would be achieved not through mutually assured destruction but through the "mutual reliance" provided by an interdependent system. They stated, "[The countries'] complementary roles lead to a situation of interdependence across the system, in which no single country is dependent on another but instead each country is reliant on the system as a whole." This quote illustrated that the countries themselves were not being envisioned as relying upon one another. Instead, the technological system itself would stand in as a proxy for collaboration, again substituting technological integration for political integration.[107]

Desert Power 2050 did not acknowledge that the distribution of super producers, importers, and balancers in the region would transform the geopolitics of energy production in the MENA region. Egypt and Saudi Arabia would become balancing countries rather than fossil fuel exporters. These countries would benefit from tariffs on electricity funneled through their countries, but they would not control the major electricity generation resources for the region. Oil-poor countries, including Morocco,

[107] See Chapter 4 for a discussion on political vs. technological integration.

would become super producers of renewable energy and the most important exporters in the system. This discussion is continued in Chapter 6 by exploring Morocco's views on energy security and integration.

Temporality and modernity. A key difference between Design I and Design II is that Design II would be highly temporally dependent, providing evidence related to the temporal significance of energy transformations discussed in Chapter 1. The copper plate would be based on the concept of "perfect foresight." Generating electricity essentially would become a matter of predicting the weather, as daily and seasonal variations in climate change that would affect both electricity generation and demand must be predicted to the minute with perfect foresight in order for the system to be reliable. Design II envisioned using the natural advantages of particular areas rich in natural resources to outweigh the natural disadvantages of variations in weather and climate. The copper plate design would attempt to flatten out the rhythmicity of nature and the vulnerability posed by the seasons through massive systems integration. Although it is a climate change mitigation project, it verges on being a geoengineering project in its scope (see the Atlantropa project in Chapter 3, which was also geoengineering project for the Mediterranean).

I argued in the introduction that the modernity of an energy system relates more to its system configuration, and how the system configuration controls time, than to novel technologies. Controlling time was an important project of the Enlightenment (Adam, 1998). During the second Industrial Revolution, technologies further changed people's perceptions of time and space. The natural rhythm of time, what Adam (1998) called *natura naturata*, became obsolete, and system builders "re-creat[ed] the variable rhythmic times of life in uniform, invariable decontextualized, quantifiable form...the control of time is extended to the seasonable rhythmicity of nature" (p. 68-69). For example, electricity systems allowed people to stay up later reading, to travel to amusement parks, and to commute via street car (Nye, 1990). The relatively high speeds of transcontinental rail led peoples' perception of the size of the United States to shrink (Allenby, 2012). As the United States industrialized, "no longer would solar energy and animal physiology set limits to human movement across the landscape" (Cronon 1991, Kindle loc. 1825). In the 21st century, system imaginers are seeking to integrate *natura naturata* into the centralized system configuration to allow for high penetration of intermittent renewable energy. Renewable energy then becomes a matter of how electrical power systems can control time—not through changing social patterns but by leaving the centralized system in place while compensating for the intermittency of wind and solar cycles in the system design. Design II is in this sense the ultimate modern project in how it controls time. Chapter 6 will compare this to the Moroccan view of time past and time present balanced in a modern electricity system.

Design III: Virtual Exports

The German utility company and Dii shareholder company, RWE, developed Design III in 2012. Design III did not replace Design II but instead provided an alternative. RWE proposed building a virtual exports system since the physical transmission infrastructure was limited and additional lines were difficult to site. This program—RWE Desert Power— would allow German consumers to opt into a surcharge on their electricity bill used to finance clean energy projects in North Africa. RWE is pursuing an initial large-scale wind and PV project in Morocco as part of Design III. They announced the project at the Dii conference in Berlin in 2012. Accusations were later made in the media that RWE was trying to "hijack the vision," which they vehemently denied, saying the project would provide a blueprint for Moroccan project development they would share with all Dii shareholders.

Design III reflected a broader trend in liberalized electricity markets that Graham (2000) called "infrastructural consumerism," providing consumers with choices for "tailored infrastructure services within internationalizing niche markets" (ibid, p. 192). In this market-based design, the focus on integrated solutions and the benefits stemming from technological integration were largely lost as the HVDC grid that would provide connectivity, stability, and reliability would not be developed. Sustainability in this design related only to carbon mitigation, not lifecycle analysis or the triple bottom line.

Design III would not require a temporally dependent, complex system-level reorganization of the Mediterranean electricity system. Therefore, RWE framed it as more feasible than Design II. However, Design III could impede the system-level scale-up of renewable energy if it created a niche consumer market rather than an infrastructural shift. For example, Moroccan government officials believe virtual exports would limit the future possibility for real exports.[108] It would also be dependent upon a high price for carbon dioxide.

[108] See Chapter 6.

Design III reflects the theme from Chapter 4 about technological integration and immigration politics in the Mediterranean region. The principles upon which the Desertec vision was rooted were the integration goals. Would there be cultural integration benefits without physical integration? For the average German consumer of desert power, or the average Moroccan renewable energy construction worker, could Design III provide an opportunity for cultural exchange? If electrons do not flow across borders, would people flow across borders to understand more about where their virtual electricity comes from? Some stakeholders suggested that the vision would be more socially just if citizens, instead of corporations, funded the power plants. In Margaret Heckel's book, *Desertec: Energy for Everybody,* which is a journalist account of the Desertec vision's history, a fictional character named Anna traveled to North Africa to see the power plant she funds.

> [Anna] owns enough mirrors of a power plant in Tunisia to supply her with all of the energy she uses. So she has an idea: Why not use the money to make a trip with her friends to see the solar power plant? As with all plants with a Desertec label, the people that built it were very keen to ensure that the local population benefited as much as possible from it. Anna knows that nearby her plant there are schools, which train technicians for installing the mirrors and even a small university with different programs. So why not go and look for herself how the power is generated in the desert? It's a cool idea– a trip to see where your power supply is generated. She dashes off an email to the Desertec Foundation 'A group of us is on our way to visit the solar plant in Tunisia. We love the idea of

community-financed Desertec power plants. What do we have to do to make more of them happen?’

Heckel imagined that energy integration would spur interest in cultural integration and exchange. But would Anna’s voyage represent green tourism or cultural voyeurism? Design III could become a means of marketing exotic electrons for export. During the colonial period, all imported goods in Germany were called “colonial goods.” They were marketed with Orientalist imagery that emphasized their exoticism (see *Figure* ***37***). The Design III picture does not exoticize North Africans, but it does omit them from the landscape by portraying a sandy, empty desert (see *Figure* ***38***). Would Design III be a means of “conquering quality of life,” as Piccard put it,[109] or improving quality of life through technological development and the negotiation of north-south differences? I argued in Chapter 4 that global energy security based upon energy equity holds higher standards than energy equality, including a just process for recognizing and engaging local populations in the development of the energy system. The local population should be seen as true participants and collaborators in the energy system rather than the exotic other. What would the role of citizens be in a system with global energy security? As with issues of neocolonialism and xenophobia, the design of the system would not yet cement particular justice outcomes. It would be dependent upon the procedural justice of the political process pursued, the goals of the stakeholders, and even the attitudes of citizens.

---

[109] See Chapter 4.

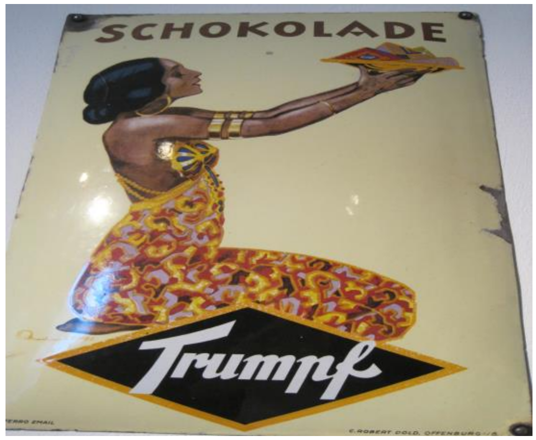


Figure 37. Advertising for Imported Chocolate during the Colonial Era. German Chocolate Museum, Koln, Photo by Author. Used with Permission.


Figure 38. RWE Desert Power Design. Source: Vorweg Gehen[110]

[110] http://www.rwe.com/web/cms/en/364512/rwe/innovation/projects-technologies/renewables/desert-power/

Table 4.

Comparison of the Three Designs

Property/ Technology	**Design I: A System for Integrated Solutions on a Crowded Planet**	**Design II: The Integration Miracle**	**Design III: Virtual Exports**
Technology advocacy/ neutrality	Technology advocacy, but based upon system properties	Technology neutral	Technology neutral
CSP technology	Mature, dispatchable, multipurpose, desalination	Expensive, immature	Focused on building the cheapest renewables e.g., PV, wind
PV	Expensive, fluctuating	Cheap and scalable	Cheap and scalable
Wind	Expensive, fluctuating	Cheapest RE technology	Cheapest RE technology
Fossil fuels	Reliable, mature technologies, provide peak power	Volatile. Limited natural gas needed for security/ backup.	Fossil fuels as carbon emitters.
Percentage renewables	80% RE future	90% RE future	Renewable energy as a niche market
Transmission system	Single HVDC corridor lines: efficient, safe, stable, redundant, connective, invisible for Europe.	HVDC supergrid. More focused on the market than the individual transmission lines. Full integration.	Market based, no transmission
Market	Separate electricity markets	Integrated Mediterranean electricity market	Market for carbon, rather than electricity
System services	Power for Europe (and some for MENA), water for MENA, peace for Gaza	Cheap electricity for all	Electricity for MENA, carbon credits for Europe
Export type	Firm power on demand	"Desert power". Fluctuating supply for export	Virtual. Carbon credits.
Sustainability	Triple bottom line (affordability, compatibility, security), using the least materials possible	Least cost possible, carbon mitigation	Carbon mitigation
Cost	Not the first priority, will pay more for an important system service. The focus is on overall affordability.	Cost optimization is the first priority	Cost as shouldered by wealthy consumers in Germany
Social benefits	Win-win. Expanding premium networked spaces, energy interdependence, Europe should help its neighbors develop	Win-win. Cheap renewable energy, mutual reliance, sustainable/ affordable power for future generations	Carbon credits for Europe, renewable energy development in MENA.
Modern energy system imaginary	A modern energy system is based on energy farming	A modern energy system controls natural variation to provide an almost 100% renewable energy future	A modern energy system is one based on market liberalization
Energy security	Security is the number of fuel sources in the portfolio, plus network stability	Low cost, limited dependency on single exporter (mutual reliance)	Does away with physical integration and its risks
Paradigm	Limits to growth	Technological optimism (integration miracle)	Neoliberalism
Demonstration of feasibility	Reference cable	Reference project	Reference project, high carbon price

Summary: The Evolution of a Vision and Design

Above, I described the evolution and negotiation of the Desertec vision and its design over eight years (summarized in Table 4). Design I—developed by a government-funded research organization—proposed to build an HVDC grid in the EU-MENA region, keeping each country's electricity market separate while sourcing dispatchable power from CSP from the deserts of North Africa for Europe. The system imaginers were advocates of CSP but within the context of its system benefits and contributions to addressing integrated challenges like the energy-water nexus. In Design I, energy security referred to the diversification of the number of fuel sources in the portfolio. Following the release of Design I, the constellation of actors advocating for it changed, most significantly through the institutionalization of the vision, with the founding of Dii and the Desertec Foundation. Dii's multiple personalities, through which it constructed its credibility, shaped the vision and its design. Other factors that shaped the design included temporal tactics to frame the future as inevitable and proximal; public responses like concerns of neocolonialism; concerns that exporters in the south of the Mediterranean would form a solar cartel; and wildcards such as the Arab Spring, the fall of PV prices, and the Eurozone crisis.

Dii's complexity and multiple identities shaped Design II by developing a market-based approach that reflected the goals of the private companies and a technology neutral approach that prioritized low system cost but did not advocate for particular technologies. Design II, the integration miracle, presented a design for a fully integrated electricity grid and market for EU-MENA that prioritized low system cost as the most important system property. Dii addressed public concerns about a solar cartel by framing energy security as a 10% import cap for Europe from any other single country plus 10% natural gas backup generation. Furthermore, since the price of PV and wind had dropped significantly in the interim, and Dii adopted a technology neutral identity, PV and wind were framed as mature and were the winning technologies of the report. Dispatchability was no longer highly valued as a system trait. Instead, the system would be highly dependent upon natural temporal cycles—the weather, seasonal variation, and solar and wind fluctuations. Because Dii's framing of sustainability was based on low cost and high renewable energy penetration, rather than limits to growth, it was willing to build excess generating capacity into the grid in order to balance the system because this was cheaper than paying for dispatchability and storage. Design II would result in a more radical shift in the system, in which the load curve would be met in novel, highly temporally dependent ways, and a centralized system manager would likely be needed to direct the flow of power on the transmission lines (described below).

Design II also addressed concerns about neocolonialism by proposing a fully integrated electricity market based on mutual reliance that would not import electricity from a country that could not meet its domestic needs. However, a proponent of Design I argued that Design I actually had a lower risk of colonialism and injustice.

> But [Design II] ended in colonialism…. Here you have Morocco, here you have Germany. Now. Our concept, you build a solar power plant here and connect it to an HVDC line, and you send this electricity here where it is needed on demand and fills a [sic] gap in the grid. This is like moving this plant virtually to that point and operating it there. That's our concept. The other concept is, you have power

plants here [in North Africa], and you connect the grid the Moroccan grid via supergrid-- I don't know how it works but it's a supergrid-- to [the] German supergrid and any fluctuations here, any surpluses, they go to Germany or they go through Spain and France to Germany and backwards. Jah. And now imagine that there is some— I don't know in Europe there is some failure, they need badly energy. What will they do? They will suck energy and the lights will go out in Morocco. Because when they suck, they suck strongly. So if the grids are connected, those who win have more power or more money to pay. They say oh we [will] pay 2 euro per kilowatt-hour because all our industry before it shuts down, we [will] pay anything. The Moroccans say 'oops!' And the lights go out in Morocco, if there's some failure. So the infrastructure here to cover the load in Morocco must be completely separated from the infrastructure in Morocco. Completely separated. And then there is no risk of this type of colonialism. There's no risk [that] the Moroccans will have some damage because the Germans need electricity.

In this conception, keeping the electricity markets separate bears less risk of unjust outcomes. The interviewee also argued that the Dii system would require increasing power systems infrastructure in the Mediterranean by five to ten times by focusing on surplus power instead of dispatchability and storage. One goal of Design I was to design the infrastructure to minimize natural resource use, in order to comply with the *Limits to Growth* philosophy and ensure the project was sustainable economically, ecologically, and socially. This was excluded from Design II. Focusing almost exclusively on low cost led to other problems, such water usage, which will be addressed in Chapter 7.

After the controversy surrounding building a transmission line through Spain, which will be described below, a third alternative emerged for virtual exports of desert power based on carbon credits. Many of the societal goals for the vision were lost without the technological integration approach, although it could still offer the benefits of carbon dioxide mitigation, development for MENA, and cultural exchange through citizen-funded power plants. None of these benefits would be achieved automatically, which is one reason to utilize the energy justice framework presented in Chapter 8.

A Dream Deferred Across Scales: The Politics of Proof-of-Concept

> *"The idea to harvest the energy from the deserts has been around for decades in one form or another- a fantastic idea. In fact, so fantastic that the chances of this idea being realized must surely be zero. Implementing a system that supplies whole continents with renewable energy from deserts would require an extreme amount of commitment and intelligence by an unusually large number of stakeholders, by governments, by industries, by NGOs, by scientists, and by private citizens.*
>
> *– Aglaia Wieland, Former Managing Director, Dii conference 2012*

In the quote above, Wieland pointed out the vision's long history and the complex stakeholder cooperation that would be required to achieve the vision. Bertrand Piccard suggested that Desertec is a deferred dream that can be achieved through some human power and shedding assumptions that hold the system imaginers back. A dream can be deferred as it goes back and forth across phases— imagined, envisioned, designed, and constructed. Networks of powerful actors would provide the momentum to propel the vision to the next stage in which it would be instantiated in power generation and transmission across continents. Means of proving feasibility can move the vision back and forth on the scale from imagined to constructed. However, as energy technologies were enrolled in the quest to "conquer" quality of life (as Piccard suggested), and to shape technological change with ethical precepts and societal goals, it became clear how different the goals and values were not only of actors across the Mediterranean but also of the stakeholders advocating for vision themselves.

The networks advocating for this vision are too diffuse to propel it forward successfully. Hughes (1986), after writing *Networks of Power,* advocated that scholars of technology and society use a network-based approach to eliminate categories and explore networks, or "seamless webs" among science, technology, and institutions. The networks working on electrical power systems integration in the diverse Mediterranean region hardly form a seamless web but rather a disjointed and at times conflicting jumble. Even the actors that worked on Desertec, as well as MedRing, the Mediterranean Solar Plan, Medgrid, and other versions of the vision, were pulled apart by centrifugal forces. This prevented electrons from flowing effortlessly across borders.

As discussed in Chapter 1, Winner (1980) argued that artifacts have politics. In the visioning phase, it is not yet apparent what politics the system will have as it moves from imagined to constructed. For example, I argued that the Desertec vision is not intrinsically xenophobic, neocolonial, or Orientalist. It will depend upon how the process plays out. The politics of a system are shaped in the visioning and design process but not yet cemented. However, in order to move to the next step, some agreement is needed about which principles to drop as ballast and which to retain. The challenge for the Desertec vision outlined in the rest of the chapter is that Desertec proponents do not agree on the "old certitudes" that should be shed or retained in order to achieve proof-of-concept, or even the appropriate method of proof-of-concept.

Proof-of-concept. Three methods of proving feasibility emerged during the design phase: 1) developing a better regulatory framework and policies to support the eventual development of the system 2) building the first reference transmission line between Europe and North Africa to prove that exports can be achieved 3) building a reference project, most likely a CSP plant in North Africa with the Desertec brand. These steps attempt to move from a system design to a constructed reality in the desert. The actors contested which method would be best and how quickly it could be achieved. When these steps failed, it pushed the vision back to the imagination stage and the very principles (the old certitudes) upon which it rested were called into question.

The first—and least developed—option for proving feasibility was to have Dii develop and advocate for a better political and regulatory framework. A Desertec founder described the institutional role of Dii as leveling the playing field for renewable energy by helping to develop regulations that would allow everyone to benefit from renewable energy. However, since some shareholder companies were interested in bidding on a pipeline of projects, the regulatory goals were overshadowed by the quest for a pilot project. Furthermore, Dii had the least success with the political framework working group due to the political complexity of the copper plate (described later).

Design I advocated for using a reference cable, rather than a reference project, to demonstrate the feasibility of exports. In 2013, DLR released a study that described building a 1,000 MW CSP plant near Marrakech, Morocco and an HVDC line to Germany, operating the plant as a virtual baseload power plant in the German electricity system (see *Figure **39***). They compared the cost between siting the power line underneath the Mediterranean versus siting it through Spain and France. They found that it would be comparable due to the cost of compensating landowners if the line were built through the countries. In some sense, DLR was again recommending developing a reference cable for proof-of-concept, as the first of the 20 lines proposed in Design I.

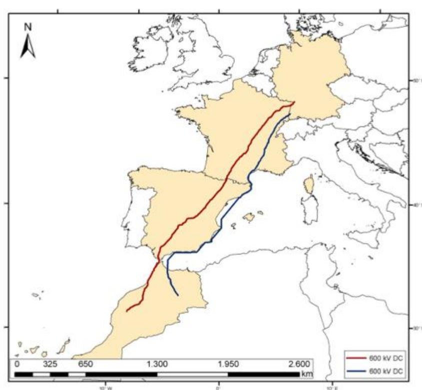


Figure 39. A Power Plant in Marrakech Connected to the German Grid. Credit: German Aerospace Center (DLR)[111]

[111] Fernübertragung regelbarer Solarenergie von Nordafrika nach Mitteleuropa

Dii—as well as RWE— pursued a reference project as proof-of-concept because many of their shareholders were project developers. They changed the framing of Desertec to match this method of proof-of-concept. They tweeted, "Desertec is not a $500bn project. It's rather lots of projects in the region." A 2011 conference pamphlet stated, "Desertec is a vision: an overall concept rather than one centralized, stand-alone project." They emphasized that while there was a big picture they would take small steps to achieve it. A Mediterranean electricity systems expert stated,

> So there's more a transparent approach—showing options is what we do and then I mean in the end… the goal is to get a good market environment, such that the market can do its best job. And then this should give us the most efficient, least costly road toward a sustainable energy system and that's how it should work because, I mean…centrally planning the electricity system for this region or for any region this size is a bit of a crazy idea.

This focuses on building the system through a piecemeal approach—taking Robert Shuman-like concrete steps[112] through individual projects to slowly grow an EU-MENA region and its power system.

I found in my interviews following the release of the 2013 DLR study that many people perceived Design II and its reference project to be more feasible than a transmission corridor for proof-of-concept. An official from BWMi stated,

[112] See Chapter 4.

I don’t think it’s very likely that we [will] have a direct HVDC connection from Morocco to Germany. I think that’s rather, let’s say, visionary and, well, maybe in 50 years or so, but I don’t think that’s very realistic. What might be, what is realistic I think is that interconnections within Europe but also to the Mediterranean partner countries in Northern Africa will be expanded.

A Moroccan energy expert echoed this stating,

And [DLR] made some proposals but they are kind of very, they're not very realistic at the moment. I don't want to say that they are not realistic at all but they now today it's kind of on the long term— in the longer view you can say…all the consumers are paying a little bit for having kind of this project- why not? But today … also the line which is going through Spain, I mean still you have to resolve this problem and the line, the underwater line, this costs [a lot.]”

In 2014, Dii released a statement entitled “Europeans do not understand Desertec,” which emphasized that they do not view single cross-continental transmission corridors as feasible. They stated

Many people believed it [Desertec] was all about a couple of huge power plants in North Africa with a big exclusive power line to Europe. This will ultimately not happen and makes absolutely no sense. And it was not the main point. The people and the local industry North Africa and the Middle East need the electricity.

> Egypt, for example, is experiencing a sevenfold increase in electricity demand over the next 35 years. Of course, the MENA region and Europe will both benefit from interconnections in the middle and long term. But many people in Europe are thinking mainly in European or national categories (Schwarz, 2014).

Dii reiterated that they are interested in the copper plate model instead of single lines but also that their vision is not for a single project but a series of steps taken over a long timescale. This piecemeal approach, which downplayed the overall system transformation required, came to be constructed as more feasible and less neocolonial than the export of firm power on demand. DLR still views their design as more feasible because it reflects known methods of electricity systems management and avoids integrating the electricity markets of developing countries with those of wealthier countries. Both the reference cable method of proof-of-concept and the reference project model butted up against political challenges described below.

The Politics of the Copper Plate

In order for the copper plate to function, the flow of electrons across borders must not be impeded by politics. Dii's third annual conference in November 2012 was supposed to convene diplomats from Morocco, Spain, France, Italy, Malta, and Luxembourg to sign an MOU with Germany for the first Desertec cooperation project between EU member states and Morocco. This would have facilitated proof-of-concept from both a regulatory standpoint and a reference cable standpoint. However, Spain failed to show up, and the negotiations crumbled.

Spain did not provide a public reason for not signing, but the reasons can be inferred. First, Spain accepted Article 9, which allows European countries to meet their carbon dioxide reduction targets based on renewable electricity imports from countries outside of the EU, during a different time period. Following the economic crisis, youth employment reached 50%. Renewable energy subsides have become politically unpopular, with the feed-in tariff dubbed the feed-in debt. Furthermore, tensions between Spain and Germany grew during the Eurozone crisis. Interviewees in Spain expressed that Germany was throwing around its money and power, neglecting other Eurozone countries' needs. Some Spaniards suspected that the Germans would be willing to break the Spanish grid by allowing Moroccan green electrons to languish there while Germany took credit for the carbon reductions. Second, Spain has had a surplus of electricity since demand dwindled during the economic crisis, and Spain's utilization of its power plants is only at 50%. There is significant curtailment of electricity from wind, as it is easier to shut off than nuclear and coal-fired power plants. Therefore, it does not make sense for Spain to import electricity, especially if it is more expensive than their domestic price. Again, this illustrates the complex and changing sociopolitical and sociotechnical context in which the Desertec system would be built.

Even if the copper plate is technologically achievable, the Spanish example shows that social and political resistance cannot be diffused through it. French historian Braudel conceived of the Mediterranean as a sea in between mountains. Spain does not want to be seen as African or for Morocco to be seen as European. Slavin (2001) stated "cultural trends had extirpated Spain's Moorish legacy to assert her Europeanness and repudiate the adage that 'Africa begins at the Pyrenees'" (p. 90). Spain does not want the Strait of Gibraltar to become a passageway for electrons any more than Spain wants it to become a passageway for people.[113] The flat copper plate would attempt to erase Braudel's mountains, but the Pyrenees Mountains are a major social and geographic obstacle to electrons flowing across the border between Spain and France. Transmission across the Pyrenees Mountains on the imagined future superhighway of electricity is the most congested in Europe. Here, Europe must confront the siting problems it attempted to avoid by siting its energy generation in Africa. There is an existing 1,200 MW (1.2 GW) capacity connection, and a new double circuit high voltage 400 kV line to increase the capacity to 2.7 GW was proposed as early as the 1980s, and again in 2003. But activists protested it due to concerns about the construction noise, the environmental impacts on sensitive regions, and possible disruption to a hot spring that attracts tourists (Ciupuliga & Cuppen, 2013). Spain currently imports more electricity from France than it exports, because prices are typically lower there. The Pyrenees Mountains are effectively a bottleneck of the sun, as electrons cannot flow freely across them. The copper plate is envisioned to even out both fluctuations of time and space through a massive centralized grid. However, the copper plate design reached a discontinuity when conflicts in the Pyrenees Mountains disrupted the potential for the flow of power.

When Spain failed to sign, people doubted the feasibility of Design II, and the Desertec vision shifted back toward the dreaming stage. Representatives from the Spanish TSO Red Eléctrica spoke derisively of the copper plate design:

[113] See Chapter 4 on immigration.

> We're shareholders of Desertec and Medgrid. We try to introduce the concept of export from North Africa. But really we consider that in the peninsula in Spain we already have enough resources for renewables…Desertec, the copper plate, is a dream. (not verbatim)

A Spanish energy analyst stated, "Exports are science fiction now." Such perceptions disrupted the framing of the copper plate as feasible. It therefore shifted back to the dreaming phase rather than being viewed as a tenable technological design.

For Red Eléctrica, the vision's feasibility is dependent upon building reference projects in North Africa. An interviewee expressed that if the Maghreb builds significant renewable energy capacity, then Red Eléctrica will build a new transmission line; furthermore, the problem is not between Morocco and Spain but in closing the transmission ring among Algeria, Libya, and Egypt. An interviewee from Red Eléctrica stated, "we'll wait to build the grid infrastructure until it becomes apparent that we'll need it." A European grid expert stated "you are in a real chicken or egg problem…because without transmission no one would invest and without anybody intending to invest, nobody would start to build transmission." System integration proponents argue that it is too difficult to secure private investment for the power plants if the line to the market does not exist. In contrast, Red Eléctrica views that the project's feasibility lies in successfully building the renewable energy capacity in North Africa.

Those advocating for the vision attempted to shift it back toward groundbreaking by securing a Spanish perception of a win-win. An official from a development bank said, “So, you know, we're trying to seduce them— what can I say.” An official from the German government stated “we are trying to get Spain in the boat…so Spain sees itself as more of a winner in the whole project.” It is not yet clear if Spain could be convinced, but it seems unlikely in the near future.

The political aspects of this conflict illustrate the myriad challenges of using technology as the glue of political integration and cooperation. The substitutability of technological integration for political integration[114] was called into question as electrons failed to move without friction across nation-state borders. The copper plate design steamrolls geographic and sociopolitical differences in the diverse EU-MENA region. However, Europe itself is neither geographically nor culturally flat, and its construction is incomplete. Even Spain itself is not coherently integrated. For example, during my fieldwork in Spain, I witnessed Catalan protestors take to the streets of Barcelona, demanding separation from Spain. Furthermore, Europe’s neighbors have struggled to become more interconnected to the EU. Morocco’s EU membership bid was rejected, and Turkey is undergoing a lengthy process to join. Deserts are not empty borderless zones connected to a Mediterranean hub (as described in Chapter 4) but complex sociopolitical landscapes.

Old certitudes and internal conflicts. The actors advocating for the vision were not internally in agreement either. After the issue with Spain and the numerous forces and processes that disrupted and shaped the vision’s design described above, the values on which the Desertec vision was based were called into question. In early July of 2013, the Desertec Foundation announced that it would no longer be a shareholder of Dii and that

---

[114] See Chapter 4.

Dii was no longer allowed to use the Desertec brand name. The "internal intrigue" of Dii, as one of its consultants termed it, came to a head. A week before, the German media had reported on a dispute between the two directors in which Aglaia Wieland wanted to pursue a reference project for export and Paul van Son wanted to pursue renewable energy to meet North Africa's growing energy needs. The Desertec Foundation announced that such disputes between experts should occur only behind closed doors and that mismanagement was damaging the Desertec brand. After all, Dii based its identity partly on being a trusted advisor. Dii countered that the dispute had been a misunderstanding and that there was no difference in strategy. The chairman of the shareholder board from RWE recommended Dr. Wieland should be fired for stirring up media controversy, and the board agreed. Some people internal to Dii suggested that this was simply a power struggle—that the co-director of Dii, who was often the silent counterpart in the media, was attempting to stage a coup against Mr. van Son. She was unpopular with some people close to the organization, who suggested the entire dispute between the directors and between Dii and the Desertec Foundation was simply due to personality conflicts.

An interviewee from the Desertec Foundation thought that the conflict partly related to differing NGO and private sector viewpoints. Several Dii shareholder representatives valued interacting with an NGO to better understand how it thinks and operates. Other Dii shareholder companies did not see the need to create two "clubs" in the first place, but Desertec's founders wanted to ensure that their brand was sheltered somewhat from corporate interests. The relationship between the two organizations has long been rocky, with the Desertec Foundation expecting funding from Dii while Dii has been reluctant to give it. The founder of the Desertec vision explained that a problem of instrumental rationality had developed in which the organizations that were founded to achieve a particular purpose had shifted their purpose to securing the organization itself. One's former allies gradually become competitors under this scenario. In the transition from the vision, to proof-of-concept, to construction, it became clear the actors did not agree on how to prove that the vision is feasible, nor did they agree on the initial premises—what were they trying to prove in the first place?

If realizing a dream requires dropping ballast in the form of old certitudes and deep paradigms, and these are not agreed upon, it will be difficult to propel the vision from a dream to a constructed power plant in the desert or reference cable across the Mediterranean. The Desertec Foundation reified the Desertec brand as an object that could be transported to a different region or stamped on a power plant. Later on, the stakeholders questioned what values this brand was based upon. Would it matter if a reference project were branded as "Desertec I"? The Foundation said that the Desertec brand is simply the concept that renewable energy from deserts can be transported to power any region of the globe. However, the Desertec Foundation is also developing a set of normative sustainability criteria for certifying power plants stamped with the Desertec brand. In Anna's trip to Tunisia, the reader is told that the Desertec brand on the power plant ensures it is an ethical power plant benefitting local communities rather than an exotic export. The Foundation's standards for ensuring this include: that the power plant should provide either local electricity for communities and industry or *dispatchable* electricity for Europe, that excess capacity should be avoided where possible, that grid stability should be prioritized, that power plants should use the least amount of water possible, that the power plant should provide education and training locally, that the local public should have a say in the project's development, that environmental impacts and rare species should be considered, that waste should be minimized, and that the plant should be properly decommissioned at the end of its lifecycle. Most of these principles were included in Design I but not in Design II. The development of this ethical framework extends the concept of feasibility from simply 'is it possible' to 'under what circumstances should it be done and what benefits should come from it?' Similarly, I argued in Chapter 3 that as CSP became enrolled in the sustainability debate people began asking whether CSP should be built and in what landscapes.

Valuing low cost in Design II as a system principle above all others created problems for Dii. Without a strong focus on other principles, the cost argument alone was not strong enough to motivate the system's construction. Former shareholder M+W Group also thought cost should be prioritized, but as the studies progressed they were convinced that the added cost from the HVDC cable would make imported electricity too expensive; transmitting electricity across the Mediterranean would add around 2 eurocents per kilowatt-hour to the electricity price. Furthermore, North Africa's electricity demand is skyrocketing, and it will be a long time before MENA countries have a surplus to export. When low cost is the main value, a simple decline in the cost of a single technology—such as PV—can derail an entire system design. Due to the reduced price of PV, some shareholders argued that it would be sufficient to build renewable energy in southern Spain, Greece, or southern Italy. If desert power is valued primarily for its cost, the significant uncertainties in transmission costs and the uncertainties of the added cost of the system once decommissioned infrastructure is accounted for can derail the vision. Furthermore, focusing on multiple goals and priorities can help to enroll additional stakeholders. If only carbon mitigation were the focus, for example, that value would not apply in Morocco, which prioritizes building a supply chain industry and local jobs through renewable energy.[115]

Dii was internally in disagreement about whether Desertec would still be Desertec without cross-continental transmission lines. Is it the same vision if it focuses on renewable energy technology in deserts for local people rather than for a trans-Mediterranean electricity network? If the vision focused only on technology in deserts for local populations, would that still reflect the original idea and its principles? Dii is ambivalent about whether the Desert brand is stamped on power plants in the MENA region. An employee from Munich Re argued that the brand is not important for building renewable energy for local use because one would not build a power plant in the desert and call it Desertec I rather than naming it Ouarzazate I, for instance. In fact, Ouarzazate I was renamed Noor I, Arabizing its identity, and MASEN has made it clear that Noor I is their project, not Dii's project.[116] Even if the electricity were to be exported, that agreement among the countries would not be called Desertec either. Dii shareholder interviewees doubted that the brand, Desertec, has ability to do work, while the Desertec Foundation saw the brand as a normative object with principles. This conflict left the vision's proponents without a shared set of values to advance the vision.

Taming Dii. When Dii did not meet expectations, and its principles were called into question, it metamorphosed into a different identity in the summer of 2013,

[115] See Chapter 6.
[116] See Chapter 6.

becoming the “Desert Power Industry Initiative” or simply Dii. Dii then framed its approach more explicitly around opening markets for renewable energy between Europe and North Africa, arguing that eventual integration through a single liberal power market in the region will make power cheaper for the entire region but that a pipeline of projects should be developed now to meet local demand. Design II focused on cost optimization, in which the cheapest renewable energy was framed as the most feasible. If the Desertec vision becomes merely a market-based project focused on low cost, then the principles behind it would be lost. There is a fundamental difference between Dii’s view of desert power as relating to “pure economics”—an inevitable future that the market will eventually reach on its own— and the Desertec Foundation’s view of the vision as embedded in normative goals, such as peace through integration and poverty reduction.

In October of 2014, the Dii shareholder committee voted to narrow Dii’s identity, turning it into a consultancy organization to provide construction services. Dii stated, “Dii adapts its business model to provide concrete services for renewable energy projects” for shareholder members. In the press release, Dii framed itself as having contributed to the greatly increased interest in renewable energy in the MENA region. It also framed itself as having identified sites for renewable energy projects; however, it no longer framed the sites as being in remote, empty deserts[117] but next to people and load centers.

> For the entire region, Dii has identified a volume of 800 GW at suitable locations *close to demand centers with access to infrastructure*. The regional electricity demand will quadruple in the next few decades until 2050 by strong population

[117] See Chapter 4.

> growth and economic development up to over 2,300 terawatt hours. (emphasis added)

In 2015, the headquarters of Dii moved from Munich to Dubai to demonstrate its commitment to local power. While Dii increased its focus on local power, it also lost its focus on the broader system transition. When the deep beliefs and paradigms that needed to be shed or retained in the vision's design were called into question, the vision retreated back to the imagining stage.

Centralized Management of Complex Systems: The Mediterranean TSO as an Innovation and a Risk

As Dii focused on a pilot project, they lost focus on the broader system. At the beginning of the chapter, I argued that the view of innovation as rooting a deferred dream did not entirely acknowledge the complex systems issues at stake. One type of innovation that is not acknowledged is the development of institutions to help manage and maintain a regional power system. Complex systems are typically defined by a lack of centralized management (Allenby, 2012), but electrical power systems, despite their complexity, are currently centrally managed. Electrical power systems are not scale-free but are still hierarchical systems. As markets were liberalized in the 1990s, and generation, transmission, and distribution were unbundled, transmission systems operators were developed to manage the traffic on transmission lines and to implement regulations such as prioritizing grid access for green electrons. It is the responsibility of the Transmission Systems Operator (TSO) to provide system security and reliability, voltage and frequency control, and measures to prevent network breakdown in case of emergency (Euro-Mediterranean Energy Market Integration Project, 2010). The Medring studies identified the lack of common rules within the region as a graver weakness than missing cross-border transmission lines. A TSO and an unprecedented Mediterranean-wide regulatory institution would need to make and enforce these rules.

California developed the TSO and was the test bed for the global trend toward the liberalization of electricity sectors. Its failures illustrate the risks that accompany these reforms. In 1998, California lawmakers established three new, complicated regulatory bodies to deregulate the power sector: the Power Exchange (PX), the California Independent System Operator (CAISO), and the Electricity Oversight Board, which oversaw the PX and CAISO. The PX created a centralized spot market for electricity, which continuously auctioned power prices. Utility companies paid wholesale prices to generators determined by the highest bid to the PX. CAISO coordinated the load on the transmission lines, attempted to achieve the lowest cost for transmission, avoided congestion on the transmission lines, and ensured sufficient reserve power. CAISO balanced generation and demand so that the transmission lines would not become overloaded, which would cause blackouts (Blumstein et al., 2002).

Compromises made among many stakeholders—consumers, generators, utility companies—established a flawed system. After three years, the regulatory system broke down resulting in blackouts affecting millions of customers. The PX declared bankruptcy, CAISO became insolvent, and the market collapsed (Blumstein et al., 2002).

Pacific Gas & Electric (PG&E) declared bankruptcy, and other utilities teetered near the edge of insolvency. Governor Davis declared a state of emergency, and the California Department of Water Resources hastily negotiated long-term contracts between generating facilities and utilities. Many of the remaining qualifying facilities, which were not being paid by the insolvent companies, went offline (Wiser, Pickle, & Goldman, 1998). In part, companies, especially Enron, gamed the system by shutting down power plants to reduce supply to artificially increase the spot market price for electricity (Williams & Dubash, 2004). However, many argue Enron was not solely responsible and that the failures were equally caused by a complicated and poorly run system. While the Power Exchange was dissolved, CAISO still operates today. In trying to address issues of efficiency and cost, California faced new risks in terms of effectively managing a complex system.

The developers of Design II do not acknowledge that a common market would likely require a TSO or equivalent—and one that operates across dozens of countries rather than within a single state, posing new risks. The Mediterranean Transmission System Operator (Med-TSO) could gain significant geopolitical power by controlling the power systems of Europe, North Africa, and the Middle East. In terms of new regionalism theory,[118] the Mediterranean TSO would be the region-state organization that would bind this technological system together. If Desertec were a 21st century Apollo Project, then the Med-TSO would be its control center. The Med-TSO would ensure that the copper plate provides electricity where it is needed when it is needed; it would be the organization to decide whether the lights would go out in Morocco if there were a failure

[118] See Chapter 4.

in Germany. Similarly, when the European Coal and Steel Community was developed in the 1950s, Jean Monnet (a founding father of the EU and first president of the High Authority of the European Coal and Steel Community) thought that a dose of *dirigisme* would be needed “to ensure genuinely free competition, to eliminate discrimination, to provide investment guidance and to prevent the formation of cartels,” which the High Authority provided (Spierenburg & Poidevin, 1994, pp. 3-4). The High Authority enforced the rules and objectives of the treaty that created the Coal and Steel Community, crafted common policies, and created a common market for coal (ibid). Today, there is a Med-TSO organization, but it acts as a think tank and does not yet possess any regulatory power. Successfully managing a regional electricity system with a common market would be more innovative than implementing renewable energy technologies. The developer of Design I had little faith that Design II could be adequately managed. It is profoundly different from the type of system that system builders have managed for the past century because of its single regional market and grid.

The German and Spanish electricity systems illustrate the importance of a system’s management plan, as they are in turmoil after reaching 20% fluctuating renewable energy capacity without one. Red Eléctrica, the Spanish TSO, runs the world’s leading renewable energy control center. It avoids shutting down baseload nuclear and coal power plants and curtails renewable energy generation instead. They explained ‘we have the control tool to reduce wind power, but we cannot disconnect the conventional generators like we’d like to’ due to cost (not verbatim). One exception was Easter of 2012, a very sunny and windy day with a typical holiday decrease in demand, when Red Eléctrica cut Spain’s nuclear generation by 20% for only the third time in history.

Germany has experienced negative electricity pricing during high periods of renewable energy generation, and conventional power plant operators must decide whether it is cheaper to pay consumers to take their electricity or temporarily shut down their power plants. If Germany can export this surplus electricity to neighboring countries, it can avoid negative pricing.

An interviewee from the German government explained that the first step in the energy transformation was reaching 20% renewable energy. From 20-50%, the challenge will be to transform the system, a step that North Africa has not yet reached. Dii focused on a single project at a time approach to help to construct markets that would one day lead to systems integration through market logic. This is another chicken-or-egg problem for electricity policy, as the system plan ought to come before the project development to avoid building a technological juggernaut, but the overall system plan is so ambitious and politically complex that it is consistently stalled.

Part of the challenge of developing regional regulatory and system's management institutions is that the development of electricity regulatory institutions has always been a political development challenge specific to sovereign nations. For example, American regulation was based on democratic debate and a struggle between the state and federal levels. Other countries are "building systems on a very different base of institutions and regulations"(Williams & Dubash, 2004). An official from MASEN explained why Morocco does not have an independent energy regulatory body,

> when you speak about a sector you need to have a thorough understanding of a history and how it comes…this sector is very special. And each country has its own specific situation and it's very dependent on [sic] its history.

Yet the liberalization framing espouses a very limited view of electricity's role in society and in politics (ibid). Chapter 6 will explore at the nation-state level the political development issues entailed in building a domestic renewable energy system and connecting it to a regional grid.

Adam (2003) observed that "we have no institutions adequate and appropriate to our current temporal politics...there is, in order words, no governance of time…almost every principle and tool is predestined against taking responsibility for the future" (p. 74). This is very important when planning a system across five decades, a system that would be too big to fail. If the broader dream is deferred but piecemeal steps continue to be taken toward it, will it, as Langston Hughes wonders in the dystopic part of his poem "stink like rotten meat and fester like a sore"?

Conclusions

This chapter illustrated that many in the electricity sector see innovation in electrical power systems as the realization of a deferred dream, rather than the implementation of radical new technologies. A modern electricity system is not innovative in the sense that it requires technologies that have not yet been developed but in the system-level reconfigurations needed to meet sustainability challenges in the power sector. This chapter illustrates how important it is to consider energy policy at the system-level, as the implementation of new technologies is affected by the broader system properties and goals. Designs for new systems face difficulties when they do not sufficiently consider the complex existing sociotechnical landscape in which they would be built, both in terms of the existing technological configuration and its challenges and the politics of the Mediterranean region rooted in a long history of conflict and collaboration.

The actors attempted to shift the vision for a new power system for the Mediterranean region from designed to constructed. They did this through temporal tactics that framed the vision as proximal, colonizing a space in the future for it. They also worked to frame the vision as feasible through particular methods of proof-of-concept, a cross-continental transmission line, a reference project in the desert, or a regulatory framework to pave the way for the vision. Disagreements about the method of proof-of-concept revealed deeper value conflicts stemming from the prioritization of low cost from the industry perspective versus the prioritization of integrated solutions and dispatchable power from the nonprofit organization perspective (i.e., Desertec Foundation). The sociotechnical vision did not exactly evolve; all three designs co-existed and eventually came into conflict, shifting from the design phase back to the visioning, or even dreaming, phase.

The Dii convened some of the most powerful energy companies worldwide and illustrated just how difficult it would be to transform electrical power systems, even if the overall centralized system configuration were maintained. From a practical standpoint, this chapter illustrated that cost is not the only reason renewable energy has not emerged, despite what is commonly assumed. In fact, Dii envisioned a system based on renewable energy that would be cheaper than a based on fossil fuels in 2050. Even when low cost is made the top priority, there are still many problems including regional politics, systems transformation, systems management, and sociopolitical conflict.

The next chapter will explore electricity policy's relationship to political development at the nation-state level, to better illustrate the complexity involved in attempting to govern a regional electricity system. Unlike the Desertec vision, Morocco views CSP as emerging and in need of R&D. Dii sought to speed up toward an inevitable future, to develop technologies today whose time has come. In contrast, Morocco is balancing its past, present, and future within its electricity policy, which reflects its political development.

CHAPTER 6

SOLAR POWER AND POLITICAL DEVELOPMENT IN MOROCCO AND ITS REGIONAL IMPLICATIONS

Introduction: Solar Power, Political Development, and Regionalism in Morocco

> *All debates on energy policy become, by definition, a debate on the stakes of the future and returns of the choices of the model of society to which we aspire as a national collectivity.*
>
> *– Maroc (Morocco) 2030 energy scenario report*[119]

Morocco as a case study. This chapter concretely illustrates the complex historical, social, and political landscape of one country in the MENA region— Morocco— highlighting the complexity of building an electrical power system across all of them. In this chapter, Morocco provides a case study for exploring North African perspectives on regional energy integration and for understanding how a nation-state's politics, political development, and history relate to visions for electricity integration. Additionally, it is important to understand Morocco's views on the Desertec vision because it would be an important hub in the system, as a bridge between Europe and North Africa. Morocco's actions and opinions on regional integration are critical for understanding the future prospects of Mediterranean electricity systems. Within a global context, Morocco is an interesting case study in electrical power systems due to its

[119] *"Tout débat sur la politique énergétique devient, par définition, un débat sur des enjeux d'avenir et renvoie à des choix de modelé de société auxquels aspire une collectivité nationale."*

unique history of regional involvement, and its present and imagined future in which regional political cooperation plays or would play an important role. Such issues would be overlooked in an examination of U.S. energy policy, in which the political discourse focuses on energy independence, not interdependence. Additionally, Morocco is the only North African country with a CSP plant under construction; while this plant is not a Desertec project, but a project under the Moroccan Solar Plan, it provides an example of the effects of the scale up of CSP in the MENA region, which will be the focus of Chapter 7.

This case study offers several generalizable findings about Mediterranean electricity integration relevant to the nation-state scale. First, each country has a tacit social contract or pact for its electricity system, shaped by its unique history and goals. This pact complicates regional policymaking that transcends sovereign borders because goals for the electricity system would have to be agreed upon at a transnational or regional level. Second, understanding each country's history is important for comprehending its specific, even peculiar, energy system configuration and institutions, and these histories matter to the stakeholders and affect regional integration processes. Third, renewable energy plays a role in national pride and nation building, which could conflict with the multilateral goals of borderless regional energy cooperation.

I found that Moroccan government officials are largely supportive of Mediterranean electricity integration. However, caution should be taken in generalizing Morocco's enthusiasm to the rest of the MENA countries. Scholars sometimes use the term "Moroccan exceptionalism" to describe the country, for reasons ranging from its historical sovereignty from the Ottoman Empire, to its ties to Europe and the United

States, to its religious tolerance, to its relative stability throughout the Arab Spring. Morocco is often viewed as accepting European culture, and it has a francophone elite class. While its official language is Modern Standard Arabic (Fus'ha) and the Moroccan dialect (Darija) is the colloquial language, French is often spoken in business and government affairs and used in official documents, although its influence is diminishing to some extent. Morocco generally focuses more on diplomacy with Europe than the rest of the MENA region and signed free trade agreements with the EU and the United States in the 2000s. Europe also provides Morocco with more financial aid than any other country (European Commission, 2010).

Political development. Throughout the dissertation, I have argued that transformations in electricity systems have significant political and social dimensions that are often overlooked. In this chapter, I explore the domestic political and social development issues related to renewable energy system transformations. While scholars have explored the political development aspects of how U.S. electrical power systems developed, this is largely an unexplored topic in Morocco, particularly in the Anglophone literature. By political development, I am referring to issues of national and social identity and cohesion, as well as changes in Morocco's political structure that are under consideration for the future but not necessarily underway yet. This chapter and the next will examine political development issues surrounding the evolution of electrical power systems in Morocco, with a particular focus on issues of inequity. This focus on inequity will aid in applying the energy justice framework in Chapter 8.

Hecht (2009) argued that technology is a useful domain for examining national identity. She found that debates in France about technology related not to its present but to what it could become in the future. As CSP is adopted in the MENA region, this chapter continues the discussion started in Chapter 3 about how government support for CSP relates to national identity and national pride.[120] In 2009, Morocco adopted an ambitious renewable energy strategy, aiming for 42% of its installed electricity generation capacity to come from renewable energy—14% from solar (mostly from CSP), 14% from wind, and 14% from hydroelectricity—or 27% of electricity consumption from renewables by 2020. I found that Morocco's renewable energy strategy relates to nation-building and national pride. This is evidenced as renewable energy has appeared in symbols throughout the country and the green mosques program, which will educate citizens in a majority Muslim country about renewable energy and energy efficiency. As a country that lacks fossil fuels, Morocco is reframing what counts as energy wealth and working to "valorize domestic resources," to build its future as an industrialized society. However, I found that technocracy in Morocco differs greatly from that in France, as experts and expertise are always subsumed under the state rather than held above it.

Morocco and modern technological systems. How Morocco imagines a modern electricity system relates closely to its political development. In Chapter 3, I argued that the framing of CSP as a farming technology has persisted over a century and a half, even while its other framings have shifted. In Chapters 4 and 5, I illustrated how the first Desertec vision portrayed a modern electricity system as a centralized system based on energy farming in the Mediterranean, rather than hunting and gathering fossil fuels. The Moroccan state has viewed a modern electricity system as a centralized one from the

[120] See the section on the Solar Plataforma in Spain in Chapter 3.

system’s inception during Protectorate, through to King Hassan II’s ambitious dam building projects for irrigation that he continued after independence from France, and finally to large-scale solar power. Centralized regional electricity integration fits into Morocco’s electricity development partly because the centralized system configuration it promotes is the configuration that has been prioritized and viewed as modern since Morocco’s early electrification.

At the core of the political development issue is the negotiation of Morocco’s past and present as an agrarian society and its imagined future, by some, as a high-technology knowledge economy. Morocco’s agricultural policy has been interwoven with its energy policy since the colonial era through the connection between irrigation and dam building. As an energy farm, CSP straddles the gap between an agrarian and industrialized society, as solar farms harvest sunlight to make the desert bloom, while growing a domestic technology supply chain and green commodity for export to Europe. It remains to be seen whether this hybridized view of CSP is a clever means of enacting policy change across conflicted social identities to balance tradition and modernity or whether it will reinforce business-as-usual. As Morocco transitions from the dam policy toward solar energy, the Kingdom balances Morocco’s identity as an agrarian society with its imagined future as a knowledge economy with a robust national system of innovation. In Chapter 5, I illustrated that the European renewable energy sector largely views innovation as a matter of rooting a deferred dream in the present, rather than developing novel technologies; furthermore, they view that progress should then be accelerated to reach this inevitable future. In contrast, the Moroccan vision for electrical power systems reflects a delicate balance among the past, present, and future that has long been important in Morocco's political development.

Social contract. One method of examining the social and political aspects of nation-state level energy strategies is to discern the tenets of its social contract for electricity. A social contract for electricity is "a set of arrangements and expectations that have arisen over time and reflect what the public expects from electric power systems that operate in the public interest" (Victor & Heller, 2006, Kindle loc. 5230). These social contracts are largely tacit and unwritten but are nevertheless powerful social constructions guiding the development of electrical power systems. Since public participation in the energy sector is typically low in Morocco, and therefore lacks citizen consent, it is more accurate to refer to a social pact for electricity rather than a contract.

> Rousseau's idea of a social contract is … not a pact between rulers and ruled, powerful and weak, masters and slaves. On the contrary, the only parties to the contract are the people themselves who consent only to rule over themselves (Dunn, 2002).

Catusse, Vairel, & Bono (2010) similarly argued that "social pact" should be substituted for "social contract" in the fight against poverty in Morocco as it lacks citizen participation.

The ability to address the principles and goals that compose Morocco's social pact is threatened by myriad challenges facing the country, including energy security and subsidies, youth unemployment, and social inequality and inequity. The new social pact seeks to address broader social needs— including reducing social and educational inequity, improving industrial policy, attracting foreign direct investment, fostering expertise, and stemming rural exodus— to achieve political stability in the post-Arab Spring context while reducing energy subsidies despite protests. I discuss how this changing social pact relates to renewable energy policy and political development.

To illustrate how the social pact has changed over time, this chapter describes its origin and formulation during the French Protectorate era to its evolution after Independence as Moroccans reclaimed their state and its infrastructure. Under the French Protectorate, Morocco's electricity system was built to serve extractive industries and colonial settlers, not locals, which left imprints on today's system and its inequities. The social pact was negotiated between the Protectorate government and French, not Moroccan, citizens, to ensure that French citizens and companies benefitted from electricity development and the export of products. After Moroccan independence, the social pact for electricity reflected a process of political development that reclaimed the state for Moroccans, and electricity governance was further centralized during this time and continued the dam building and irrigation policies developed under the Protectorate. In the 1990s, Morocco emerged from the authoritarian "years of lead" and integrated a promise for universal access to electricity into the pact while beginning to liberalize its electricity system under international pressures.

The Regional Aspects of the Social Pact. This chapter discusses the implications and the prospects for the social pact in a regional context. It illustrates how Moroccan energy needs and Moroccan energy policy both reflect and complicate plans for future Mediterranean electricity systems integration. I found strong support in my interviews for the eventual export of renewable energy from Morocco to Europe, provided that Morocco has ownership over its solar plan (rather than Europe having ownership over it) and that there is a just process for developing plans for regional integration. Many Moroccan officials I interviewed perceived regional integration as a key part of energy security and sustainable development. They see themselves as unfairly excluded from European electricity markets, especially since they produce electrons that are compatible with the European grid. At the same time, Morocco's focus on nation building and national pride through renewable energy is perhaps contradictory to the multilateralism implicit in the Desertec vision. Recognizing that the 44 countries within the Desertec vision have individual social contracts for electricity systems' development illustrates part of the challenge for multilateral, regional electricity systems planning. As electricity grids begin crossing nation-state lines around the globe, how will it affect the promise states and their populations make about the distribution of the social benefits and burdens of electricity development? While there is no answer to this question yet, it will be important to consider if the trend toward transnational electricity systems continues.

In Chapter 4, I discussed attempts to frame the Mediterranean not as a shatterbelt, but as a region of connectivity and deep integration. Chapter 5 illustrated the conflicting perspectives in the region that disrupted the feasibility of the Desertec vision. This chapter illustrates how Morocco is influenced by its storied past, its complicated present, and its imagined future. Numerous centrifugal forces tug Morocco in different directions: its historical ties to Europe, its aid and economic dependency on Europe, a long history of conflict with neighboring Algeria, global energy markets, a new focus on economic integration with countries to the south such as Mauritania, and the influence of the agendas of multilateral development banks. Morocco's energy sovereignty is affected by the pull of these forces. At times, these multiple forces lead to contradictions in Morocco's energy policy. For example, while Morocco develops national pride around a program of renewable energy self-sufficiency, it also continues to explore for oil and to frame itself as electrically European. These centrifugal forces present a coherence problem for the region and its relations. The narrative below illustrates these centrifugal forces and contradictions.

Justice. I argued in Chapters 4 and 5 that the politics and implications for the justice outcomes of the envisioned regional electricity system are not yet cemented but are dependent upon procedural justice. Given the colonial history in the region, it would be an important first step toward Mediterranean electricity integration to foster integrated projects that achieve true north-south collaboration that is not based on coercion but on procedural justice. This would be a useful form of "proof-of-concept" that would improve the social feasibility of the vision.[121] Morocco offers a model for such proof-of-concept through its integrated projects model, which combines social goals with technology adaptation that does not copy and apply technologies but rather adapts them to specific social contexts. Morocco seeks to develop the capacity to have ownership over the vision for regional electricity systems integration and to be considered collaborators in technology development. Applying the integrated projects model to the region could foster north-south partnership to address social goals and treat Moroccan experts as true contributors to energy innovation instead of technology adopters. Capacity building is a

[121] See Chapter 5.

prerequisite to this so that less powerful countries are not in a position in which they can be easily coerced.

Morocco: Geography, Economy, and Demographics in Brief

Orientalist depictions of Morocco, such as those initially used in the Desertec vision, frame it as a nation characterized by sand dunes and camels. In contrast, Morocco's diverse landscape includes 400 kilometers of coastline; the High Atlas, Middle Atlas, and Anti-Atlas Mountain ranges; maquis shrubland; short grassland; forests teaming with monkeys; canyons; and gorges, in addition to the sand dunes. It is not an unpopulated desert but a rapidly growing country with a population of 33.3 million people (World Bank, 2013) that is projected to reach 41.36 million people by 2050 (Haut-Commissariat au plan, n.d.). Morocco is remarkably geographically similar to California in terms of land area, length and width, shape, continental location, climate, vegetation, and offshore current, as well as population (Zeigler, 1997). Its economy differs greatly, with California's GDP per capita averaging around $46,000 per person and Morocco's at $2,940.

Morocco's name in Arabic— al Maghreb— means the far west, as it is the furthest west Arab country. It is often framed as a bridge between North Africa and Europe and is just nine miles from Spain across the Strait of Gibraltar. Algeria borders Morocco to the east. South of Morocco is a territory the UN calls Western Sahara, but Morocco considers it as part of its borders. Its sovereignty has been contested since 1975 when the Spanish colonizers left, and the UN does not recognize it as part of Morocco. Not including Western Sahara, Morocco's area is 172,000 square miles with a length of 750 miles and width of 250 miles (Zeigler, 1997).

Figure 40. Political Map of Morocco. Source: Pat Website (public domain maps)[122]

The World Bank classifies Morocco as a lower middle income country with a gross national income per capita of $2,940 (World Bank Group, 2014). Morocco's GDP growth has been relatively strong since 2000, averaging 5% per year (SIE, 2012), the highest growth in North Africa.[123] However, these increases in GDP are somewhat misleading because they largely reflect years when favorable climatic conditions yielded

[122] http://ian.macky.net/pat/map/ma/ma_blu.gif
[123] Morocco weathered the global economic crisis fairly well in part by spending 2.2% of GDP on a 2010-2020 stimulus package (ESMAP, 2011).

more agricultural products, and *Figure **41*** below illustrates the variability of GDP growth over the past decade (ESMAP, 2011).

Morocco is low on the human development scale compared to other Arab countries (Catusse et al., 2010). It also has significant urban-rural inequalities; “per capita household consumption in rural areas is only 54% of that in Morocco’s urban areas” (World Bank, 2011). Its urbanization rate in 2013 was 59.2% as people, especially youth, flee rural areas with limited infrastructure for cities (Haut-Commissariat au Plan, n.d.-d). Its overall unemployment rate is 9.5%, and the unemployment rate is in fact higher in cities (14.4%) than in rural areas (4%) (Haut-Commissariat au Plan, n.d.-c) The unemployment rate for those without a college degree is 4.6%; unemployment is higher among educated people, at 15% for those with a college degree and 19.8% for those with a more advanced degree (Haut-Commissariat au Plan, n.d.-b)

In terms of economic activity, Morocco is a largely agrarian society, with agriculture making up 20% of GDP and employing roughly 40% of the population (World Bank, 2012; ESMAP, 2011). In rural areas, this agricultural focus is more pronounced, with 72.7% of the population employed in agriculture, forestry, and fishing (Haut-Commissariat au Plan, n.d.-a) Tourism is Morocco’s second largest sector; it employed 41% of the population in the fourth quarter of 2013 (hcp.ma). Morocco’s manufacturing capacities are not well developed. Industry (including building) employs 20.2% of the population (Haut-Commissariat au Plan, n.d.-a; Rivlin, 2013; Vidican et al., 2013). Morocco’s holds 75% of the world’s phosphate reserves, making it one of the top three exporters worldwide (Oxford Business Group, 2012). Phosphorous is an essential component in fertilizers, food and drink, pipe corrosion prevention, and detergents.

Finally, remittances from the 3 million Moroccans living abroad add more to the economy than phosphates (Maghraoui, 2009).

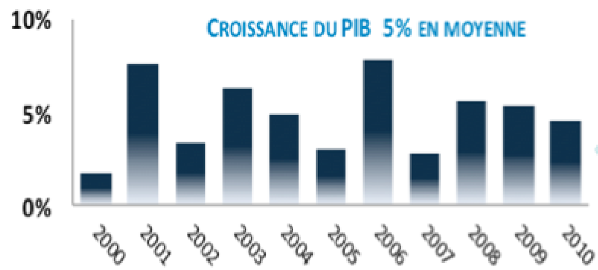


Figure 41. Moroccan GDP Growth, 5% Average Since 2000. Source Société d'investissement énergétique, 2012.

Morocco's government is a parliamentary monarchy. The ruling family dates back to the Alaouites of the Maghreb; the first Alaouite, Moulay Chérif, took the throne in 1631. In addition to its historical legitimacy, the ruling family has religious legitimacy because it is *sharifian*, meaning the family descended from the Prophet Muhammad. The king is therefore called the Commander of the Faithful. The Moroccan ruling family and state are called the *makhzen*. The parliament is elected, with a multi-party system.

The Socioeconomic Stakes of Morocco's Contemporary Energy Policy

Is there a future for Morocco? – Rida Lamrini

This section overviews the societal context of Morocco's electricity system to illustrate how it fits into political development and issues of inequity, as well as to provide the foundations for explaining Morocco's evolving social pact for electricity. The development statistics interspersed below tell an incomplete story and quantify aspects that are difficult to measure, but they provide context for how Morocco's problems are perceived and constructed in order to understand the current social pact for electricity and its relationship to political development. Contemporary Moroccan energy policy is a common thread running through Morocco's socioeconomic challenges from unemployment and poverty to anomie among educated youth and rural exodus. Examining energy policy and energy systems illuminates many of Morocco's societal challenges and goals, as Moroccans continue to transform what was a colonial electricity system into a system that does work for Moroccans. Energy policy considers both Morocco's future development and how the Kingdom imagines the future itself, such as its perceptions of the future's malleability, openness, and predestination. The specificity of Morocco's challenges illustrates the complexity that would be entailed in constructing a regional energy system, fusing the energy particularities and needs of dozens of nation-states.

In 1999, Mohammed VI inherited the throne from his father, King Hassan II, sparking hope for a new future across Morocco. The new king was nicknamed the King of the Poor for his focus on social inequality. He renewed the country's focus on human development and improved public services and instituted a Truth and Reconciliation Commission to investigate and rectify the human rights abuses of the past. He furthered economic liberalization under the theme of "new public management" with increased efficiency, rationalization, and provision of public goods (Catusse et al., 2010). His slogans "a new concept of authority" (*une nouveau concept de l'autorité*) (ibid) and "the New Morocco" (*le nouveau Maroc)* increased focus on marginalized populations and women's rights (Lamrini, 2006). However, seven years after Mohammed VI took the throne, as excitement died down, Moroccan author Rida Lamrini asked through a young Moroccan interlocutor whether there was a future for Morocco. He stated that it is literally a question that Moroccans inhabit, as the dream of young people often is to leave the country, rather than to stay and construct a better future. He stated, "Politicians are discredited. Short of ideas. With neither a project for society nor a mobilizing workplace. The elites are conspicuously silent, indigent."[124] Those guiding Morocco's renewable energy policy seek to address this dilemma, to construct a future for Morocco in which renewable energy is the mobilizing project for society.

Emerging industrial policy. Morocco's new industrial policy illustrates a clear shift toward envisioning Morocco as a future knowledge economy with a national system of innovation. Currently, France and Spain remain Morocco's largest commercial partners. Morocco sends 53% of its exports to the EU, drawing its diplomatic and economic focus to the north (Société Marocaine d'Assurance à l'Exportation, 2013; Zisenwine, 2012). Despite its favored geographical position between Europe and North Africa, Morocco has not yet grown significant export industries outside of phosphates, which suffer from declining commodity prices, and its trade deficit has been steadily increasing from $3 billion in 2001 to $18.7 billion in 2007 (Rivlin, 2013) especially due to its increasing dependency on foreign oil. Its attention is also being pulled to the south as it seeks to become an economic leader in Africa, to tap into new export markets. For

[124] *"la classe politique discréditée. A court d'idées. Sans projet de société, ni chantier mobilisateur. Les élites brillent par leur silence, leur indigence."*

example, one energy expert in Morocco expressed that European PV markets were saturated and that the markets of tomorrow would be in sub-Saharan Africa.

To grow and diversify its economy, Morocco has recently enacted a comprehensive industrial policy, particularly in the energy and manufacturing domains. In 2005, Morocco launched the Emergence Plan (*Le Plan Émergence*) to advance the competitiveness of the industrial sector and to increase GDP growth, add jobs, and reduce the trade deficit. The plan targeted the sectors in which Morocco already had a competitive advantage—offshoring, automobiles, aeronautics, agriculture/food, and leather textiles. Many interviewees emphasized Morocco's success in the first three categories, in particular the new Renault vehicle manufacturing plant in Tangier. Jobs at call centers have grown at Rabat Technopolis and Casanearshore, and the European Offshoring Association named Morocco the Offshoring Destination of 2012 ("Morocco Named '2012 Offshoring Destination of the Year' by the European Outsourcing Association," 2012). The National Pact for Industrial Emergence (*Le Pacte Nationale Pour l'Émergence Industrielle)* updated this strategy in 2009.

Along with the Emergence Plan, the Moroccan Innovation Strategy, led by the Ministry of Industry, Commerce, and the Digital Economy (*Ministère de l'Industrie, du Commerce et de l'Economie Numérique (*MCINet),[125] seeks to grow a national innovation system. This strategy also clearly envisions Morocco as a future knowledge economy and industrialized country. It seeks to bolster research-industry collaborations, to improve Morocco's competitiveness in technology, to turn Morocco into an attractive center for R&D in the Mediterranean region, and to provide financial mechanisms that promote

[125] Formerly called the Ministry of Industry, Commerce, and New Technologies

innovation (MCINet presentation, 2013). MCINet seeks to increase the number of patents per year by 1,000 and the number of innovative start-ups per year by 200. MCINet also runs the Moroccan Center for the Promotion of Exports (*Centre Marocain de Promotion des Exportations* under MCINet*)* with 31 target markets not just in Western Europe but also within the Maghreb and North Africa, Russia, China, the United States, and Canada (Maroc Export, 2013).

Research and development. A number of challenges related to Morocco's R&D sector must be addressed for Morocco to become a knowledge economy. The head of the country's energy development fund stated that the country's R&D sector was "sleeping" until recently. In 2008, the country's R&D budget was only 800 million MAD ($85 million). According to one interviewee, energy policymakers aim to grow Morocco's R&D capacities to foster a competitive sector by the time Morocco's low cost labor advantage is expended.

The structure of Morocco's higher educational system, which reflects the French system's focus in basic research rather than the German system's focus on applied vocational skills, is one challenge for growing R&D. The head of the Moroccan Institute on Solar Energy and New Energy Technologies (*Institut de Recherche en Energie Solaire et Energies Nouvelles* or IRESEN) explained to me that France could afford to focus on basic research in its universities since its industries conduct applied research. Since Morocco does not have a developed industrial sector, focusing only on basic research in universities does not serve Moroccan industry. "Morocco is above all today a technology consumer" he said. "We always have a tendency to copy-apply, copy-apply. And it's dangerous."[126]

Renewable energy plans reflect an effort to grow R&D capacities in the universities and to develop more vocational and industry-specific training programs, which is an area in which expertise is growing in Morocco. According to interviewees, Morocco has 15 public universities with science and technology departments, with 6,000 professors working in science and technology. These universities host 31 training programs in renewable energy, with 150 researchers active in renewable energy with 65% working in solar energy and 25% working in wind, biomass, or hydroelectricity (Barhdadi, 2013). Appendix One provides a list of many of these programs.[127] These research units have produced 600 publications and are working on 35 international R&D projects with Moroccan specialists (ibid). New opportunities are under development, including the new International University of Rabat's program in energy and sustainability.

Despite these strengths, one interviewee explained that foreigners have been hired to teach courses in new programs due to insufficient local expertise. Morocco suffers from brain drain as 6,000 researchers have left for developed countries as part of the Moroccan research diaspora. The renewable energy sector has recruited some experts home, such as Ahmed Baroudi, who was working in the space and telecommunications sector in France before King Mohammed VI asked him to return to run the country's

---

[126] *Le Maroc est surtout aujourd'hui un consommateur technologique… "on a toujours tendance à copier-appliquer, copier-appliquer. Et là c'est dangereux. »*

[127] It is challenging to find data on R&D and public universities in Morocco. I am relying on unpublished research conducted by interviewees on the sector and on a forum I attended on renewable energy education in Morocco.

energy investment fund. However, there are numerous disincentives to return home as an academic researcher. For instance, any professor, no matter how accomplished, would have to start as an assistant professor at the lowest salary of 12,000 MAD per month ($1,449/month), which is equivalent to a US graduate student's part-time salary.

Another challenge in the R&D sector is the lack of competitive research funding and university autonomy. According to interviews, until recently, research funding was shared evenly among the existing research centers, which was enough for conferences but not for serious research. Often research teams do not receive their funds until the end of the project. Universities have little autonomy in Morocco; the professors work for the Ministry of Finance, and the presidents of universities have very little power. The Ministry of Finance evaluates every line item public universities spend, which makes it difficult to gain approval for purchasing laboratory equipment. Law 0100 in 2000 gave universities greater autonomy on paper, but it has not been implemented. The renewable energy sector seeks to address this, and IRESEN was established to fund competitive research proposals from research teams that include international collaborators. These efforts in industrial policy and R&D amount to major capacity building efforts to put Morocco on a level playing field with its neighbors to the North. These efforts would put Morocco in better position to achieve positive outcomes from energy integration projects.

A technocratic state without rule of experts? In her history on the development of French nuclear power, Hecht (2009) coined the term "technocratic prose," which refers to placing technology above and beyond the sphere of politics and out of the reach of politicians. She stated that "technologies gave these elite [technologists] a unique vehicle for political action" (p. 11). These technologists were key to shaping nuclear power as a technology of national pride in France. I use the term technocracy in reference to Hecht's conceptualization of technocratic prose and experts playing a key role in influencing the state, rather than to mean non-elected bureaucrats (as the term is often used in Europe). I explore the role of technocracy as an evolving aspect of Morocco's political development and energy policymaking below.

Morocco's energy policymaking has a technocratic impulse, reflecting a linear model of technology policy that STS and Science and Technology Policy scholars have critiqued in the United States. This is evidenced through the framing of energy policy as founded in statistics, called in French *les données*, meaning the data, or literally the givens. When Abdelkader Amara was appointed as the new Minister of Energy, Mines, Water, and Environment in 2013, the Ministry's website underwent a complete overhaul and "key indicators" and "key statistics" became prominent features of the site. *Figure* ***42*** below illustrates the Ministry of Energy's policymaking process in which the steps include: collecting statistics, analyzing and interpreting statistics, and communicating for a given action, which forms the energy policymaking step. While it is drawn as an iterative process, it also assumes—like the classic science and technology policy linear model—that data leads to accurate statistics, which leads to good policy and, implicitly, which leads to socioeconomic benefits.

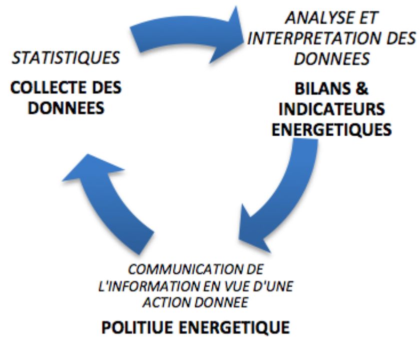


Figure 42. The Ministry of Energy's Linear Process of Energy Policymaking. Source: Moroccan Government.[128]

This focus on *les données* is reflected in the foundational documents of Morocco's new energy policy. For example, the *Maroc 2030* scenario study on energy, quoted at the beginning of the chapter, framed electricity planning as a social, political, and development issue. Yet the report also framed electricity policy as founded upon *les données*. A quote from the study summarizes this perspective: "In the field of energy, quantitative data play a primordial (important) role, given the capacity of the structuring of the sector on the rest of the economic and social system" (p. 55).[129] The study explains that errors in the estimation of demand could have macroeconomic consequences for years to come. Indeed, this was seen in the case of South Africa in the 1990s (Victor & Heller, 2006). Founding energy policy on *les données* becomes, in part, a strategy to address uncertainty.

Morocco mitigates the uncertainty of long planning scales by using both *les données* and traditional centralized rule by a monarch. While the model above suggests that there is a technocratic impulse in Morocco, it does not go as far as technocratic

[128] http://www.mem.gov.ma/SiteAssets/PdfStatistiques/AnalyseIndicateursEnerg24Mai2013.pdf
[129] *"Dans le domaine de l'énergie, les données quantitatives jouent un rôle primordial, étant donné la capacité de structuration que ce secteur a sur le reste du système économique et social."*

prose, because the Moroccan state is always held above the technology and the experts. While it is clear that data do inform decisions, the state plays a more central role than the figure above illustrates. In order to cope with electricity development's long planning periods, the Moroccan state chooses winning and losing technologies, as one interviewee put it, "setting a direction and going for it," in addition to allowing some voluntary actions under the policy, such as enabling a wind company to sell its energy to the grid.

Since the state must shoulder risk by supporting 20-40 year energy development projects— beyond the lifetime of many companies— it is seen as justified in putting conditions in place, such as requiring local content and requiring foreign companies to partner with a local research institution. Here, the government is simultaneously involved in incentivizing private investment and subsuming it under state control; unlike in Western liberal economies, the state is explicitly viewed as the sector assuming the risk, rather than private investors. An interviewee summarized this stating, "so the condition is, if you want [the state] to buy electricity from you [the foreign company] for the next thirty years, you need to transfer the technology to these [local] companies." He continued

> in Morocco we believe that the state has to show the way, because the public involvement is important, because I told you, there is not something called the truth and we have to find it. The state is there to show the way, to show a way, because we need that.

As the Moroccan state acts as a moral arbitrator to stipulate the appropriate actions of Moroccans in society (Ben Ali 1997; Maghraoui 2009), it also acts as a technological arbitrator to select appropriate technologies for Morocco.

By comparison, Dii's vision of energy policymaking is fundamentally different. Dii seeks to frame its vision as the inevitable endpoint of technological and political progress. In Dii's vision, experts play an important role in accelerating progress toward this vision, provided politics do not, as Dii puts it, get in the way. The economy is framed as the technological arbitrator. The state selecting winning technologies is the opposite of Dii's technology neutral position described in Chapter 5, which was framed as objective and unbiased but also suggested that a private company unelected by the public should make decisions based upon market logic about what technologies are best. One Moroccan interviewee described this approach as equally arbitrary to the state choosing winning technologies. In one view, the state assumes the risk and sets the course and in the other, private investors assume the risk and market logic supposedly sets the course.

Dii's model of prioritizing market control and technocracy was not entirely accepted in Europe. For example, the head of the German Development Corporation (GIZ) and a resident fellow at the German Council on Foreign Relations argued that what is at stake in the Desertec project is far broader than clean energy (Gnad & Vietor, 2011). Instead, a "Mediterranean Solar Union" of "supranational dimensions" could revive the European Union and develop positive mutual dependencies on both the North and South sides of the Mediterranean. They argued that what started as a comprehensive vision is being closed down and needs to be opened back up. Therefore, they recommended that the Vice President of the European Union and the European External Action Service take charge of it. They argued that Desertec is too important to be left in the hands of an industrial initiative and "requires the boss's attention" [i.e., the Vice President of the EU]. They state "visions that affect society as a whole—especially a common European vision, which is able to replace financial transfer payments as a substitute for policy—need to receive political priority." The *Irish Times* accused politicians of "outsourcing" their duties to Dii instead of tackling crucial questions about the future of the EU, the future of North-South collaboration, and the future of energy in the Mediterranean (Kinsella, 2009). This tension between state and private sector governance over electrical power systems is an evolving political development issue at stake in constructing a multilateral electricity system but is rarely discussed.

Morocco's technocratic impulse has likely been influenced by efforts ongoing since the early 1980s to liberalize its economy. In its democratization efforts, Morocco clearly trends toward liberal forms. As the Emergence industrial policies described above illustrate, neoliberalism has not taken the state out of technology planning (Catusse et al., 2010). Rather, the role of the state and expertise in energy planning is evolving. Moroccan energy policy reflects a balancing of neoliberal and traditional governance, in which a very political realm with intersecting social goals is contradictorily segmented into a) a rational management process bridging technocratic and political spheres b) a state-led, centrally controlled process. It is outside of the scope of this study to explain in depth the effects of neoliberalism on Morocco, although I do avoid the blunt neoliberal critique that has been popular in the literature over the past several years (i.e., neoliberalism is fundamentally bad and market liberalization has been corrupted by an authoritarian Moroccan state) (e.g, Bogaert, 2011; Joffé, 2009). I am interested more specifically in the technocratic impulse of energy policy in Morocco, why it seems to lack rule by experts, and how this might shape energy policy in Morocco in the future.

Traditionally, Moroccan elites fell into one of three categories—the *makhzen* or royal family, wealthy merchant families like the Soucis, and technocrats (in this case unelected bureaucrats) who work for the government based on their expertise (Ben Ali, 1997) Following gradual neoliberal reforms that started in 1983, there has been some decoupling of the sphere of public action reserved for experts and the political sphere that family parties dominate, which has allowed for some public discourse on topics that used to be handled only by elites in positions of power (Catusse et al., 2010).

When King Mohammed VI came into power in 1999 many assumed that a “linear” development and modernization process would follow (Tozy, 2008). More emphasis was placed on sourcing new political leaders, with less focus than in the past on leadership based upon ethnicity or family ties (ibid). This has created a tension related to expertise in which the elected politicians are often untrained, while those working for the King are (ibid). According to Tozy (2008) "The monarchy skims off the best and the brightest to attend les grandes écoles in France and become appointed technocrats, while elected officials remain woefully underskilled" (p. 38). After faring worst that expected in the elections, Morocco’s Islamist Peace, Justice, and Development party replaced some fundamentalist leadership with trained experts (doctors and engineers) with Islamist leanings (Tozy, 2008). Expertise is clearly valued in Morocco to some extent but as Tozy (2008) stated, “The dilemma of power in Morocco is to nurture a class of political leaders who take part in the conduct of public affairs without having any assurance that they can change the basic orientation of political life."

Despite Morocco's technocratic impulse and reforms to broaden the scope of political participation, experts, especially those who use technology as a vehicle for political action, are surprisingly missing. One interviewee at a private research organization who used to be employed by the state said that researchers should not be involved in forming policy. It was up for the state to choose the way and for the experts to follow. Not all scientists agreed and, instead, bemoaned that when Morocco is in need of technical expertise, foreign experts are often consulted in the development of national policy strategies rather than domestic experts. Moroccan solar researchers—even those who were the first to study CSP in Morocco before it was adopted by the state—feel irrelevant, disempowered, and ignored. As one interviewee put it, the R&D sector is sleeping, the government controls university management, and outside experts have little voice in policymaking. One researcher expressed that the government believes they consult experts, but the local experts perceive themselves as excluded as the Bureau of Foreign Studies brings in foreign experts. Furthermore, some Moroccan researchers felt excluded from international events such as the Dii conferences. Another energy researcher said

> … we have approximately 150 active researchers and they have worked on this field [solar power] for many years. And now we can consider them as experts in the field. They have, they have skills, they have expertise because they…gave many, many lectures, they have [sic] produced many publications in very prestigious journals and reviews, so they…are experts in their fields. But only [a] few, let me see, practically, nobody, no one of them has been frequently

> approached and asked to present and to provide his expertise in the form of the implementation of Desertec or solar energy plants....there are [sic] experts wanting to participate in the implementation of the Moroccan strategy. They have this predisposition, but they want to be involved, to be involved in the implementation. They don't want to go and ask to be involved. They want to be invited to be involved...Most of the authorities are looking for experts from outside...and we are here! And we don't ask for money. We are nationalists. We would like to work for our nation, for our country. We like our country, and we want to participate. But…we would like to be invited.

They want to have the privileges of elites through the deference shown by an invitation, but they are not seen as players in the political process.

Therefore, unlike in France, technology does not give experts a unique license to participate in the political sphere. While there is a technocratic impulse in Morocco, it does not involve the rule of experts, particularly not domestic ones. Instead the experts are subsumed under the state. Two nonprofit associations provide coordination and networking functions for the academics working in renewable energy and promote collaborations between industry and academia—SMADER (the Moroccan Society for the Development of Renewable Energy) and MANEREE. The researchers who tried to promote solar energy before it was popular in Morocco developed these organizations to gain a voice in the process.

The attempt to develop new sources of domestic expertise was rekindled following the Arab Spring, and new actors sprang up in civil society. For example, organizations, such as MENA Policy Hub and Sim Sim, empower young people to participate in policy analysis. MENA Policy hub writes white papers and hosts debates on issues including waste management, sustainable development, and energy, and presents its results to decision-makers. The president stated on the website,

> our ambition [post Arab Spring] is to respond to the large regional and national stakes with a young perspective and to tap into the opportunities offered by social media, raising strong and high a space for dialogue, for collaboration, and forging a culture of analysis, of inquisitiveness, and of reflection in our institutions and our young citizens.[130]

As Morocco evolves in the post-Arab Spring context, it is unclear what the future role of experts will be in the Moroccan state. One question is whether or not the portrayal of energy policy being about statistics will serve to mask significant social issues imbedded in energy transformations[131]—especially if advice from local experts and citizens is not institutionalized. This improves transparency, but it also risks depoliticizing a key political and social domain in Morocco. If the only legitimate knowledge is that which can be expressed through statistics and figures, it could impede the willingness to make predictions for the future about the social effects of new energy

---

[130] *Notre ambition est de répondre aux grands enjeux nationaux et régionaux à partir d'une perspective jeune et de puiser dans les possibilités offertes par les médias sociaux, levant haut et fort un espace de dialogue, de collaboration et forgeant la culture d'analyse, de l'enquête, de la réflexion dans l'esprit de nos institutions et nos jeunes citoyens.*

[131] See Chapter 1.

systems that do not fit into this quantitative framework. No one in my interview sample was willing to speculate about any future harms or societal losers stemming from regional energy integration typically because the interviewees saw this as unknowable information due to its complexity. Estimations for future social benefit and drawbacks are needed even if quantitative precision is lost. However, new organizations like MENA Policy Hub suggest the relationship between citizenship and expertise in Morocco is changing, possibly offering new opportunities for addressing Morocco's energy crisis. Will the new social pact allow for the incorporation of forms of expertise from new participants in civil society? Morocco's liberal and technocratic impulses illustrate an ongoing tension—one described by Ezrahi (1990)—between those who govern being those have the right to govern and those who govern being those who have the knowledge to govern. Chapter 7 continues this discussion by examining public engagement in CSP siting.

Morocco's Contemporary Electricity System

Transitioning the Moroccan electricity system from fossil fuels to renewable energy as part of Morocco's industrial strategy envisions Morocco as a future knowledge economy. To achieve this future, Morocco's energy crisis must be overcome—addressing Morocco's complete lack of fossil fuel wealth in the face of skyrocketing electricity demand. As electricity access increases and Morocco's GDP grows, demand projections indicate that Morocco must at least double its installed capacity by 2020 and double it again by 2030. According to an interviewee from the national utility company ONEE (Office National de l'électricité et de l'eau potable), Morocco must double electricity generation capacity as early as 2017, not 2020. As *Figure* ***43*** illustrates, electricity consumption increased 6-8% per year over the past ten years.

Morocco's energy needs and its energy consumption profile are dramatically changing. The defining factors of increasing energy demand include economic and demographic growth, urbanization, and industrial and agricultural growth (Royaume du Maroc Haut Commissariat au Plan, 2006). The biggest consumers are the industrial and residential sectors, not the agricultural sector. In 2010, industry used 38% of electricity, households used 33%, the transportation sector used 18%, the agricultural sector used 6%, and the tertiary sector used 5% (Société d'investissement énérgetiques, 2010). Rural electrification contributed to increasing electricity demand, as the electrification rate grew from 65% in 2002 to 86% in 2006 to 93% in 2007 to 95.4% in 2008 (World Bank, 2009). This electrification rate might be overestimated, as one interviewee expressed that sometimes the rate is calculated based upon whether a village has any access to electricity (e.g., if their schoolhouse has access) rather than counting each individual household. Almost no information is available about this, and the national utility company indicated that they count at the household level.

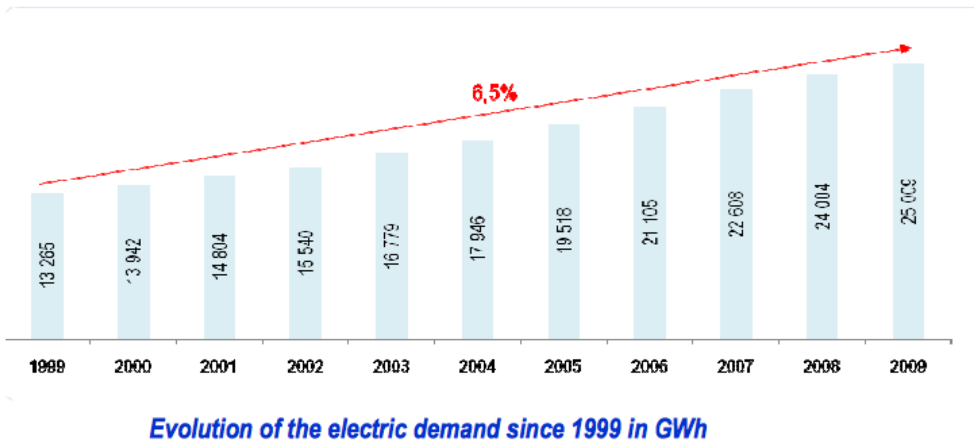


Figure 43. Morocco's Increasing Energy Demand Since 1999 in Gigawatt-hours. Source: International Atomic Energy Agency.[132]

Morocco’s total installed generating capacity in 2009 was just 6.2 GW, with ONEE contributing 4.4 GW of capacity and independent power producers contributing 1.8 GW—compared to 75 GW of installed capacity in California, 100 GW in Spain, and 177 GW in Germany. Morocco has a grid of 260,000 kilometers of low, medium, and high voltage transmission lines (Martínez, 2014; Office National de l’électricité, 2013; The World Bank: Energy Sector Management Assistance program, 2009). To meet increasing demand, Morocco seeks to develop 4 GW of solar and wind capacity by 2020 and 520 MW (.52 GW) of hydroelectricity and pumped storage, although the percentage of overall hydroelectricity generating capacity will go down due to increasing demand. *Figure **44*** and *Figure **45*** compare current capacity to planned capacity. If the targets are met, Moroccan electricity consumption would exceed the 20% EU renewable energy standard and would reach Germany’s current levels. By comparison, neighboring

[132] *http://www.iaea.org/INPRO/activities/WS_on_Long-range_planning/INPRO_Presentation_Morroco_Vienna_13_17_Juin_2010_English.pdf*

Algeria's installed capacity is 93% natural gas, and in 2008, only 3% of electricity in the MENA region came from renewables (International Energy Agency/ OECD, 2010).

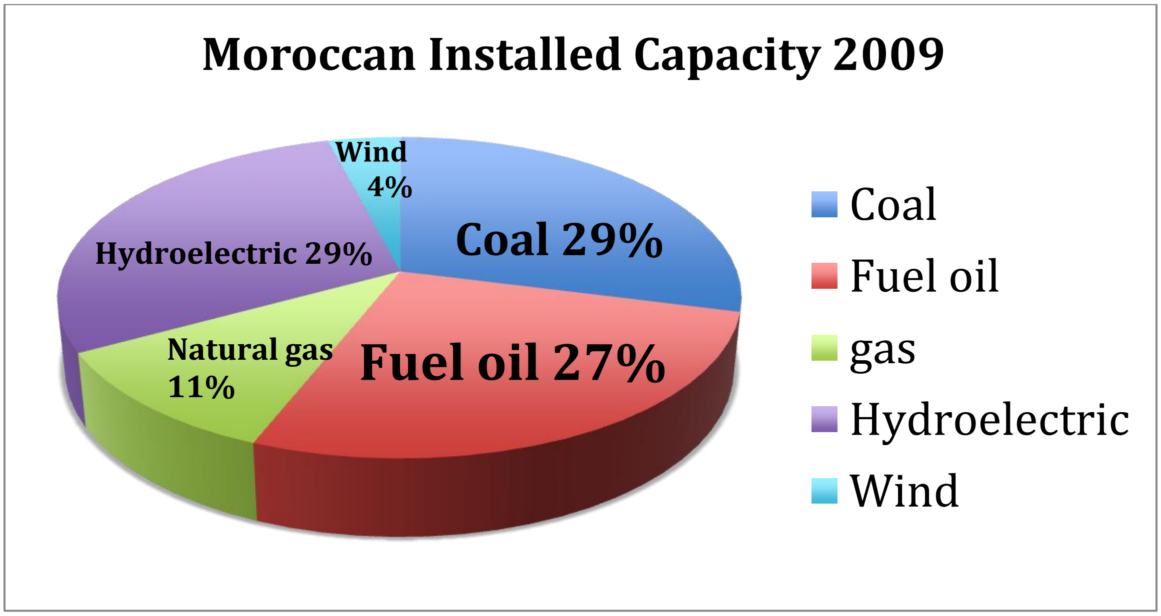


Figure 44. Morocco's Installed Generation Capacity in 2009, Source MEMEE, Chart by Author

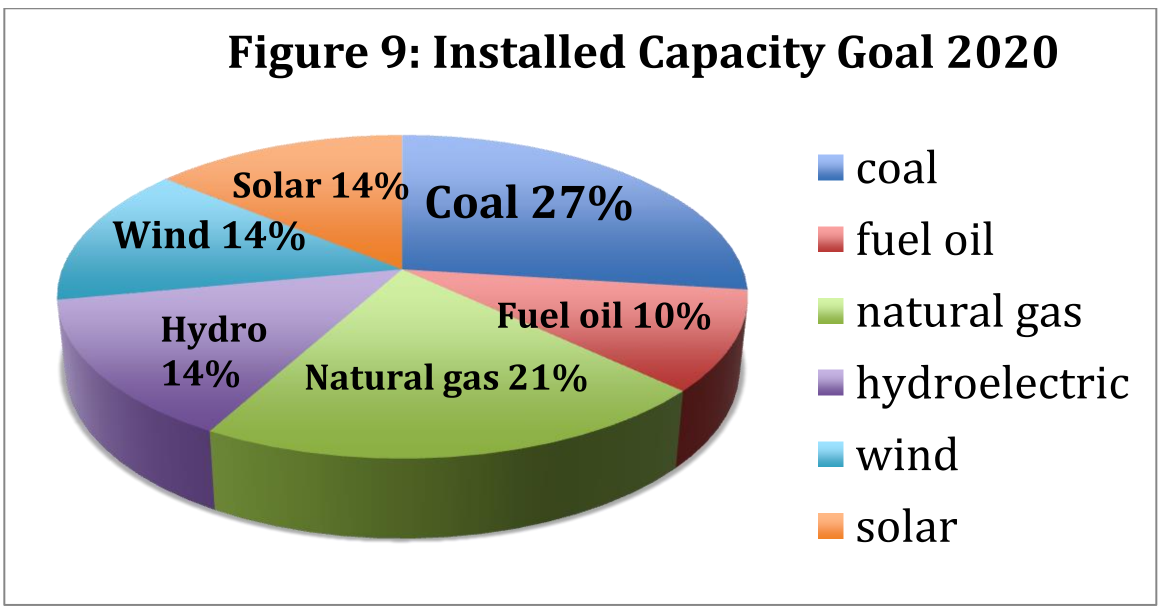


Figure 45. Morocco's Planned Installed Capacity for 2020, Source MEMEE, Pie Chart by Author

Recently added capacity in Morocco has largely come from natural gas, fuel oil, and coal. For example, the 472 MW Ain Beni Mathar plant commissioned in 2011 is mostly natural gas fired with a small amount of solar trough (see *Figure **46***). The plant uses the natural gas with which Morocco is compensated for being a transit country in the natural gas pipeline between Algeria and Spain. Morocco is planning another extension of its Jorf Lasfar coal-fired power plant in addition to the 660 MW coal-fired power plant in Safi to be finished in 2017 (both phosphate centers) and 300 MW of fuel oil plants in Kenitra, north of the capital city of Rabat (ESMAP, 2011). Fuel oil plants are used during peak load, and it is possible that CSP with storage could meet a specific system's need by replacing fuel oil to provide power during peak hours. Morocco also has large reserves of shale oil with deposits at Timahdit and Tarfaya that are undeveloped and will likely be part of Morocco's long-term energy strategy, although little focus has been placed on them so far.

Figure 46. King Mohammed VI Inaugurating the CSP Portion of the Ain Beni Mathar Integrated Solar Combined Cycle Plant (Natural Gas plus a Small Portion of CSP) in 2011.[133]

As Moroccan energy demand increases, its energy dependence deepens, along with its overall trade deficit. This energy dependence is framed as an energy security issue, even though almost all interviewees expressed support for regional integration. According to an interview with MASEN, Morocco imported 95% of its total energy in 2013 and 99% of its fossil fuels. Morocco is already dependent on electricity imports. Morocco and Spain share a 400 kV submarine transmission cable across the Strait of Gibraltar with a transfer capacity of 700 MW (Vidican et al., 2013). Algeria and Morocco have three transmission interconnections including a 400 kV circuit overhead line plus two 220 kV overhead lines with a total transfer capacity of 1,400 MW (ibid). Imports from Spain and Algeria grew from 10% of consumption before 2006 to 18% in 2008 because drought decreased hydroelectricity consumption to 7% (Energy Sector Management Assistance Program (ESMAP), 2011; “Indicateurs Clés,” 2014). Imports

[133] http://oujda-portail.net/ma/hm-the-king-inaugurates-integrated-solar-combined-cycle-power-plantin-eastern-morocco-19180.html#.VQEg7GZTPn8

decreased in early 2009 due to increased water availability for hydroelectricity (ibid) and reached 14% in 2012 ("Indicateurs Clés," 2014). However, conflicting information exists on the quantity of these electricity imports as European sources often report higher figures, with some claiming as much as 20-25% of Morocco's electricity is imported from Spain, suggesting the information is sensitive due to energy security concerns.

In order to decrease this dependence, Morocco plans to incorporate large quantities of intermittent renewable energy into its grid, posing new challenges for grid stability and reliability. In other words, renewable energy again poses a challenge in terms of a broader system transformation, as argued throughout this dissertation. A representative from ONEE, the national utility company, stated "the integration of the grid with renewable energy is a major challenge for ONEE."[134] ONEE has built 460 MW of pumped storage (STEP) with an additional 350 MW under construction. STEP provides energy at night by transferring water from a basin that is higher in altitude to one that is lower. ONEE is also working on consumer load balancing programs, in which consumers are asked to reduce their consumption when wind resources are scarce, and it is developing a pilot smart grid program in Casablanca. As illustrated previously, electricity systems are temporally dependent; grid management initiatives address peak times of consumption to maintain the highly valued system property of reliability that would be necessary for developing a future industrial economy. While demand increased an average of 5% from 2011 to 2012, it increased 10% during the evening peak hours and increased more than 5% during the hottest and coldest months, requiring the construction of expensive plants that operate mainly during peak hours. As one energy expert in

---

[134] *Parce que l'integration des reseaux aux energies renouvelables c'est un defi majeur pour l'ONE.*

Morocco put it, "7-10pm [are] three hours [that] ONEE [sic] fears like the devil".[135] The reliability of supply worsens in the outskirts of the grid. While staying in the small southern desert town of Merzouga, I experienced load shedding, especially during peak hours, while demand was always met during the time I spent in the capital of Rabat. Significant and uneven increases in demand are a new challenge for energy access, as they could result in a lack of reliability for households and industry alike, or even the loss of electricity for people who have come to depend upon it.

These measures alone are insufficient to ensure the future reliability of the grid in Morocco and along with it its energy security and valued system services. Again, the systems-level transformation provides the impetus for regional integration. An official from ONEE explained that energy security for Morocco involves developing national energy resources in addition to a favorable regional context for coordination and integration through initiatives like Desertec to balance out intermittency. He stated, "Regional coordination is necessary for ensuring energy security."[136] Interconnections with Spain and Algeria can help balance the load by importing electricity during peak hours. This illustrates how difficult the system context of electricity makes energy independence in reality. The solution to fossil fuel dependency at the system-level requires regional grid dependency, pulling Morocco toward the region.

Power sector investment and international influence. To meet increasing demand, Morocco needs a $10 billion infusion in its electricity system in the near future

[135] As Chapter 3 explained, peak load has long been during these hours in North Africa
[136] *Et il faut une coordination regionale pour assurer cette securite energetique.*

for transmission, generation, and distribution (The World Bank: Energy Sector Management Assistance program, 2009). Unfortunately, these weighty needs for capital coincide with financial stress in Morocco's energy sector. Some recently electrified villages do not pay their electricity bills, leaving ONEE insolvent and unable to pay all of its contractors, according to interviewees. By the summer of 2014, ONEE was over $6.2 billion (51 billion MAD) in debt, and the government signed a plan to raise 45 million MAD in capital by 2017 for ONEE (Agueniou, 2014). Samir, Morocco's refining company, is also in dire financial straits and recently received an injection of $500 million from Corral, its holding company, to recapitalize it ("500 millions USD pour refinancer Samir," 2014). Local banks may be in a favorable position to provide financing for the electricity sector, but there is limited foreign currency on the market and, given the size of the investment, local banks would then concentrate all of their risk in the energy sector (ibid). Increased electricity rates for consumers who use more than 100 kwh per month will provide some financing although not nearly enough.

Overall, Morocco will need assistance from foreign investors and development banks to cover its energy investment needs, considering the weak state of the sector (ESMAP, 2011). Worldwide, capital available for energy investment has again plummeted, leaving developing countries in search of funding (Dubash, 2003). Two-thirds of the required capital for energy development is in Asia, and 40% of that capital is in China (Royaume du Maroc Haut Commissariat au Plan, 2006). Morocco hopes to secure Asian capital for projects in the disputed territory of Western Sahara that European investment banks will not fund (Ortiz, 2014). In April 2014, Morocco called on

Japan to make an investment promised in 2013 to fund $2 billion in African energy projects (Alternative Energy Africa, 2014).

However, Morocco has had limited success in attracting foreign direct investment (FDI) in the past (Royaume du Maroc Haut Commissariat au Plan, 2006). The lack of investment is partly due to investors' risk perceptions.[137] The 2013 Corruption Perceptions Index ranked Morocco 91st out of 177 countries, and the World Bank's Ease of Doing Business ranked Morocco 87th out of 189 countries. This is a perception index, not an absolute measure of corruption, but investors' perceptions of risk due to corruption and inefficient bureaucracy have figured heavily into Mediterranean renewable energy projects and have been a major concern for Dii and other CSP developers (Komendantova, Patt, & Williges, 2011).

Development bank funding has been tied to liberalization efforts—tugging Morocco in the direction of liberalizing its power sector. Part of European investment in Morocco's energy sector has gone toward liberalization measures (European Commission, 2010). In the early 2000s, the World Bank formally acknowledged that the needs of each country's electrical power sector are unique (Byrne & Mun, 2003). When it became involved in Morocco's new energy strategy in 2009, it intervened tentatively due to criticsm due to past problems with neoliberal strategies (World Bank, 2009). The World Bank shifted from a deregulation model to a Private-Public Partnerships model (Dubash & Williams 2006) that is used today in the Moroccan renewable energy sector.

Education, Renewable Energy, and Inequity in Morocco. Morocco's primary goal behind this significant investment in the renewable energy sector—even considering

[137] See Chapter 5 for the Dii's perspective on risk perceptions.

the urgency of increasing demand— is to generate jobs, more so than generating electrons. One of Morocco's top scholars in the field of energy reframed Morocco's lack of resources, stating that Morocco's greatest resource is men and its second greatest resource is solar energy. If the country does not valorize its greatest wealth—people—through human development and democracy, then its other resources cannot be valorized. This view of citizenship reflects Morocco's evolving political development context since the Arab Spring. Lamrini (2006) argued that the problem is not inherently poor UN development statistics but a lack of political will and an indifference of citizens that needs to be addressed through a clear vision and individual empowerment to reform the political system.

The lack of valorization of human capital and citizen disempowerment is reflected in the anomie of educated youth in Morocco and the MENA region. The MENA region's youth unemployment rates are among the highest in the world, coupled with a rapidly growing youth demographic (Vidican et al., 2013, citing ILO 2011a). Seventy-nine percent of Morocco's urban unemployed population is within the 15-34 year old age bracket (African Development Bank), and Morocco's overall youth unemployment rate is over 20%. Many of these unemployed youth are educated; while only 4.2% of the non-educated workforce was unemployed in 2009, 18% of the educated workforce lacked jobs (Maddy-Weitzman & Zisenwine, 2012). A young Moroccan participating in frequent protests relating to unemployment told the *New York Times* in 2013 that she dreamed of finding a job in Morocco's growing renewable energy sector (Alami, 2013). Yet most of Morocco's new jobs are sprouting up at call centers in Rabat and Casablanca, under names like "Technopolis," through Morocco's growing offshoring sector. Following the

Arab Spring, young Moroccans are demanding a higher standard of living, and many young educated scientists and engineers are leaving the country as part of the Moroccan research diaspora, challenging Morocco's dream for a national innovation system as well as its overall economy.

This lack of valorization of Morocco's human capital is also reflected in systemic educational disparities and challenges. Morocco spends one quarter of its state budget, or 5.4% of GDP, on education. It has not achieved the outcomes expected from such a large investment, with an adult literacy rate of only 71% (UNICEF, 2012) (although this is the average literacy rate for lower middle income countries) ("Literacy rate, adult total (% of people ages 15 and above) | Data | Graph," n.d.).[138] There are a variety of reasons for illiteracy, including choosing which of Morocco's many languages to teach in and finding teachers qualified to teach in it (Alami, 2013). Public university is free in Morocco, but a high quality education and advanced degrees are often out of reach for lower to middle class Moroccans. Morocco hopes renewable energy will improve educational opportunities for young people that lead to jobs. At a 2013 forum hosted by the Moroccan Society for the Development of Renewable Energy (SMADER) on developing training and educational programs in renewable energy, a frustrated young woman in the audience stood up to complain that such training opportunities would likely only be available to the wealthy, perpetuating existing disparities.

Educational disparities and dysfunctions relate to broader economic and social inequality and inequity, and energy policy in Morocco therefore faces the challenge of

[138] Measures of literacy in Morocco vary greatly. In 2009, the World Bank measured the literacy rate at only 56.1%.

exacerbating uneven development. The mountain and desert regions have been called "depressed Mediterranean zones" (*zones Méditerranéen défavorisée*) due to their relative isolation and poverty (Roux, 1997). Young people are leaving these areas in droves in search of urban employment, resulting in an urbanization rate of 55.1% (Royaume du Maroc Haut Commissariat au Plan, 2006). These depressed zones are the target regions for renewable energy development, interweaving renewable energy development with these broader socioeconomic issues. A huge gulf separates the two Moroccos, or the Moroccan elite living in large cities from the rural or urban poor living in villages and slums. This came to a head in 2003, when Morocco, previously assumed to be immune from religious extremism and violence, experienced seven simultaneous suicide bombings in Casablanca. These attacks targeted symbols of wealth and foreign influence, not governmental power, illustrating the effects of extreme poverty and social change (Sater, 2010). The suicide bombers came from the burgeoning Casablanca *bidonvilles* (slums), where people often must pirate electricity to gain access (Zaki, 2010). The government responded with social programs aimed at dispersing the *bidonvilles,* as well as repression as thousands of people were arrested (Howe, 2005). At a seminar arranged to discussed the bombings, the president of Al Akhawayn University, an elite American-style university, expressed that inequalities in educational access were partly to blame for the bombings (Howe, 2005).

The challenges described above provide the context for understanding how Morocco's changing needs affect the formulation of a new social pact for electricity. The next section illustrates how plans for renewable energy are developing in the context of national pride.

Renewable Energy and National Pride

> *"Economic development will not be complete without its radiance (rayonnement) on all of the national territory…"*
>
> -- *Massolia on the Second Moroccan Forum on Energy* ("Deuxièmes Assises de l'Energie," 2011)

Renewable energy provides Morocco with an opportunity to reimagine itself as what Hecht (2009) called "a technological nation" and an emerging, industrializing knowledge society. It has the beginnings of a shared national project, part of capacity-building efforts to put Morocco on a level playing field within the region. In her study on French nuclear power, Hecht (2009) used the term the "radiance of France" to explore the "strength and flexibility of the association between technological prowess and national identity," in which the term radiance in French (*rayonnement*) means both radiation and radiance (p. 4). The quote above addresses Morocco's renewable energy development in terms of socioeconomic development designed to radiate to the disadvantaged rural areas of the country. Morocco seeks to accomplish this through the commercialization of its sun and wind. As a country that lacks the oil wealth of many of its neighbors, Morocco seeks to reframe what counts as energy wealth and "valorize" it. Just as people have framed alternative energy technologies, Morocco is framing alternative energy wealth. Mehdi Alaoui M'Daghri, co-founder of the Morocco Solar Festival in Ouarzazate stated, "We organized this festival to show one idea—gold is in the sky. The sun is a treasure for our country…for arts and culture, science and technology, knowledge and discovery" (Hocke, 2014).

As such, Morocco is reimagining itself from being a fuel-impoverished country to being a country rich in energy resources in need of valorization. To valorize a resource in this context means to unlock the socioeconomic benefits of resources through commercialization and technological development. In 2013, the new Moroccan Minister of Energy said at the Dii conference that the Ministry's objective "is to valorize our solar energy resources." Through solar radiation maps like the one below, Morocco is framed as a national awash with solar gold waiting to be harvested. Some interviewees even referred to Morocco's "*gisement solaire,*" which literally means Morocco's solar deposits, reframing what is typically thought of as fossil fuel deposits into deposits of renewable energy. The discourse is similar for wind. Furthermore, the trade winds that brought Morocco phosphates also created plump algae that can be valorized to produce biofuels. The *Maroc 2030* energy scenario study even refers to the "valorization of the privileged geographic position of the country for regional integration" through the Maghreb-Europe pipeline and the Morocco-Spain-Algeria grid. Energy efficiency is even seen as a resource to be valorized. Other interviewees discussed the valorization of Morocco's human resources through entrepreneurship initiatives and increasing employment opportunities in order to develop innovative energy solutions.

Mascir, a new private research organization developed as part of Morocco's efforts to reform its R&D sector, also focuses on the valorization of energy resources. It even has a "Director of Business Development and Valorization." Biofuels made from

Moroccan algae are “Champions league” technologies, or those that will compete abroad.[139] These technologies have their own technological specifications— such as fungible fuels from algae that work in any car— and also social specifications, such as avoiding genetically engineered algae so the fuel would be socially acceptable in Europe. Other technologies being designed are “local competitors,” like at-home breast cancer or leukemia testing for rural areas or quality control testing designed for small producers to certify their products for export. In this case, local means dedicated to the Moroccan or similar market, which could in fact encompass many countries. It means that the technology focuses more on providing the best price than on the best performance, although it would meet minimum efficiency standards. The previous director of Mascir stated "So it's big science but designed to be cheap and designed to be easy to use by cooperatives." Mascir is also developing biodegradable plastic bags that would address the issue of the plastic polluting the Moroccan landscape. These technologies are geared toward people in rural Morocco and Maghrebian countries. This reflects the disparate goals behind Morocco’s energy policies—to develop a major high-technology export while meeting the needs of the most impoverished citizens in the country.

[139] This refers to a prestigious soccer tournament organized by the Union of European Football Associations.

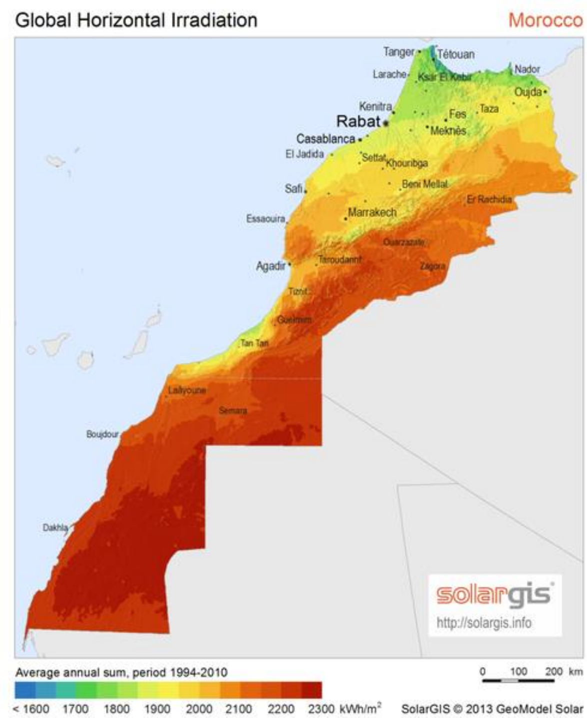


Figure 47. Solar Irradiation in Morocco Measured in Kilowatt-hours per Square Meter. Creative Commons License, SolarGIS © 2015 GeoModel Solar.[140]

As renewable energy resources were reframed as wealth, renewable energy development became a symbol of national pride. At the 2013 Dii conference in Rabat, Fathallah Sijilmassi, the Moroccan head of the Mediterranean Solar Plan, stated that the conference was "emotional because Morocco since the beginning was one of the active tangible pioneers in the field of renewable energy with tangible projects like Ouarzazate." Examples of renewable energy as national pride appear throughout the country. For example, centers of transportation advertise Morocco's commitment to renewable energy to tourists and citizens alike. The airports in Rabat and Casablanca have signs in the airport security line that count how much of the airport's energy is coming from solar PV and the avoided carbon dioxide emissions (see *Figure **48***). In the customs line to enter

140 http://commons.wikimedia.org/wiki/File:SolarGIS-Solar-map-Morocco-en.png

Morocco in the Casablanca airport, tourist and business travelers alike watch a video with a man holding the sun in the palm of his hand followed by a young girl with the dawn behind her saying “we need new sources of energy to improve quality of life.” In another example, the new train station in Marrakech has a free solar charger for travelers to charge their electronic devices (see *Figure **49***).

Figure 48. Solar Counter in the Casablanca Airport. Photo by Author.

Figure 49. Free Solar Charger in Marrakech. Photo by Author.

The new Moroccan 100 dirham bill (about $10) pictures wind turbines in the desert and a desert caravan, juxtaposing tradition and modernity (see *Figure **50***). A Moroccan interviewee who runs the Sahara Wind company stated about the new bill

> The previous bill showed a hydropower dam, agricultural activities, and women sorting through oranges, which represented Morocco's main economy…So it’s just to tell you this is essentially the building of a nation, the building of a new economy. And Moroccans will see that every day…they’ll do business with that…

This offers evidence of Morocco’s process of balancing between its traditional agricultural economy and a knowledge-based society. Although citrus has been replaced with wind turbines on the currency, the foreground still represents one of Morocco’s stereotypical activities—desert caravans.

Figure 50. The New Moroccan 100 Dirham Bill (Roughly $10). Photo by Author.

Renewable energy is becoming enrolled in symbolic ways in Moroccan politics, again fusing renewable energy with traditional economic and religious activities. For instance, SIE is working with the Moroccan Islamic Ministry to promote energy efficiency in 15,000 of the country's roughly 50,000 mosques, resulting in a 40% reduction in energy use. Morocco is the first Islamic country with a "green mosque" label. Integrating renewable energy into mosque architecture and sermons is an effective communications tool to explain to the public that saving energy is important. Morocco has also taken measures to improve the efficiency of 2,000 hammam fires (Royaume du Maroc Haut Commissariat au Plan, 2006). The hammam is a public bath, traditionally heated with firewood, which serves social functions, e.g., a meeting place for women, a place for women to try to find wives for their sons, as well as livelihood functions because some households lack showers. They have also worked to improve the efficiency of 100 pottery kilns, a traditional economic activity (ibid). Tying renewable energy and energy efficiency to important aspects of religion and the traditional agricultural economy sends a powerful educational and symbolic message about the importance of renewable energy and energy efficiency.

Perhaps in contradiction to developing a renewable energy strategy based upon national pride, Morocco has long-term aspirations for a major oil discovery and continues its oil and natural gas exploration activities. Rumors circulate about significant offshore oil or gas discovery but none has been confirmed. Morocco appears to be ambivalent about what natural resource it sells to Europe—sun, oil, or natural gas. Since Morocco's energy policy is based upon socioeconomic goals, and environmental goals play a minor role, it is not necessarily committed to a renewable energy future.

Morocco's version of technological neutrality[141] is based upon valuing any natural resource that situates it on more stable footing in terms of energy dependence and a potential export to Europe. It underscores a commitment to a vision for a future in which Morocco is an industrialized country with a strong export commodity, rather than a commitment to a particular technology or a particular genre of technology. While renewable energy provides an opportunity to shape "a new Morocco" in a world in which only two countries (Spain and Germany) generate a significant portion of their electricity from renewables, oil would allow Morocco to benefit from the traditional resources that other nations in the region have. Below I will illustrate that several times throughout its history Morocco has developed a national reputation around large-scale renewable energy projects—first dams and then CSP—while continuing quietly to develop fossil fuels.

Moroccan Electricity Systems Under the Protectorate: the Colonial Social Pact

Before explaining how Morocco's social pact is changing today in relationship to renewable energy, I will explore the foundations of the social pact from early electrification to the present. From 1911 to 1956 Morocco was under French and Spanish rule, although as early as 1830, Europe already had significant influence over Morocco both politically and technologically (Miller, 2013). Understanding Morocco's colonial energy past is essential to interpreting its energy present. Almost no social and cultural history of colonialism in Morocco exists (Maghraoui, 2013), which is the genre of history in which this study would be interested. While scholarship is lacking on the history of

[141] See Chapter 5.

African electrification in general (Barjot, 2002b), enough has been written in the Francophone literature to distill the general principles of Morocco's early social pact for electricity, which developed within a colonial electricity pact tied closely to agricultural policy and resource extraction. This section also provides an English description of Moroccan electrification, which is lacking in the literature.

Although various communities argue that the French Protectorate was "an aberration not especially worthy of study," Miller (2013) illustrated its importance to "modern Moroccan history as an unfolding, variegated, often discontinuous and a textured canvas, yet all of one piece" (Kindle loc. 421). Maghraoui (2013) argues that colonialism is part of an "unfolding process of 'modernity.'" Therefore, studying the colonial power system will provide longitudinal grounding for the analysis of the contemporary viewpoints of what is viewed as a modern electrical power system for Morocco. The colonial electricity system left imprints on today's system and its various contradictions and inequities. This reflects findings from the STS literature that electrical power systems develop momentum, rigidity, and obduracy as they form and have lasting impressions on social justice (Hommels, 2008; Hughes, 1983). It explains the historical relationship between electricity and agricultural policy in Morocco, including why Morocco has significant installed hydroelectric capacity despite its capricious water sources and persistent drought. The footprints of this system include the lack of attention given to *bidonvilles* (slums) and the mountainous zones of the country, the focus on privileging elites, the focus on electricity development for resource extraction rather than improving citizens' capabilities, the focus on valorizing resources, and a strong focus on centralization and state control. The system had to be reshaped to provide electricity and electrical modernization for the average Moroccan.

Under the Protectorate, Morocco was the focus of incomplete engineering dreams based on myths of the type described in Chapter 3. Part of the ideological foundation of French colonization was the myth that Morocco used to be the Granary of Rome—or a significant producer of grain exported to the Roman Empire—but Arabs had neglected the land and only French technology could return it to its former state (Davis, 2007; Swearingen, 1988). Miller (2013) described such colonial motivations as "…the oft-invoked and misguided image of a Moroccan 'Far West'— an empty land, an unutilized space, ripe for exploitation by the pioneering spirit" (Kindle loc. 2722). This frontier provided a space in which to pioneer new technologies, such as dams, road construction techniques, electrified rail (Berthonnet, 2008; Bouneau, 2002), and city planning (Miller, 2013). These large-scale technologies were imagined as emblematic of what one historian called "the drunkenness of Saint Simon" (Couvreux, Moussa, Marseille, Beltran, & Cladé, 2002). Saint Simonianism was a French utopian socialist movement in the 1950s and 1960s, reflected in the fantastical projects the French imagined in Africa, especially dam building, and the grandiose, modernizing dreams that underpinned them (ibid).

At the start of the Protectorate in 1911, there was no electricity infrastructure in Morocco (D'Angio, 2002). Louis Lyautey, the first director general of the Protectorate (*Résident Général)* from 1912-1925, tried to physically ground the civilizing discourse within agricultural modernization and the construction of power plants and railroads (Davis, 2007; S. G. Miller, 2013). He divided the country into 'the useful Morocco' (*le Maroc utile*) in the arable plains, and 'the useless Morocco' (*le Maroc inutile*) in the mountain and desert regions (Swearingen, 1998). He sought to secure the desert and mountainous areas (to prevent uprisings from Berber tribes) while developing "useful Morocco," which was the official colonial focus (Bisson, 2003). This established inequalities between the coasts and mountains of Morocco that still exist today.

Lyautey built new French cities near the medinas, or traditional walled cities where Moroccans lived. The juxtaposition of the "new cities" built by the French with the medinas illustrated a perceived difference between tradition and modernity and both the technical and moral as part of the civilizing discourse (Heurtebise, 2002), as the new cities had access to technology and the medinas largely did not. Lyautey vowed to leave the medinas alone, to "supply them with water and electricity…but that is all" (Miller, 2013, loc. 2320). This was merely rhetoric used to justify the Protectorate's existence, as there is no evidence that average Moroccans benefited from electrification during this time period. In fact, the French thought that electrifying the medina would spoil its traditional qualities. In the medina in the city of Fes, citizens, grain mill operators, and students in the city's historic religious boarding schools wanted access to electricity, but the French implemented regulations to maintain the traditional look of the medina for tourist purposes (Apelian, 2012), preventing electrification and even the installation of gas pumps by Shell (Porter, 2000). In some cases, students used electricity furtively to study at night in areas not frequented by tourists (Apelian, 2012). By attempting to make time stand still in the medina, the French actually shaped it and along with it they shaped a distinct perception of what counted as traditional and what counted as modern (Porter, 2000).

Large-scale electrification was delayed under the Protectorate due to lack of funds, time needed to securitize the Atlas Mountains, the need for a decree enacted in 1914 to bring Morocco's waters under state control, and the prioritization of the Tangier-Fes railroad line as stipulated by the Franco-German treaty that resolved the Agadir Crisis (D'Angio, 2002). Morocco attracted significant capital for electricity development in the 1920s (Barjot, 2002a). The infusion of cash needed to build the first power plants in the country, which were coal-fired, was financed by a consortium of Parisian banks called Morocco's General Company (*la Compagnie Générale du Maroc)* (D'Angio, 2002). Once electrification began, several companies controlled the distribution of electricity, the largest of which was the Moroccan Business for the Distribution of Water, Gas, and Electricity (*la Société marocaine de distribution d'eau, de gaz et d'électricité* or SMD), which served Casablanca and Rabat (ibid). Electricity demand skyrocketed in Morocco and other French colonies, but most of it stemmed from European settlers' usage, electrified rail, and extractive industries, not local demand or Moroccans benefiting from electrification (Barjot, 2002b).

French experiments with electrified rail played an important role in colonial electrification and the integration of the two systems intensified resource extraction. The French sought to "valorize" Morocco's electrical resources to transport phosphates from mines to the port of Casablanca (Bouneau, 2002). By 1933, Morocco had the continent's only electrified rail and had 1,427 km of transmission lines running to most Moroccan cities, the phosphate mines, and the railroad (Barjot, 2002a).

It was under the French Protectorate that Morocco's agricultural policy became intertwined with electricity policy, beginning a long history related to the energy-water nexus impeding plans for large-scale technological systems in Morocco. The French hoped that, after their difficulties colonizing desiccated Algeria, Morocco would provide an El Dorado of water resources that they could exploit (Davis, 2007; S. G. Miller, 2013; Swearingen, 1988). They viewed the Moroccan High Atlas Mountains as “a chateau of water,” with three large rivers fed by snowmelt, l’oum er Rebia, le Sebou, and la Moulouya (pronounced Malwiya) (Saul, 2002). The French hoped Morocco would become a contemporary Granary of Rome—to supply Europe with large-scale grain exports—and they implemented an ambitious strategy to grow grain for export. A decade later, it became apparent that Morocco’s water resources had deceived the French, as they were subject to capricious rainfall and persistent drought, which foiled the Granary of Rome vision. In fact, recent evidence illustrates that while North Africa did provide grain to Rome during the Roman Empire, it did so with traditional methods and at nowhere near the scale the French assumed (Davis, 2007). Like the incomplete engineering dreams described in Chapter 3, Morocco’s agricultural policy under the Protectorate was based upon ideology, false premises, and a lack of sufficient understanding of the landscape.

Furthermore, exports to Europe were disrupted by French politics. French grain producers successfully lobbied for a ceiling on Moroccan imports so that their market was not flooded with Moroccan grain (Swearingen, 1998). Even with this ceiling, Morocco exported grain even as people starved (Sater, 2010). The neocolonial concerns surrounding Desertec relate to Morocco becoming not a Granary of Rome, but the Electricity Depot of the EU, even while local people lack access. This was one motivation behind proposing a single market prioritizing regional reliability, which was then disrupted by EU politics. The concern is also that solar power plants would be built with a similar lack of understanding of the landscape and local people's needs (this will be further addressed in Chapter 7).

In 1925, Théodore Steeg replaced Lyautey and faced the culmination of the Granary of Rome crisis as severe drought, locusts, and famine devastated the country (Swearingen, 1998). Under Steeg, agricultural export policy shifted in what Swearingen (1988) called the "California Dream," shifting Morocco's attention across the Atlantic in hopes of turning Morocco into "a new California" (*une nouvelle Californie)*. The French sent missions to California in the 1930s to study its agricultural and irrigation technologies and to Tennessee to study dam building (ibid). Swearingen (1988) quoted Georges Louis, the head of a French expedition to California in 1932, who stated "California, through irrigation, had caused the desert to blossom, creating immense wealth that had become a magnet for men, creating more wealth" (p. 69). A journalist at the time stated "the miracle of irrigation, which made California's fortune, is occurring again on Moroccan soil." (p. 75). This "miracle of agriculture" discourse described by Swearingen (1988) is similar to the discourse surrounding CSP and Dii's "irrigation miracle" to put deserts into service by building solar farms to make the desert bloom with cheap renewable energy to spur wealth through electricity exports. The Protectorate also compared their plans for large-scale irrigation to the Tennessee Valley Authority, to uplift rural areas and stem rural exodus (Swearingen, 1988). However, few benefits of large-scale dams in this time period went to Moroccans.[142] The Protectorate developed a policy to irrigate one million hectares, in which "not a drop of water [was to] reach the

---

[142] The TVA built large hydroelectric projects in the United States that were aimed at poverty reduction and advocating for public versus private electricity systems (McCraw, 1971).

sea,” initiating a period of dam building that played a crucial role in forming both Morocco’s agricultural and electrical power systems. The focus on exports shifted from grain to citrus and vegetable bumper crops grown through irrigation and labeled with the “Maroc label” that imitated the Sunkist label to mark the quality of Moroccan exports (compare to the marketing techniques of Design III in Chapter 5). Today, Morocco still looks to California guidance on energy policy, implementing similar liberal reforms and CSP technologies. This also illustrates the long emphasis placed on fostering export markets to Europe.

Because the exploitation of hydrologic and hydroelectric resources under the new California plan required a centralized state and national plan to amortize large investments (Couvreux et al., 2002)— and centralized electricity was needed for commercializing phosphates— the development of electrical power systems was also envisioned at a large scale with the centralization of production and interconnection from the start (Couvreux et al., 2002; Saul, 2002). This was unusual in Africa (Frémeaux & d'Almeida, 2002) where most electricity systems mostly evolved piecemeal (Saul, 2002), and it illustrates the historical roots of Morocco’s contemporary emphasis on centralized, state-run electricity systems. Hydroelectricity development had also become more urgent after World War I increased coal prices (Saul, 2002). A single state-controlled company, *Énergie électrique du Maroc* (EEM) or Electrical Energy of Morocco, was established in 1924 to “rationally develop” hydroelectricity and irrigation (Saul, 2002). They had a monopoly over electricity generation (ibid). The first reservoir dam, Sidi Maachou, was completed in 1929 and supplied drinking water and 65 million kWh per year of electricity (Swearingen, 1988; Saul, 2002).

While Morocco's grandiose plans for renewable energy development (hydropower) and irrigation were a source of pride used to substantiate the colonial enterprise, fossil fuels quietly played an equally important role in the system (similar to today). Because hydroelectricity alone could not meet Morocco's energy demand due to weak rainfall and unpredictable drought, the French simultaneously built thermal power plants (Saul, 2002). This came at a high cost because, even considering the long amortization periods of hydroelectricity, thermal power plants were 20 times more expensive than hydroelectricity (ibid). The port of Casablanca became the hub of thermal electricity generation. From 1924-1938, EEM further consolidated the energy system, purchasing the existing coal generation from Casablanca and building a diesel power plant in Oujda near the Algerian border in 1929 and one in Agadir in 1930. From 1938-1955, five dams were constructed, as well as expansion of Roches-Noires coal-fired plant in the Carrières Centrales *bidonville* (slum) outside of Casablanca, which played a leading role in Morocco's energy system (d'Almeida-Topor & Frémeaux, 2002; Saul, 2002). Roches-Noires was originally a diesel plant built in 1924 that was converted to coal-fired generation when the French discovered a modest deposit of anthracite coal at Jerrada in 1929 (Debbarh, 2015).

Although Morocco's electricity system governance was centralized, it was also a mixed public-private effort due to a delicate colonial balance of addressing the social goals promised within the civilizing discourse while satisfying citizens in the metropole by ensuring benefits to French companies. French entrepreneurs and companies benefited from North African electrification, as Morocco was an attractive place to do business for French electricity firms (Barjot, 2002a). Barjot found that foreign companies gained much more revenue in Morocco than in Algeria and Tunisia, even though they conducted more business in Algeria. In addition to the state-run EEM, a French firm called the General Society of Companies in Morocco (*Société générale d'entreprises au Maroc*) played a leading role in electrification. They built dams and 11 high voltage lines from 1921 to 1939, which EEM purchased (ibid).

Electricity policy in Morocco had to balance between providing services in Morocco and gaining public support in France, especially during the Great Depression. Due to the dam building efforts, as well as building 300 km of electrified rail, Morocco was perceived at home and abroad as the most advanced of the North African countries in electrification by the 1930s. One means of bolstering public opinion for North African electrification in France was through colonial expositions that celebrated the progress made in French colonial electrification as part of national pride, such as the one curated by former Director General Lyautey in 1931 (Hodeir, 2002). This was one of several international fairs Lyautey organized to celebrate France's infrastructural achievements in North Africa (Miller, 2013). An exhibit called the "electricity fairy" illustrated electricity and its applications, including a series of lit fountains that showcased both France's hydroelectric works and electricity. The electricity fairy analogy suggested a magical, feminine, and benign process of electrifying the colonies and fits into France's "peaceful penetration" of North Africa discourse. Lyautey's exhibit also advertised the importance of French electricity-related exports to the colonies, totaling 218 million francs (Hodeir, 2002). Due to these public communication efforts, and the benefits provided to French companies, support for Moroccan electrification remained strong in France (Barjot, 2002b).

Electrification nearly ground to a halt during World War II (Saul, 2002). After the war, Morocco grew rapidly while facing drought. By 1943, 75% of its electricity came from hydroelectricity. In 1949, the giant D'imFout dam was completed at 50 meters high (by comparison, for a U.S. audience, the Hoover dam is 85 m) on 907 hectares (Hoover 89 hectares), producing 170 million kWh annually (Hoover dam 4 billion kWh) and irrigating the plain of AbdaDoukkala for agricultural and mining needs (ibid; Swearingen, 1987). In 1952, EEM opened a new phase of Roches-Noires to make up for lost hydroelectric capacity due to drought, bringing the total capacity to 28 MW. In 1954, toward the end of the Protectorate, 58% of Morocco's electricity generation came from hydroelectricity, 37% from thermal power, and 5% from diesel.[143] Transmission infrastructure totaled 1,000 km of 150,000 Volt (V) transmission lines, 1,500 km of 60,000 V, and 1,720 of 22,000 V (Saul, 2002). From 1945 to the end of the Protectorate, electricity consumption doubled every 5 years (ibid), and between 1926 and 1956, Morocco's consumption multiplied 44-fold (ibid). This illustrates that Morocco's energy consumption has been growing rapidly for nearly a century, and growth is not a recent trend as many have assumed. Between 1929 and the end of the Protectorate in 1956, the French built 14 dams in Morocco, 10 of which included hydroelectricity capacity. The dams' total irrigable area totaled 221,450 hectares and 1,920,560,000 cubic meters of reservoir capacity (based on data from Swearingen, 1988). (The total electricity generating capacity is unknown).

This history shows that colonial electrification was a source of inequality that exacerbated uneven development, benefiting foreigners and local elites and powering

[143] This is the latest date during the Protectorate for which I can find data on the energy mix.

resource extraction, rather than benefiting local citizens. While the colonial social pact for electricity was ideologically couched in the civilizing discourse, in practice it focused on resource extraction— providing reliable electricity for agriculture and the phosphate industry for export. Saul (2002) argued that from a development perspective, Morocco was not, in fact, electrified during the Protectorate. Rather, the electrification that occurred was of "colonial character," not meant to power Moroccan households, but to serve key extractive industries and an agricultural export industry. EEM accompanied development rather than driving it (Saul, 2002). Building infrastructure and public works was part of the civilizing discourse (D'Angio, 2002), but in order to maintain public support in France, the social pact focused on benefits to French companies rather than Moroccans. Promises for increased access to electricity in the medinas went unfulfilled because access to electricity in homes was largely for European settlers and local elites, illustrating deep social inequalities (Barjot, 2002a). By the end of the Protectorate in 1956, Morocco was 115th in the world in terms of kWh per person of electricity consumption (Saul, 2002). As French settlers fled Algeria in 1962, the electricity company there lost 87% of its customers (Berthonnet, 2008); the situation in Morocco was likely similar but no data is available. It is no surprise, then, that Ley imagined that large-scale energy systems for the MENA region are only needed where major extractive industries exist;[144] the processes used to generate household electricity demand in Western countries were not a focus in the colonies.[145] Furthermore, electricity cost 25%

[144] See Chapter 3.
[145] These processes included housing codes that mandated that new homes were wired for electricity and included appliances in the mortgage, door-to-door salesmen from utility companies selling appliances, government programs to convince rural women to adopt electrical appliances, and subsidized rural electric cooperatives.

more than in France due to the high costs of dam construction (Saul, 2002). Electricity still costs more in Morocco than in France and Spain.

By the end of the Protectorate, 150,000 Moroccans lived in the *bidonvilles* that persist today (Zaki, 2010). The residents of the *Carrières centrales bidonville* neighborhood, the location both of Morocco's first major thermal plant (Roches Noires) and the birthplace of Moroccan independence movements, pirate electricity in order to gain access today (Miller, 2013). Three decades later, Morocco was still not fully electrified, and it was not until the 1990s that universal access to electricity became part of the social pact for electricity.

It is also questionable whether electricity development facilitated technology transfer during the colonial period; technology transfer is a key foundation of the Desertec vision's "win" for North Africa. Berthonnet argued that dam technology was not transferred to Algeria because the French brought in engineers to conduct the work. After colonization they continued this model by bringing French construction firms in through cooperation agreements. There may have been technology transfer in Morocco because Lyautey established a school for training Moroccan cadets and schools to develop an elite class of future government workers loyal to France (Miller, 2013) but data is lacking. There was continuity in the French-Algerian technological relationship even after independence, as French companies provided technical assistance in the further development of electrical power infrastructure (Frémeaux & d'Almeida, 2002). It is not clear if this was true in Morocco, which remained a leader in hydroelectricity development.

North African energy integration in historical context. At first glance, the contemporary transmission integration between Morocco and North Africa appears to be an example of technological integration without political integration.[146] However, electricity integration in the Maghreb has historical roots dating back to the French Protectorate in the 1940s. In 1941, General Weygand, a French general during World Wars I and II, held a meeting in Algiers about connecting the Moroccan, Algerian, and Tunisian grids (Saul, 2002). Morocco was perceived in France as the most advanced North African country in electrification, with a production of 220 million kWh (Saul, 2002), because Algeria and Tunisia had less hydropower resources (Berthonnet, 2008). The French planned that Morocco would triple its electricity production and export 200 million kWh to Algeria within eight to 10 years (Saul, 2002). In 1945, the target was reduced to exporting 100 million kWh from 1953-1956, increasing thereafter. Unlike with grain exports, they stipulated that Morocco's needs had to be met first (Saul, 2002). Morocco exported electricity to Algeria from 1956 until the oil crisis in 1974 (Debbarh, 2015). In 1988, Algeria began exporting electricity to Morocco because Morocco's hydroelectricity had declined due to drought (ibid). Additionally, Algeria had discovered large natural gas reserves after independence, and the balance of energy wealth between the two countries had reversed.

After 1975, electricity integration in North Africa was pursued under the Maghreb Electricity Committee (*Comité Electricité du Maghreb*), founded by Morocco, Algeria, and Tunisia (Royaume du Maroc Haut Commissariat au Plan, 2006). Libya and Mauritania joined the Committee in 1989. That same year, five North African countries,

[146] See Chapter 4 for a discussion on this binary.

including Mauritania, formed the Arab-Maghreb Union (UMA) for political cooperation in the Maghreb. In 1990, the UMA established expert commissions to study fossil energy, renewable energy, and mining. A 1995 study by the UMA recommended that regulatory measures be established for an energy market in the Maghreb. The Arab-Maghreb grids are now connected as one "ELTAM" grid (Egypt, Libya, Tunisia, Algeria, and Morocco) (ibid). A connection between Morocco and Mauritania is also under consideration. The U.S. Deputy Secretary of the Treasury under the Clinton administration encouraged a liberalized, Western-oriented open market across North Africa (Howe, 2005). But significant electricity and other trade is still lacking due to political disputes and a North African economic/ export orientation toward Europe.

The Social Pact after Independence

After 1956, Morocco viewed achieving energy independence as complementary to achieving political independence in its development as a new state (Debbarh, n.d.). Very limited data is available about Moroccan electricity systems during this period, since Morocco was a state in transition with a relatively closed government. Morocco began consolidating its central control and sovereignty over its electricity system. While greater state control of the electricity sector was later viewed by development banks as economically inefficient, it was a matter of political development; to become a nation Moroccans had to take ownership of their country and build up domestic capacity, especially in the sectors in which French technical firms had played a major role. First, Morocco began exploring for oil, hoping a discovery would bring economic independence and geopolitical power through a new export commodity, but very little was discovered (ibid). Morocco settled for building refining facilities in the 1950s and 1960s so it could import crude oil instead of more expensive refined petroleum products such as today's widely used butane bottles. The Moroccan government created the National Business for Petroleum Products (*Société Nationale des Produits Pétroliers* or SNPP) in 1974 to manage the state's interest in oil activities (ibid). Morocco's oil refining company, the Anonymous Moroccan Business for the Refining Industry (SAMIR or *Société Anonyme Marocaine de l'industrie du Raffinage)*, was completely state run, and the other refining company, SCP, was 75% state run (ibid). Furthermore, the National Office of Electricity (ONE or *Office National d'Électricité*) replaced EEM in 1963, bringing all electricity activities over 10 MW under state control (ibid).

After King Mohammed V's death in 1961, King Hassan II inherited the throne. Hassan II faced the political development challenge of maintaining Morocco's traditional past—which was essential both to its identity and to upholding the legitimacy of the regime, which was based upon the ruling family's history going back to 1631. At the same time, he faced the challenge of modernizing the state and the economy. Roberson (2014) encapsulated this tension between tradition and modernity in a quote by King Hassan II who stated, "In this way, we shall graft the past onto the present to prepare for the future" (p. 57). Roberson (2014) stated, **"**A key question [for King Hassan II] was how to embrace aspects of the modern era while not abandoning significant traditions that served as a source of identity" (p. 59). In part, Hassan II sought to modernize the country by continuing the Protectorate's dam building policies in earnest under the 1968 dam policy—*politique des barrages*— that renewed the goal to build one dam per year in order to irrigate one million hectares (Swearingen, 1998). The *politique des barrages* continued to interweave electricity policy with agricultural policy throughout the 1970s and 1980s and was an important part of Morocco's national pride. The King officiated over groundbreaking or inauguration ceremonies, giving them national recognition as the King's project, to build a national identity for Morocco through a new, sovereign version of what was originally a colonial project. Major Moroccan buildings and technologies were printed on currency to foster recognition around these nation-building projects (Roberson, 2014). For example, the 50 dirham bill under King Hassan II pictured a dam on the back.

The social pact for electricity began to balance exports with local goals. King Hassan II's goals for agricultural policy included: to assure the nutritional needs of the country, to develop agricultural exports, "to earn foreign currency," and to raise the standard of living to slow rural exodus (Swearingen, 1988), similar to today's goals for solar farms. (Chapter 7 will discuss interviews in which Moroccan citizens supported electricity exports as a means to "earn foreign currency.") By the early 1970s "the policy had attained almost mythic proportions" (ibid, p. 163); King Hassan II was more successful at implementing the Protectorate's dam building and irrigation goals than the French were (ibid). Installed hydroelectric capacity quadrupled from 317 MW in 1956 to 1,266 MW in 2003, or 21% of installed capacity (Debbarh, n.d.).

Even after Independence, Morocco was vulnerable to the influences of foreign investors and governments within the region. The 1973 "Moroccanization" decree sought to pursue a Moroccan form of liberalism post-independence, giving more economic control to elite merchant families, such as the family that ran the refining company SNPP, but under the power of a "techno-bureaucracy" (Ben Ali, 1997). However, Morocco changed course in the 1980s, when it required international economic assistance due to a phosphate boom followed by a crash. Morocco's economic growth rate was one of the lowest in the MENA region, averaging 1.5% per year, and it needed private investment (Rivlin, 2013). Morocco was further strained by a significant drought that lasted from 1980-1985 (Doukkali, 2005). It became clear that Morocco's economy could no longer entirely be supported through clientelism (ibid). Morocco was therefore open to the influence of multilateral development banks that pushed further liberalization of its economy and energy sector (Ben Ali, 1997) By comparison, Morocco's wealthy natural gas-rich neighbor, Algeria, has not taken any steps to liberalize its electricity market (RCREE, 2013), as its energy wealth precludes the need to attract foreign investment.

Morocco's Structural Adjustment Program (SAP) of 1983 implemented greater economic liberalization, reversing some of the state control implemented after Independence. Tariffs on imports were dramatically reduced as recommended by the World Bank and the IMF, exposing the economy to much cheaper products from overseas. According to an interviewee who lived through this time period, this made electronics like TVs much more accessible to Moroccans but bankrupted many Moroccan businesses. Morocco privatized oil refining, indexed its tariff and tax reform at the Rotterdam rates, and standardized the tax rates on different energy products, such as a diesel and butane (ibid). In 1996, Morocco signed a free trade agreement with Europe and in 2003 with the United States, but Dawson (2009) found that Morocco did not secure advantageous terms in these agreements with wealthier, more powerful countries.

The international dynamics that shaped Morocco's economy explain why it has the most liberalized electricity sector in North Africa. It is the only country in the MENA region with private generators of electricity (RCREEE, 2013). Through ongoing liberalization, ONE lost its vertically integrated monopoly over the electricity sector (Debbarh, n.d.). The distribution of electricity in most major cities including Casablanca, Rabat, and Tangier changed to private distributors such as Rédal in Rabat (ibid), with 46% of total demand provided by private and municipal distributers by 2011 (ESMAP, 2011). Independent generators could sell to the grid, leading to public-private partnerships between ONE and independent generators, attracting private investment. For example, ABB/CMS[147] constructed Morocco's coal-fired plant at Jorf Lasfar. The Wind Company of Detroit and EDF developed the Abdelkhalek Torres wind power plant, and Endesa and Siemens partnered with ONE to build the first natural gas power plant in Morocco at Tahaddart (ibid). As of 2011, 68% of electricity generated in Morocco came from independent generators and the remainder from ONE (ibid). This liberalization was not the result of market logic, but was the result of steady international pressure to shape the Moroccan economy and along with it its political structure.

Rural electrification become part of the social pact in the 1990s and began to address the uneven development that resulted from the colonial social pact. The period of rule under King Hassan II was marked by political repression and human rights violations and is now called "the years of lead." Due to domestic pressure, including two assassination attempts, and international pressure, stemming partly from a book published in France that criticized the King (*Notre Ami le Roi*), Morocco instituted numerous social

[147] a Dii shareholder company, see Chapter 5.

reforms in the 1990s (Maddy-Weitzman & Zisenwine, 2012). Electricity was at the center of the King's demonstration of benevolence. This included the Program for Rural Electrification (the PERG or *Programme d'électrification Rural Globale*), which aimed to bring electricity to 12 million people, 1,892,000 homes, and 35,600 villages (Royaume du Maroc Haut Commissariat au Plan, 2006).[148] The PERG included a small solar component. However, solar PV was reserved for the poorest and most remote homes (and nomad tents) in the country; 9,177 households in 646 villages received solar PV panels, which is a negligible part of Morocco's overall electricity mix (ibid). ONE convinced rural communities to replace kerosene lanterns with butane bottles and electricity (Debbarh, n.d.). The program was largely successful, and the rural electrification rate climbed from 18% in 1995 to 46% in 2000. Today, the local ONE office is a common site in small villages across Moroccan landscape. This represents a major shift away from the colonial social pact. Furthermore, Morocco is relatively unique in Africa in having achieved high electrification rates.

Fossil fuels post-independence. As Morocco continued its prominent dam policy, it, again, quietly developed more fossil fuel generation than hydroelectricity. Even as an Arab State, the oil crises changed Moroccan energy policy by illustrating Morocco's vulnerability to capricious oil markets. In the 1980s, coal became cheaper than oil, and Morocco began substituting coal for fuel oil in its thermal power development. In 1994 and 1995, ONE completed the first two units of the coal-fired power station at Jorf Lasfar, a port that exports phosphates. For fossil fuel generation,

---

[148] The World Bank, the European Investment Bank, the African Development Bank, and the Arab Fund for Economic and Social Development supported the PERG (Vidican et al., 2013).

Morocco was dependent not only on external fuels but also on international technology firms. Some assume that technology transfer and know-how come through this private development, but this assumption lacks empirical proof. Multinational energy giant ABB (later a Dii shareholder) and American CMS Energy completed phases three and four of Jorf Lasfar in 1998 and five and six in 2001 for a total of 1,356 MW and a $1.5 billion investment with a partial risk guarantee from the World Bank. At the time, this was the largest influx of FDI Morocco had ever secured (Müller-Jentsch, 2001). From 1986 to 2003, coal consumption increased from 17% of Morocco's energy mix to 32% as Morocco concentrated much of its electricity supply at Jorf Lasfar (Debbarh, n.d.). Despite continued dam building, Morocco's energy dependence steadily increased as its only coalmine (at Jerrada) peaked in 1984 and closed in 2000 (Debbarh, n.d.; ONE presentation of NPP project, 2010).

Morocco also developed natural gas capacities with imports from Algeria. In 1996, the Maghreb-Europe pipeline was completed, which funnels natural gas from Algeria through Morocco to Spain. Morocco receives revenue and a portion of the natural gas, which it used to finance the 380 MW Tahaddart natural gas combined cycle power plant. Although it is not renewable, natural gas offers an interesting opportunity for Morocco to enhance cooperation within the Maghreb (Royaume du Maroc Haut Commissariat au Plan, 2006, p. 20).

In 1992, Morocco enacted a new hydrocarbon code that made it one of the world's most attractive places for oil exploration by multinational firms based on continued hopes that finding oil would bring geopolitical power to the state (Debbarh, n.d.). Morocco simultaneously shifted its dependence away from oil toward coal and natural gas through the Jorf Lasfar and Tahddart plants. In 2000, Lone Star Energy, a U.S.-Moroccan company, announced a major oil and gas discovery in Talsint in eastern Morocco near the Algerian border. The Minister of Energy and Mines, Youssef Tahiri, declared that Morocco would begin exporting oil from 12-15 billion barrels of reserves ("The oil club's newest member," 2000; Howe, 2005). People saw it as a symbol of the new king's good luck and a gift from God (ibid). However, the estimate of the reserves was far too high—there was only a negligible amount of oil— and it brought embarrassment to the presumptuously exuberant country. Still, the hope for discovering oil remains high, and Morocco continues to incentivize exploration in hopes of securing a valuable export commodity.

The implications of energy policy in this time period are that increasing local electricity access in the social pact came at a high cost for Morocco as a fuel-poor nation. Trade-offs of increased energy access included steadily deepening energy dependence, subsidies on electricity and butane gas that strained the state's budget, and a significant trade deficit as Morocco imported almost all of its coal, natural gas, and unrefined petroleum products (Debbarh, n.d.). Starting in 1973, Morocco's petroleum bill exceeded its revenue from phosphate exports. Energy dependence increased from 73% in 1970 to 85% in 1980 to 97% today (Debbarh, n.d.). Moroccan became both heavily energy dependent and heavily indebted to development banks.

In summary, the social pact for electricity in post-independence Morocco pursued the large-scale state-controlled technological visions of the Protectorate era and established expectations that the Moroccan government would construct large-scale energy systems tied to the irrigation of one million hectares of land, feeding a nation, and developing an agricultural export policy while bolstering the state's sovereignty. Immediately after independence, Morocco's social pact for energy focused on its provision from an increasingly state-controlled apparatus in order to put Moroccan resources back in Moroccan hands. This changed with the neoliberal trend, as electricity was increasingly privatized based on international pressures. As Morocco moved beyond the years of lead, the newest part of the pact was a promise for the state provision of universal access to electricity to be achieved within a relatively short time period, balancing domestic use with a yearning for a fossil fuel export commodity. Numerous centrifugal forces and dynamics affected the pact, including international energy trends (1970s oil crises) and pressure from multilateral development banks. With increased investment by multinational companies, energy dependence concerns, privatization, and new leadership, the pact started to change again in the 2000s.

Renewable Energy and a Changing Social Pact for Electricity

This section explores the future prospects of the social pact for electricity in Morocco as it pursues an ambitious renewable energy strategy and possible regional integration. Some aspects of the pact are new, while others reflect Morocco's past along with it challenges and contradictions, as Morocco is pulled in different directions.

The Arab Spring and a changing social pact. The provision of energy subsidies in Morocco is part of what Yousef (2004) and others have called the "authoritarian bargain," or the provision of public goods in exchange for limited or no political participation. This authoritarian bargain is on shaky ground across the MENA region since the uprisings that reverberated across the Arab world in 2010. These uprisings affected Morocco through protest organized by the February 20th Movement, composed mostly of youth contesting the social inequalities and inequities described above and a lack of political participation (Morocco campaign #feb20 #morocco, 2011). The government was not overthrown, and the Parliament, not the King, was the target of the protests (ibid). In 2011, Morocco established a constitutional commission to investigate changes to political institutions, which increased the power of the Prime Minister and Parliament over the monarchy (Maddy-Weitzman & Zisenwine, 2012). This change is a somewhat precarious balance between what Sater (2010) called tradition and modernity in post-colonial Morocco—between the long tradition of the monarchy and the newer parliamentary tradition.

Morocco's changing social pact for electricity fits into these broader social changes in the Arab world and the revision of the authoritarian bargain, largely through targeting energy subsidies. According to interviewees, in 2012, energy subsidies reached a crushing 6% of GDP and 80% of the country's total subsidy bill, or $5-6 billion. The subsidized price of electricity is not available (Vidican et al., 2013) and is more complicated to calculate than fuel subsidies, since electricity prices vary based on the time of day and season. Currently, electricity is subsidized both for industry and households (World Bank report, 2007). Electricity rates are structured based on consumption levels, with different rates for households in the 0-100 kwh range, 101-200, 201-500, and 500 and above (Debbarh, n.d.). Taken within regional context, subsidies are much lower in Morocco than in all other MENA countries except Palestine (RCREEE, 2013). Moroccan electricity prices are also higher than in neighboring countries due to Morocco's energy dependence, deregulation, and renewable energy development (ibid).

The most significant energy subsidy in Morocco is on butane, not electricity. Due to the efforts of the PERG to eliminate kerosene, life in Morocco runs on butane. The butane subsidy rate has remained the same as prices have risen. In 2012, a 12 kg bottle of butane cost about $17.20 (140 MAD) on the market and was sold for roughly $4.90 (40 MAD) (Vidican et al., 2013). The Moroccan government originally envisioned butane would be used for cooking, but by the 2000s it was also widely used for heating water, agricultural water pumping, and lighting (ibid). In 2006, butane gas composed 18% of Morocco’s consumption of petroleum products and had largely replaced kerosene lanterns (ibid).

Figure 51. Butane Gas used with a Portable Stovetop in my Apartment Rented in Salé, Morocco. Photo by Author.

The previous social pact that guaranteed these butane and other energy subsidies is crumbling, but government announcements to reduce energy subsidies are invariably met with protest. In April 2014, trade unions took to the streets of Casablanca to protest the reduction in energy subsidies and the end of wage increases that had followed the Arab Spring ("Morocco's unions protest austerity plans," 2014).

The Moroccan government is under pressure from development banks to balance the state budget and maintain its credit rating by eliminating these subsidies. Macroeconomists argue that the subsidies are inequitable because 80% of them go to the middle and upper class in Morocco who use more energy, particularly given that few Moroccan households can afford a vehicle. While the subsidies may be regressive, they are in some sense the largest transfers of power between the wealthy and poorer parts of the country (World Bank, 2011). Furthermore, poor households depend on the subsidies to afford energy and a reduction in subsidies could disproportionately affect them. In the summer of 2014, the Moroccan government signed a plan with ONEE to eliminate fuel subsidies but to provide 14 billion MAD to subsidize electricity rates over four years (Agueniou, 2014). Electricity rates will remain the same for households that use under 100 kwh of electricity per month and subsidies will be reduced for those who use more, which are presumably the wealthier households (ibid). The Moroccan government is attempting to renegotiate the social pact that provided cheap energy to its citizens while maintaining the stability of the state and support for impoverished citizens.

Developing Morocco's new renewable energy strategy: from nuclear to CSP. Moroccan plans for renewable energy are developing within this evolving social pact for electricity, which focuses on addressing key social challenges that threaten Morocco's well-being and stability while taking politically unpopular measures to reduce or eliminate energy subsidies. The Moroccan government is pursuing this through a renewable energy policy with multiple ancillary goals, such as job opportunities both for uneducated people and unemployed college graduates, the development of a supply chain manufacturing industry for CSP, the improvement of educational opportunities in renewable energy, and the prevention of rural exodus to *bidonvilles* where extreme poverty has bred religious extremism.

Morocco began reevaluating its energy policy in 2006, starting with a foresight exercise that became the *Prospective Maroc (Morocco) 2030* scenario studies. The High Planning Commission (*Royaume de Maroc Haut-Commissariat au Plan*) conducted these studies, which provided a nuanced look at how contemporary Moroccan energy policy was shaped and played an important role in formulating the country's new energy strategy (Royaume du Maroc Haut Commissariat au Plan, 2006).[149] The scenarios focused on four key questions important to Morocco's future social pact for electricity, as well as energy justice:

- What level of external energy dependence is tolerable for Morocco?
- What levels of technology risk will Morocco accept for obtaining greater well-being?
- What should be the role of the market and public regulation for improving social equity?
- How should Morocco balance public priorities between energy activities (like rural electrification) and other social activities with a redistributive effect (Royaume du Maroc, 2006)?

[149] They also conducted these studies for tourism and agriculture because they view these sectors as having the most constraints on sustainable development and competitiveness.

The report focuses on ensuring that economic development radiates over all of Morocco. Because universal electrification and access to butane had not yet been achieved, there was an energy gap at the heart of Moroccan society analogous to the digital gap in access to information technologies. They defined the social pillar of sustainable development as the impact of the price of energy on these vulnerable populations. They also framed energy justice in terms of equality with European levels of energy access, pointing out that despite its strong economic performance Morocco is nowhere close to achieving the well-being of its European neighbors, and it lacks widespread access to technologies like air conditioning and cars.

The *Maroc 2030* scenarios included 1) a reference scenario (business-as-usual), 2) a domestic energy self-sufficiency strategy, and 3) an open regionalism scenario. The self-sufficiency strategy focused on developing Morocco's domestic resources through public-private partnerships and improving overall industrialization. It depicted a future in which Morocco would be an emerging economy like China or India, imagining it will use the "engine of export" and comparative advantage from low wages to offset the trade imbalance through FDI.

The key difference between the self-sufficiency strategy and today's policy is that the scenarios placed more emphasis on nuclear power than CSP. In this scenario, Morocco envisioned adopting the technology that its colonizer, France, used to heal its wounded pride after World War II (as described by (Hecht, 2009)). Morocco has considered nuclear power since the 1970s when King Hassan II announced that the country would pursue it using the uranium in its phosphates, as part of his strategy for modernizing the country. Nuclear power has been viewed similarly in Morocco as it was in France, as a means of achieving energy independence and the development of economic clusters, an engine of economic growth, and an opportunity for reduced carbon dioxide emissions. In 2007, Morocco finished a 2 MW research reactor, for which it had received permission from the United States under a 2001 treaty. When the scenario study was conducted in 2006, ONEE was planning to construct a 900 MW nuclear reactor by 2017. In 2010, Morocco signed an agreement with France to advance its nuclear power ambitions ("France to help Morocco's nuclear energy drive," 2010). That same year, Morocco presented plans for two nuclear power plants under the Copenhagen Accord signed at COP 15 and developed the National Center for Nuclear Energy, Science and Technology (CNESTEN). However, Morocco's neighbors and its former colonizers have a strong influence on its policies. When Spain balked at Morocco's nuclear ambitions, the plans were shelved. Again, Morocco's energy future was shaped by the influences of international and regional actors.

As addressed in Chapter 3, CSP has risen during times when nuclear energy has fallen from favor, as a large-scale source of energy and a source of national pride. Today, Morocco's focus on nuclear power has been replaced with CSP. Solar energy officials express that nuclear power is no longer an option after the Fukushima accident. After Fukushima, a social movement called *Maroc Solaire, Maroc sans Nucléaire* (Solar Morocco, Morocco without Nuclear Power) formed to oppose nuclear power. A shift from nuclear power to CSP could signify a major disjuncture from the energy policy of Morocco's former colonizer.

On March 6, 2009, at the *Assises de l'énergie* conference, King Mohammed VI presented an updated renewable energy strategy.[150] The Moroccan Strategy for the Development of Renewable Energy and Energy Efficiency sought to increase installed generation capacity to 42% from renewable energy by 2020, split among 14% solar (2 GW), 14% wind (2 GW), and 14% hydroelectricity at a cost of $9 billion**.** As a result of this ambitious plan, half of the 15 large-scale renewable energy projects underway in the MENA region today are under development in Morocco (RCREEE, 2013). The Strategy also seeks to develop local sources of hydrocarbons and to achieve market integration with the Maghreb and Europe. Later, a strategy for energy efficiency was launched with the goal of reducing electricity consumption by 12% by 2020 and 15% by 2030, especially in transportation and buildings. Additionally, Law 309 implemented liberal reforms in the electricity sector.

The Moroccan Solar Plan and a changing social pact. Improving electricity access has been part of the social pact since the 1990s, but ensuring economic development from energy policy in marginalized areas of the country is becoming an important part of the new social pact for electricity in Morocco. While in the 1990s economic development was left mostly to multinational firms like ABB, today Morocco seeks to build up its R&D and economic capacities to ensure it achieves socioeconomic benefits from electricity development. As part of this initiative, the Moroccan Agency for Solar Energy (MASEN) was founded in 2010 as a quasi-governmental, quasi-private sector

[150] At the time of the *Maroc 2030 study*, Morocco's renewable energy and energy efficiency strategy focused on building 1 GW of wind and solar, increasing rural electrification, and providing energy for hammam fires (public baths) and pottery kilns, plus implementing 250,000 solar hot water heaters.

organization to put solar technologies on a level playing field with other energy technologies. MASEN is an example of what Victor & Heller (2006) call a "dual-firm," which is a company managed like a private enterprise that is often partly publically and partly privately owned and has the political connections necessary to develop viable projects. As evidence of its power, its offices overlook the Rabat neighborhood of Hay-Riad, "a haven for the upper and middle classes," (Elsheshtawy, 2008, p. 102), and it has also been successful recruiting engineers living in the Moroccan research diaspora back to Morocco to work on solar energy.

Their ambitious primary objective is to build 2 GW of solar electricity generating capacity by 2020, or 14% of Morocco's total generating capacity. MASEN takes a technology neutral approach among the various solar technologies. A MASEN official said "we are most interested in the price of the electron, not the specific solar technology." However, MASEN has had a clear preference for CSP from the outset. It is starting by developing two phases of proof-of-concept for CSP trough technology in Ouarzazate, with three hours of molten salt storage. Then it will test CSP power tower technology, followed by a small demonstration of large-scale PV. CSP has the trade-off of higher investment and fewer jobs but with export potential and storage (Vidican et al., 2013). It is also more compatible with the grid and generates energy through molten salt storage during Morocco's peak hours.

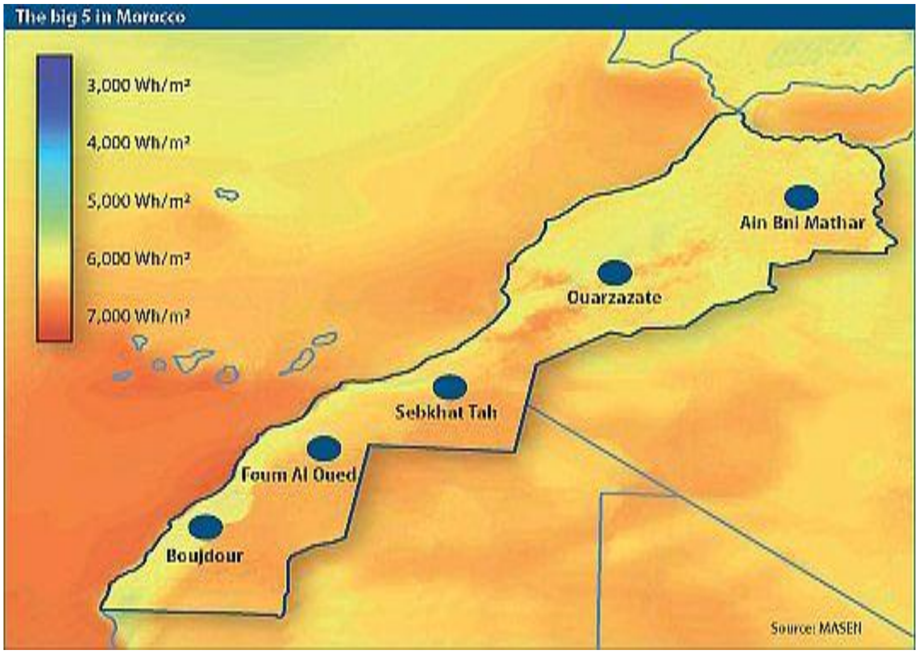


Figure 52. The Moroccan Solar Plan's Five sites and their Levels of Solar Irradiance[151]
Source: Moroccan Agency for Solar Energy.

MASEN will develop CSP at five sites, starting with 500 MW in Ouarzazate, followed by 400 MW in Midelt, 500 MW in Foum Al Oued, 500 MW in Sebkhat Tah, and 200 MW in Boujdour for a total of 2 GW (see *Figure **52***). *Figure 54* shows the locations of Morocco's hydroelectric and thermal power plants, illustrating that many of its thermal power plants are along the coast and the border with Algeria, and much of its hydroelectric development is in the Atlas Mountains, the country's poorest region. MASEN is attempting to address spatial inequalities in the country between the wealth in urban areas and the poverty in rural areas.

MASEN is therefore invested in addressing the social needs in the regions in which it works. Reflecting the framing of system imaginers described in Chapter 5, MASEN sees itself as an "animator, enabler, and catalyst." In contrast to Dii, it sees itself

[151] Solar irradiance is the amount of solar radiation measured in watts reaching Morocco within a square meter over one hour.

as a catalyst not just in accelerating technology development but also in promoting socioeconomic development in Ouarzazate and the surrounding areas, linking MASEN to the social goals of reducing unemployment and rural exodus. “Our project should have an impact from kilometer zero to kilometer 1,000—the entire country,” said one MASEN official. He continued, “since there is a negative correlation in Morocco between solar radiation and development, we are working in the poorest areas of the country.” Socioeconomic development initiatives are also necessary to bolster MASEN's public image and gain public trust for a government agency dramatically altering regional land use by consuming a plot of land the size of the city of Rabat in a relatively isolated rural area and altering the local economy. A MASEN official stated

> …one of the most important aspects of the Moroccan Solar Plan, is the development of.. the region where we are implementing [sic] [the project]. It's a fact that the most suitable parts [of the country] to develop solar energy in Morocco are the places where you have no other industry— no other economic sector that is developed and the region is very poor…we drop a very huge investment in this region, and the local population can be stressed by [sic] that.

Some of the development work is directly related to the project site. For example, the World Bank’s environmental assessment of the Noor CSP plant in Ouarzazate claimed that the site’s infrastructure was designed to be accessible to nearby villages. This included increased access to roads, water, and electricity. MASEN has also undertaken charity work in the Ouarzazate region, such as providing bicycles, glasses, dentistry, and school buses for local children, as well as supporting the boarding school for girls in Ouarzazate. MASEN is particularly focused on women and girls in the region who have less access to education and entrepreneurial activities than men. They have also hosted entrepreneurship workshops in Ouarzazate unrelated to solar power to spur economic development. However, one interviewee from MASEN cautioned that they were not meant to replace government development agencies. Interagency collaboration would be useful in this context, but it is challenging because King Mohammed VI controls MASEN and political parties control the ministries that work on development. Chapter 7 will discuss local perspectives on solar development.

In addition to building solar energy capacity, the king integrated three other ambitious ancillary goals into MASEN's strategic mission in a framework called “integrated solar development”. These intermediary goals are rarely part of the conversation about integrated renewable energy infrastructure in the Mediterranean but are essential to meeting Morocco’s social pact for energy. They seek to address the general social and energy problems described above as part of an evolving social pact for electricity in Morocco. This includes, for example, energy dependenccy and the trade deficit, rural exodus, and unemployment for both educated and uneducated demographics.

First, MASEN is required to create a local workforce in the solar sector. Some of the low-skilled construction jobs will be targeted toward the uneducated workforce in the region in which they will be building the plants. MASEN will also support educational opportunities to grow a skilled workforce through new educational programs related to solar energy (see Appendix I). This envisions Morocco as a future knowledge economy, in which it no longer has low labor costs but has developed enough R&D to industrialize.

Second, MASEN must develop related industries in Morocco to ensure the majority of the materials (e.g., mirrors, steel, turbines) for the power plants come from local sources. Thirty percent of the plant's material must come from local content. From a private sector perspective, this increases the projects' risk because the projects are dependent on fledgling enterprises, which could result in schedule slippage and cost overruns. However, at the 2013 Dii conference, the head of ACWA Power argued that they were able to submit the lowest bid for Noor I because they used 50% local content to bring down the electricity price to 15 euro cents per kilowatt hour, half of what solar electricity costs in Spain. The head of ACWA Power then became invested in the success of Moroccan industries stating, "I need to pray every day for the wealth and success of Morocco so I get my money back [from investment in the power plant]."

MASEN's third goal is to conduct research and development to create "disruptive technologies" that reduce the cost of solar power. MASEN views R&D as necessary to solar energy's "survival" especially since it must now compete with newfound Moroccan shale gas deposits rather than other renewable technologies. The German Aerospace Center (DLR), which conducted the Desertec feasibility studies, will partner in the creation of the Institute for Training in Renewable Energy and Energy Efficiency, an R&D platform in Ouarzazate similar to the PSA in Spain at Almería that was discussed in Chapter 3. Morocco could currently build cheaper renewable energy with PV and wind but is taking a chance that it could become a global leader in CSP technologies and research. By developing different kinds of solar technologies in Ouarzazate, MASEN will identify Morocco's specific solar R&D needs. This would being to move Morocco away from the "copy-apply" model identified above as a challenge in its R&D sector toward capacity building for becoming true collaborators in international R&D projects and competitors in the international solar energy industry.

All of MASEN's primary goals, and the goals of Morocco's renewable energy strategy in general, are socioeconomic, not environmental. Moroccan electricity agencies view climate change as an opportunity for attracting finance and demonstrating Morocco's prowess in renewable energy technologies, especially as Western nations have largely failed to develop renewable energy to scale. The new Minister of Energy stated at the Dii conference that "the carbon emissions market is an opportunity for Morocco to finance clean projects."[152] Therefore, climate change is seen as an opportunity for attracting the capital needed to grow Morocco's electrical power system, even while Morocco's energy policy focuses mostly on social rather than environmental goals. Morocco also expects to reduce its carbon dioxide emissions by 3.7 million tons per year through the Moroccan Solar Plan, which they emphasize is a noble and voluntary effort made when the nations responsible for the problem are taking fewer mitigation steps. Morocco emphasizes that it is developing the technology to do the right thing even though Western nations have not. Furthermore, since European countries value green electrons as goods in-and-of-themselves, green electrons possibly will provide the export commodity for which Morocco has been long searching. Green electrons are valued in Morocco more as an export commodity than for their contribution to the environment.

---

[152] *"Le marché des émissions de gaz à effet de serre est une opportunité pour le Maroc pour le financement des projets dits propres."*

Morocco's socioeconomic goals for CSP and its CSP development strategy suggest that Morocco sees CSP as an emerging technology. In Chapter 3, I discussed CSP's long history as an emerging technology dating back to the 1850s. In Chapter 5, I described how in the 2000s Desertec proponents framed CSP as mature and ready to deploy because they wanted to reduce its appearance of risk. Overall I argued that the perspective on innovation in the electricity sector in the West is to carve out a space for a deferred dream to take root, rather than to develop innovative technologies. In contrast, Moroccans frame CSP as emerging and in need of R&D for its survival. While the term innovation is lacking in the Desertec discourse, it is common in the Moroccan discourse on renewable energy. This makes sense, as Morocco is focused on CSP because of its possibility for building up the capacity to grow into a future knowledge economy with greater industrial, R&D, and educational capacities.

In Chapter 3, I argued that a technology's emergence should be understood as situated and contested. At the nation-state level, a technology's emergence relates to a country's goals for renewable energy. Morocco wants to be involved in renewable energy innovation, so that emerging technologies will bolster the country's Emergence plan to develop the future of Morocco as a knowledge economy. In contrast to Desertec, it behooves Morocco to view CSP as an emerging technology for Morocco, offering opportunities to help it industrialize through supply chain industries, education, and R&D. This is similar to Spain's focus on CSP in the 1980s at its Solar Research Platform, which the Spanish government viewed as an opportunity for an Industrial Revolution and for fostering national pride during a time of political transition.[153] What counts as an emerging technology should be historically situated and interpreted in the context of how a country imagines a modern electricity system. What would also be innovative for Morocco would be to develop an R&D agenda for CSP that is Moroccan, which balances its identity with meeting technological and development goals. Hecht (2009) argued that the footprints of French national identity were woven into its nuclear reactor design. Morocco has not yet reached the point at which it has shaped the technology as its own and is developing the capacity to do so. An initial step in creating this national identity for CSP was the King renaming the Ouarzazate I power plant in Arabic Noor, which means light.

Overall, MASEN's ancillary and financial goals for CSP reflect the new social pact for electricity, which focuses on solving socioeconomic problems such as unemployment and rural exodus, while reducing the energy subsidies that used to be part of the "authoritarian bargain" but threaten the state's solvency because Morocco is fuel-poor. Success in Moroccan renewable energy development will be measured by the creation of a new energy industry, rather than energy generation alone or environmental benefits. Several interviewees explained that without the achievement of these ancillary goals, Morocco might as well generate electricity through other means with which it has more experience, like coal. An employee in the electricity sector in Ouarzazate expressed that energy is not a good in-and-of-itself but rather a means of developing a national industrial fabric through renewable energy development.[154] However, according to one

[153] See Chapter 3.
[154] *L'énergie de son importance n'est pas une finalité en son soi, le Maroc mise tout particulièrement sur*

interviewee, CSP's payoff in local jobs is uncertain, and these ancillary goals are putting the young agency under pressure. Morocco is taking a significant political risk with CSP as it sets high expectations that CSP can fulfill myriad socioeconomic benefits.

Table 5 ties MASEN's goals to Morocco's broader societal goals.

Table 5.

The Socioeconomic Goals Underpinning the Moroccan Solar Plan

Moroccan Energy goals	Social goals
Meet doubling of demand →	Energy access, increasing standard of living
Green jobs →	Unemployment both for educated and uneducated demographics
Grow an industry/ local content →	Industrialize Morocco, fight unemployment
Local socioeconomic development →	Stem rural exodus
Grow R&D capacities →	Grow a knowledge economy
Reduce subsidies, trade deficit →	Governmental stability, economic health
Reduce CO_2 →	National pride, means of securing financing
Green electrons →	Export commodity

Financing the Moroccan Solar Plan. Morocco is focusing on solving socioeconomic problems through its solar energy policy while simultaneously eliminating state energy subsides. The Moroccan government will not enact a feed-in-tariff (FIT) or other program that would result in large energy subsides, as was enacted in

une intégration industrielle permettant l'augmentation de la participation du tissu industriel national dans le développement des énergies renouvelables.

Spain and Germany,[155] because it would be contrary to the goals of their new social pact. This reflects the general sentiment in the MENA region, as only Syria and Palestine have FITs (RCREEE, 2013). However, ONEE will have to subsidize the difference between the price of the solar electricity and the subsidized grid price. MASEN took several steps to reduce costs, including requiring project developers to provide 20% of the project capital (130 million euros, or $177 million) and to rely on concessional financing from development banks.

Noor I was financed through grants and loans from international development organizations, and it is likely that they will finance the subsequent phases as well. The Moroccan government and, in small part, private banks will provide the remaining financing. Concessional financing is provided at an interest rate of 3.5% rather than 8% from private financiers, which will ultimately reduce the price of the electricity by 20% according to MASEN. These initiatives brought the initial projected cost of 20 euro cents per kilowatt hour down to 14 euro cents per kilowatt hour. The government will subsidize the difference between the cost of the electricity and the grid price, or a gap of about 2 cents per kilowatt hour during peak demand (ibid). Morocco's requirement that the bidders provide 20% (130 million euros) of the capital for the project made it challenging for many European companies, which were struggling due to the financial crisis and repeal of European solar subsidies, to place a competitive bid.

ACWA Power's subsidiary NOMAC won the bids on Noor I and II, along with two Spanish construction firms, but according to the Moroccan magazine, *Economie Entreprises*, they are only responsible for about 5% of the project. ACWA Power— a Dii

[155] See Chapter 5.

shareholder company— is a Saudi utility and water desalination company with a new focus on renewable energy, and a dual market firm controlled by the Saudi government. Morocco is the primary North African location for Saudi investment, especially in public works and infrastructure, including large investments in Morocco's energy system in addition to being a popular vacation spot for Saudi princes (Howe, 2005). Some solar industry experts were shocked by ACWA Power's low bid on Noor I, which was 29% below other bidders (“Plan solaire marocain: Masen sous pression,” 2013). *Economie Entreprises* reported that the Saudi state investment funds, Sanabil and the Saudi Agency for Public Pensions, provided the necessary capital, meaning it was not provided under free market conditions but under an agreement between the governments of Morocco and Saudi Arabia. The Saudis are planning to build 42 GW of solar power by 2032 domestically, and Noor I will serve as a pilot project for them. Some people are concerned that this collaboration between governments in the MENA region could lead to a rentier model for solar power in which government elites benefit from investment but not local people and the economy focuses on a single natural resource for export. This model could be contradictory to the prospects for fulfilling the social pact for electricity in Morocco. Of course, the goals between the oil-rich and oil-poor countries in the region for renewables are quite different.[156] The switch to renewables in Saudi Arabia would free up oil that it can sell for over $100/ barrel on the international market rather than subsidizing it at home at $4/barrel for electricity generation. In Morocco, it means greater energy security by reducing dependency on fossil fuel imports and possibly developing an export that is a source of geopolitical power.

[156] See Chapter 4.

If Arab countries continue to develop a sense of national pride for the solar sector, as Spain and Germany did, the technology with its strong Judeo-Christian roots, as described in Chapter 3 with the discussion on Luz Energy, could develop an Arab identity. In June 2013, King Mohammed VI visited the Ouarzazate site and renamed the solar plant Noor I, reflecting Morocco's renewed focus on making Arabic the national language. Now that ACWA Power has also won the bid for Noor III, it seems that Arab companies are poised to take over the CSP sector. If they reduce the cost of the technology while European CSP companies continue to lose bids and to falter due to the elimination of subsidies in Europe, the European CSP sector may crumble.

A growing chorus from Europe claims that renewable energy will only thrive in the Mediterranean if North Africa's power sectors are liberalized. Yet so far renewable energy has achieved more success developing in a dual-market system in which ancillary social goals are the focus of renewable energy development, and renewable energy development is symbolic of national pride and national identity.

Centralized systems, modernity, and citizenship. Morocco's renewable energy strategy, with its focus on large-scale CSP, wind, and hydroelectricity, illustrates that a modern electricity system for Morocco is still conceived as a centralized system. With the dawn of the Moroccan Solar Plan, solar energy became enrolled in large-scale energy planning and nation-building.

Distributed solar technologies have received very little attention compared to CSP (RCREEE, 2013). Morocco lacks the policies that would be needed to develop a distributed electricity system. It does not have a net metering system, which would allow owners of rooftop PV systems to receive credit for surplus energy generated during the day and fed into the grid. Additionally, small solar PV plants under 1 MW cannot access the grid. According to RCREEE (2013), "The current legal framework does not authorize renewable energy developers to access low voltage lines, which generally prevents development of small-scale grid-connected RE projects" (p. 29).

Prior to the Moroccan Solar Plan, solar PV panels were framed not for the elite as they are in the United States but for the poorest, most marginalized and remote homes that could not be connected to the grid during the PERG program initiated by King Hassan II (see above). For example, *Figure* ***53*** shows a nomad tent in the Moroccan desert with a small solar PV panel. I found a similar outlook in rural Ouarzazate. PV was framed as a technology appropriate for the poorest and remote communities, and grid access was desirable. Over lunch at the Dii 2013 conference, Bertrand Piccard recounted how the villagers he met were convinced that “the cable” was the only desirable method of electricity access. He tried to convince them that PV could be equally desirable and modern.

Figure 53. Solar Panel Near a Desert Nomad Tent Outside of Merzouga, Morocco. ONEE owns the solar panels, and residents buy prepaid cards for the electricity. Photo by Lynnsee Starr, used with permission.

Some focus has been placed on a distributed solar hot water market to reduce demand for butane, but solar hot water has mostly been used in hotels requiring large quantities of reliable hot water (RCREEE, 2013). I interviewed a citizen who wanted to install solar hot water in his apartment but found it to be too difficult to find a distributor and someone to maintain the system due to the informal market. Solar hot water faces stiff competition from water heaters that run on heavily subsidized butane. The new Minister of Energy is more supportive of distributed energy, so it is possible the focus on distributed energy will increase in the future ("Des centrales photovoltaïque pour l'espace local un gain pour les citoyens et pour l'état," 2013).

Some people are critical of the centralized nature of Morocco's renewable energy plans and advocate for energy policies for improved energy citizenship, meaning citizen engagement and ownership over energy development, and distributing power among private and public actors rather than increasing financial ties with and indebtedness to Saudi and other foreign companies. The head of the Sahara Wind company in Morocco stated

> CSP poses a governance risk by keeping the current power structure intact, by purchasing steam turbines whose technology cannot be transferred from industrialized countries with funding provided by a rentier state, which is giving away its fossil oil resources in the exact same way...

He believes such technologies will continue to have authoritarian and anti-democratic properties, even if they utilize renewable fuels. Additionally, the head of a dual market firm in Morocco explained that it was important that energy development in Morocco offer paths for people to become empowered as full citizens who care for common pool resources. He stated

> What is important is to create the conditions for all these people to become citizens. And citizenship for me is critical— very important— to make people aware of that and to offer them, to all people to offer them the chance to be citizens. As simple as that. Sensible. That's why concerning [our company]— all what we may address as projects and systematically ask one question to our directors— how do you guarantee the social return for any investment? If a social return is possible, then we do it.

This is an entirely different viewpoint on what citizenship may be within a post-Arab Spring context. Such a perspective on citizenship would likely change the social pact for electricity into a social contract with the consent of citizens. The literature and practitioners typically find that such citizen empowerment in energy development is gained more readily from distributed projects. Below I take a closer look at centralized plans for solar energy in Morocco and the Mediterranean region and their benefits and drawbacks. Chapter 7 will then explore the challenges of energy citizenship and empowerment in large-scale energy projects at the local level and the implications of these projects for energy justice.

Solar farms and Morocco's dam policy. Morocco is grappling with its image as an agrarian society versus a future, imagined by some, that it will become an industrialized nation, a knowledge economy, and a center for exports to Europe traded within liberalized, regional markets. Today, the agricultural sector makes up 21% of Morocco's GDP, employs 38.7% of the population (including forestry and fishing), and comprises 40% of exports. Morocco is developing the industrial policy discussed above to build a knowledge economy—attracting FDI, building technology parks and call centers, improving training opportunities, and developing new industries like renewable energy.

An official from MASEN explained that historically Morocco's power plants have been built on the coasts and the "veins of the grid inject energy into the mountainous areas." The Moroccan Solar Plan would reverse this situation with the mountainous and desert regions becoming the major energy producers. It is true that thermal power plants have long been built on the coasts all the way back to the initial Roches-Noires coal-fired power plant in the coastal city of Casablanca described above (see *Figure 54*). However, the mountains have long been sites of renewable energy generation (dams) due to the perception that they are a "chateau of water." The Moroccan Solar Plan therefore fits into the *politique des barrages* dam building policy dating back to King Hassan II's rule and even to the Protectorate.

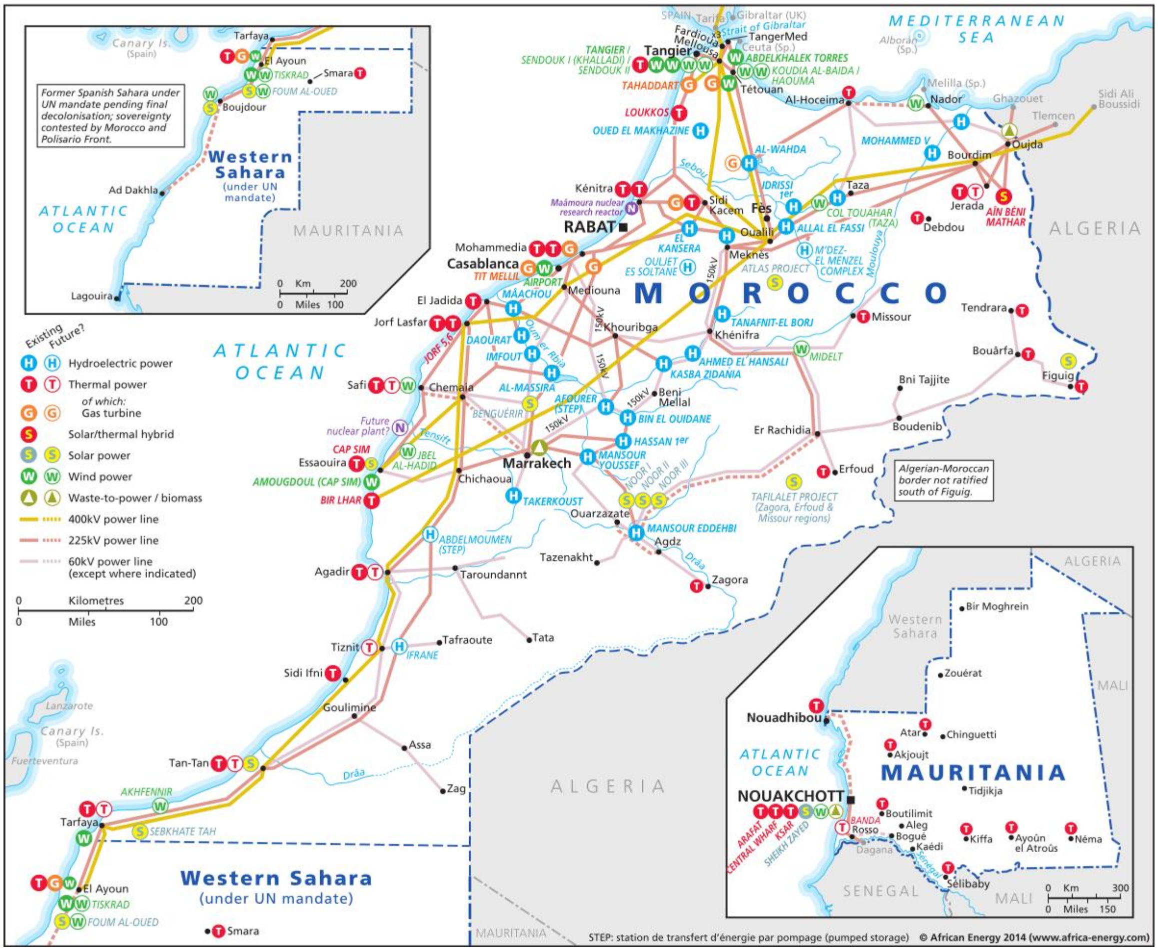


Figure 54. Moroccan Power Plants. Source: Cross Border Information. Used with permission.[157]

CSP policy illustrates how Morocco in its political development continues to balance King Hassan II’s declaration that “we shall graft the past onto the present to prepare for the future” (as quoted by Roberson, 2014, p. 57). CSP straddles the gap between Morocco’s identity as an agrarian society versus its imagined future as an industrialized society. I illustrated in Chapter 3 that the framing of CSP as a solar farm has persisted over a century and a half. Under the Moroccan Solar Plan, solar farms would harvest sunlight to make the desert bloom while growing a domestic technology

157 http://archive.crossborderinformation.com/Article/Morocco%27s+power+sector+infrastructure.aspx?date=20141130&docNo=4&qid=1#

supply chain and a potential commodity for export. Noor I will utilize water from the Mansour Eddahbi dam, built in 1972 for irrigating 19,000 hectares, controlling floods, and generating electricity (Swearingen, 1988). Put differently, Noor I is a solar farm irrigated by the *politique des barrages*, making the desert bloom with green electrons that could one day be exported to Europe.

The goals for agricultural export under the 1970s dam policy are nearly the same as the goals for energy export today—to earn foreign currency, to develop an industry, and to raise the standard of living in rural areas to prevent rural exodus. The vision that Morocco will one day export large amounts of green electricity to Europe is similar to Morocco's long-standing ambitions to become a major agricultural exporter to Europe. Under the Moroccan Solar Plan, Morocco imagines itself as a future exporter not of technology but of commoditized electrons. Oil, or other fossil fuels, would offer a similar export commodity but it would not provide the balance among the past, present, and future that CSP farming does.

Solar farming balances tradition and modernity in contemporary Morocco. For example, there is a long tradition of viewing the King as builder, who leaves a lasting imprint on the country's infrastructure by transforming a place from quaint to high modernist (Elsheshtawy, 2008). When new infrastructure projects are completed, the king comes to inaugurate them. *Figure **46*** illustrates the groundbreaking ceremony for the solar portion of an ISCCS natural gas plant in Morocco, with the king inaugurating the power plant. Such events still include the traditional hand-kissing ceremony, which has generally fallen out of favor as old-fashioned in Morocco (Boukhari, 2013). Dam building therefore becomes not the work of Moroccan or foreign engineers but the work of the king. Dam building was also viewed as a project of agriculture not a project of large-scale technology.

Unlike Desertec Design I, CSP is seen in Morocco as emerging. But similar to Desertec Design I, a modern electricity system is seen as one based on farming. This illustrates a balancing between the past and the present that is absent from Desertec Design II. The Desertec vision frames innovation as the achievement of a deferred dream, the end goal in the inevitable march of technological process, while the Moroccan vision relates to a delicate balancing among the past, present and future. CSP is a hybrid of tradition and modernity.

The country's agricultural focus is problematic because, as illustrated above by the history of Morocco's relationship between its capricious water resources and agricultural development, the country suffers from persistent droughts making it difficult to grow traditional crops, e.g., olive and almond trees. The water-energy nexus has long challenged agriculture and energy in Morocco from the myth of the Granary of Rome onward. As a young Moroccan policy analyst stated, "people see Morocco as an agricultural society, yet we have no water and we're well positioned within the region to excel at other exports." An interviewee from ONEE said

> The problem is that today water, it's a resource that's rarer and rarer. And so, the dam policy was really successful in the past but today we cannot continue to count on the dams for responding to water needs. It is necessary to go toward different procedures….like water desalination… but these procedures are …consumers of electricity….when we think of the future, when we reflect on the

availability of water, we must think about the availability of energy for responding to the availability of water.[158]

Chapter 7 will further illustrate the challenges of the energy-water nexus and will further explore solar power as part of *la politique des barrages*.

Mediterranean Systems Integration and the Social Pact

This section addresses the prospects for the Desertec vision in the context of the evolving national social pact for electricity in Morocco. As electricity grids begin crossing nation-state borders across the globe, how will it affect the promise states make to their populations about the distribution of the societal benefits and burdens of electricity development? In my fieldwork, I found strong support for regional energy integration and renewable energy exports among Moroccan government officials. Furthermore, many Moroccan policy officials viewed Morocco as unfairly excluded from the European electricity market. They are generally supportive of exporting electricity to Europe in the medium to long term, but some interviewees spoke of inequities stemming from the top-down way in which the Desertec vision was institutionalized. They want to develop mutually agreed upon terms that avoid coercion but also allow access to European markets.

---

[158] *Le probleme c'est que aujourd'hui l'eau, c'est une ressource qui est de plus en plus rare. Et donc, la politique des barrages elle a tellement bien reussi dans le passe qu'aujourd'hui on ne peut plus continuer a conter sur les barrages pour repondre aux besoins en eau.Il faut aller vers des procedes differents.*

The open regionalism scenario in the *Maroc 2030* studies viewed the most desirable future for Morocco as one in which it is deeply integrated with its neighbors' electricity systems. It envisioned extensive electricity interconnections with Europe and the Maghreb, which is similar in principle to the Desertec vision. Morocco has significant potential to export green energy to Europe to improve north-south solidarity and the intermittency of renewable energy, as well as to preserve the environment and reduce emissions under the Kyoto Protocol, of which Morocco is a signatory. The report concluded that the regionalism scenario would be the most positive for sustainable development, but it expressed skepticism about the scenario's feasibility because it would require the reactivation of Maghrebian collaborative processes through the Arab Maghreb Union, which has only met once since 1996, in addition to the North-South cooperation. The report criticized European countries for cooperating with North African countries on a bilateral basis rather than encouraging co-development within the Maghreb, although some multilateral organizations exist.[159]

MASEN supports the eventual regional integration with the EU grid and the export of solar electricity after meeting its 2 GW (2,000 MW) goal. A representative from MASEN stated, "for us, 2,000 MW is only like an appetizer…especially if we reach grid parity." (Grid parity is reached when the price of solar power equals the market price for electricity.) Dii's CEO Paul van Son said that Morocco was the first country to approach

[159] Morocco is a member of the Euro-Mediterranean Forum and the facility for developing gas and electricity interconnections. At the time of this study, Morocco had recently signed the *Intégration du marché maghrébin de l'électricité* with Algeria, Tunisia, and the EU to further integrate the grids among the countries and possibly export electricity to Europe through a liberalized market. The Maghrebian market for electricity is still under discussion today, and a presentation by Algerian Sonelgaz at the Paving the Way for the Mediterranean Solar Plan conference in Rabat argued that such a market is possible and should be pursued.

the Dii when it was established. At the 2013 Dii conference in Rabat, the new Moroccan Minister of Energy stated

> ‘The EU has moved toward renewable energy legislation and creating an institutional environment for renewable energy. The south of the Mediterranean has also put ambitious plans for renewable energy in place and growing an electrical market. Our signature indicates that we support this market. We wish to share between north and south of the Mediterranean.' "With these interconnections with Algeria and Spain, we’re geostrategically positioned for playing a major role in the exchange of electricity with the Mediterranean.”[160]

One interviewee argued that once Morocco becomes an exporter of energy to Europe, it will become an industrialized country. Through the export of renewable energy to Europe, Morocco could fulfill the vision of becoming a knowledge economy.

Morocco as Electrically European

The fact that Morocco is tugged between the Arab world and Europe in terms of its identity and politics is reflected in its energy policy and system. This is illustrated in the contradiction that even as Morocco is building an independent sovereign renewable energy system based on national pride, it also adopts a European identity for its electricity system. Morocco’s energy sovereignty has been torn since the inception of its

[160] Single quote indicates a non-verbatim quote and double quote indicates a direct quote.

electrical power system—from choosing to continue the dam building plan started by the Protectorate, to pursuing nuclear power only to be stonewalled by the international community, to seeking international cooperation to ensure its electricity system will continue to be reliable while integrating high levels of renewable energy into it. Within a system context, CSP is a technology that would benefit from transnationalization or regionalization as it is scaled up, in order to maintain the centralized system configuration explained in Chapter 1 and ensure its reliability. Similarly, nuclear power for Morocco would have required support from Spain and international regulatory bodies.

Since there is a cable connecting Morocco to the Spanish grid under the Strait of Gibraltar, MASEN's view is that "Morocco is already electrically European." The Moroccan grid operates on the same frequency as Europe and "we produce the same electron as Sweden." An interviewee from ONEE emphasized the success of the interconnection between Morocco and Spain, developed in the 1990s as evidence of its European infrastructural know-how. Despite the skepticism of funders, operators, and many others, the interconnection worked well and its capacity was even later increased. He said that "Morocco is the first country to have the courage to construct interconnections with Europe" in the 1990s, and that the decision to pursue the "logic" of regional energy cooperation was made long ago. The first interconnection between Morocco and Spain was built in 1997 and was reinforced in 2006, and he indicated that Morocco is currently working on an interconnection with Portugal. He expressed that ONEE is very supportive of exporting renewable energy to Europe, but that it was necessary for Europe to implement mechanisms that favor the transfer of energy. He stated "it is necessary to create an example today, one can consider that Morocco is a country integrated into the European market, because it is interconnected to the European market."

The Spanish transmission systems operator does not see Morocco as electrically European because its electricity sector has not been fully liberalized. Morocco is the only country in the MENA region that has attracted private investment in renewable energy, but they do not yet have an independent energy regulator. They are only welcome in the Spanish grid as a market player, not as a partner. As detailed in Chapter 5, Dii's vision of a copper plate in the MENA region might work technologically, but areas of political resistance in Spain and social resistance in the Pyrenees between Spain and France would likely stop electrons from flowing out of Morocco.

While the Spanish TSO viewed Morocco as having different infrastructure from Europe, Morocco viewed political problems in Europe as impeding the vision for regional integration. A number of interviewees said that politics in Europe, rather than in North Africa, were blocking energy export. An official from ONEE stated, "We are convinced by regional cooperation through the development of these two components—namely interconnections and renewable energies— to enhance the energy needs. But it is also necessary for the European electricity grid to develop, to avoid having electrical islands in Europe, especially between Spain and France." [161] From the Granary of Rome vision onward, politics in France and Spain have affected Morocco's export economy. An

---

[161] *Il faut creer par exemple aujourd'hui, on peut considerer que le Maroc est un pays integre au marche europeen, parce que il est interconnecte au marche europeen. Et nous sommes convaincus que la cooperation regionale passe par le developpement de ces deux composants a savoir les interconnections et les energies renouvelables pour valoriser les besoins energetiques.*

advisor from the Ministry of Energy emphasized that Morocco and Germany could have a successful bilateral cooperation on electricity transfer, but Spain and France are in the way. They perceived a reduction in enthusiasm for energy integration following the economic crisis and decided that they could proceed faster alone than waiting for European companies to develop projects.

MASEN views Desertec as a good and simple concept to produce electricity where it is cheapest and to transmit it over HVDC lines. However, the conditions for export must be right, MASEN explained, as the issues go "way beyond electricity" to matters of geopolitics, security of supply, and the economic crisis, with 35% of Spain's power plants shut down due to lack of demand. Achieving an agreement between Morocco and 27 EU countries would be very complex. They emphasize that Desertec is a concept or a vision for the distant future and decline to estimate when power export might be achieved.[162] They fault Dii for setting unrealistic time expectations, even within the consortium, and they cite high staff turnover as evidence that expectations were not met internally. They think that Dii is moving away from exports because the investors' expectations for how quickly exports could be achieved were not met. More proof-of-concept in the form of political and regulatory frameworks that lay the groundwork for regional integration would be required, but, as discussed in Chapter 5, Desertec has had the least success with this form of proof-of-concept.

Human development or technology development?. Many people in Europe view market liberalization as a precondition to achieving a regional energy grid with high

[162] See Chapter 5 for a discussion on the temporal complexity of the vision.

levels of renewable energy generation. At the 2013 Dii conference, an official from the Moroccan Ministry of Energy stated that Morocco was liberalizing its grid so that it will be able to export to Europe. S/he said their objectives as part of Desertec and the Union for the Mediterranean were to support solar and to close the solar energy cost gap through exports to Europe, meaning that European subsidies would help Morocco to finance the cost gap between electricity from solar versus from fossil fuels. An official from ONEE emphasized the importance of access to the European market for financing renewable energy in the south:

> There is not a loser in this business, it's win-win, because on the southern side it will be a valorisation of renewable energy, so a means of supporting the development of renewable energy in the south, a supplementary support that permits a faster development of renewable energy in the south. In the north [they will gain] clean energy, available, and that allows the developed countries to reach their environmental objective that are more and more ambitious. So it's win-win.

Some in the development community focus on CSP in terms of human development needs, which would help to fulfill Morocco's social pact, while others focus on technological development, to bring CSP technology down the cost curve and then share the benefits of the technology across the globe. One side advocates for European development banks to make charitable contributions to CSP in MENA. The other side advocates for a market-based approach in which subsidized financing would be combined with energy exports to achieve a competitive market price for CSP. A representative from the German development agency BMZ said at the Dii 2012 conference:

> I’m from a development agency. My mandate and my immediate concern is the development of Northern African countries. …the needs there are immense— the need for electricity is very large and growing, production is lagging behind, and so the immediate need is to install capacity for the domestic need… as a development agency, we are not in the business of supporting export schemes.

An interviewee from the World Bank responded to this by expressing that charitable aid would be insufficient for developing CSP as a market feasible technology

> people who think that you can get the [technologies of scale from CSP] through aid funding don't know how little aid is available… or they don't understand how far down the cost curve CSP has to come. Every way we run the numbers, you can't get enough scale on the manufacturing side to bring down the costs to a competitive level without accessing the subsidized European market [through exporting the energy.]

While national and regional identities and national pride form around CSP, the World Bank frames it as a globalized technology that should be produced in the most geographically efficient regions in accordance with a Ricardian model of trade. They view CSP as a globalized technology producing an export commodity, flattening national identities for the technology. Were an electron to become a commodity, it would fit into a globalized export paradigm in which goods are exported even when they are not surplus goods, in other words when local supply has not been met even though local communities have shouldered the drawbacks of the production of the good. For example, once food became a globalized commodity, rather than a technology of national pride, countries exported significant amounts of food from places where people were starving or malnourished. Ensuring that local demand for electricity is met may ironically be valued more highly than meeting local demand for food. MASEN emphasizes that local electricity needs must be met before electricity can be exported; in fact even during the colonial era, the French emphasized that Moroccan electricity demand should be met before exporting to Algeria. If regional integration reduced access, it would violate Morocco's social pact for electricity, which has focused on improved access since the 1990s.

Energy security, regional integration, and multilateralism. The Moroccan government is focusing on developing renewable electricity from domestic resources to reduce its dependence on volatile oil prices. Despite this focus, Moroccan officials also perceived that the country would be more secure by increasing regional energy integration. An interviewee from ONEE explained that energy security for Morocco meant both developing national resources as well as regional interconnections and coordination mechanisms. There are two reasons for this perspective. The first is the now familiar idea that regional electricity integration is part of a system-level challenge in which Morocco would need interconnections to balance peak loads and to provide backup generation as it builds intermittent renewable energy.[163] The second is that regional integration appears to be secure for Morocco as long as it has its own fuels and its own export commodity. Once it has built up this capacity, it will not be in a position in which other actors in the region could easily coerce it. It is a testament to the promise of integration that Morocco views integration as more secure than importing oil. The caveat is the importance of developing the right kind of dependency that would put Morocco on secure footing.

Morocco's current interconnections with its neighbors are tenuous from a security standpoint. Morocco imports electricity from Algeria, but relations between the two countries are sour for numerous reasons, especially the Western Sahara issue, and the border between the two countries is closed. The Arab-Maghreb Union, founded to improve economic and political interconnections among the Maghreb countries, has only met once since 1996. At first blush, it appears that this case proves it is possible to have technological integration without political integration. However, the history described above illustrated that the French developed this transmission interconnection when they controlled both countries, and it became historically entrenched or path dependent. Morocco and Algeria cooperate best on energy issues, and the political tensions between the two countries impede deepening energy integration. Electricity integration in the absence of political integration lacks the security of supply that Morocco seeks to develop, especially if integration were to increase.

[163] See the n-1 criterion described in Chapter 5. Morocco avoided blackouts with electricity imports when it temporarily lost its coal-fired generation.

Positive political relationships and mutual trust must co-evolve with export for energy integration to be secure. A Moroccan energy professor who wrote a book in the 1980s about exporting wind energy from Morocco to Europe argued that good North-South collaboration is needed to enable export, in which the needs of both sides are satisfied and the social rift between North and South is closed. Although it is difficult to store electricity (and therefore to withhold it for political reasons), Europeans bear risks of security of supply, while Morocco, which negotiated unfavorable terms for the free trade agreements with Europe, seeks to become a better negotiator to improve its security (Dawson, 2009). By building up its negotiation and R&D capacity, Morocco will be in a better position to avoid being coerced by neighboring countries in integration processes.

As argued in Chapter 5, multilateral cooperation on standards and management is also needed to achieve a secure regional grid. Managing a fully integrated Mediterranean electricity market would give more power to the Mediterranean TSO, which would be needed to manage traffic on the transmission lines. When I suggested that the Mediterranean TSO would take over grid management, an official from ONEE laughed at me. He said that each country would continue to independently manage its grid. Within a regional market, all of the national TSOs would work with the same rules and the same conditions through an organization like METSO West, which includes Libya, Tunisia, Algeria, Morocco, Spain, Portugal, Italy, and France. “Because no one will accept it if someone else is to direct their grid,” he said. Yet Design II of the Desertec vision required regional management for a single energy market, and it would be impossible to develop if none of the countries were willing to cede grid management to a regional authority. Dii wants to depoliticize the electricity system by encouraging the creation of independent regulatory bodies in North Africa stating, "Case-by-case decisions [about electricity regulation] based on the discretion of public bodies should be kept to a minimum" (Desertec Industrial Initiative, 2012). This removes country's social goals and promises for electricity under the social pact from the equation and does not consider the history of the post-colonial process in which Morocco came to control its electricity system.

Desertec and Neocolonialism. In Chapter 5, I described the neocolonial critique of Desertec—as a European scheme to exploit North Africa's resources. In contrast, Dii's CEO Paul van Son stated in an interview with the Tripoli Post, "Your country [Libya] would never allow any more western industries to colonialize it. I cannot imagine it. There is no way of colonialism. Nothing will happen if a country doesn't like it" ("Renewable Energy is a Win-win Situation for Everyone, Says CEO of the Desertec Industrial Initiative (DII)," 2010) Van Son's quote implies that the neocolonial critique frames Africans as potential victims lacking sovereignty. Furthermore, if Morocco exported electricity under coercive conditions, it would not meet its energy security goals; in order for the situation to be secure, good relations among countries would be required. Van Son further argued that colonization entails taking something away from the country, whereas in Design II, countries will export a commodity that would be lost if it were not utilized. On one hand, overlooking the problematic history of North African collaboration and colonial era projects like Atlantropa[164] could perpetuate colonial discourses and stereotypes of North Africa and taint the Desertec vision. On the other hand, assuming that North Africans will not want to export electricity to Europe without

[164] See Chapter 3.

listening to their opinions and analyzing their visions is problematic. I found in my interviews more support for exporting renewable energy from North Africa to Europe than the European critics of the “neocolonial Desertec scheme” have assumed, but I also observed discontent related to the procedural justice of the design of the Desertec vision.

Some Moroccans distanced today’s collaborations with Europe from the colonial past. For example, the director of a Moroccan research center that facilitates cooperation between European and Moroccan researchers, whose grandfather played an active role in achieving Moroccan Independence, stated

> But generally, Morocco, we have no problem with our colonial past...It was our history....Now it's ok, we cooperate....no one said FDI is just French entrepreneurs using Moroccan workers. No, actually, they're bringing them jobs and know-how and opportunities to produce something meaningful.

This illustrates that branding all interactions between North Africa and Europe as neocolonial is treacherous, because it could preclude fruitful collaborations in which knowledge is exchanged and created and value is added to the economy.

Others were supportive of Desertec as a concept or idea, but were dissatisfied with the lack of avenues for North African participation in the development of the concept. Dii’s identity as a convener of stakeholders to discuss regional power systems was contested. An interviewee involved in energy research in Morocco encapsulated this point of view, stating

> the initial Desertec idea is an idea, is a proposition, an idea that might be pertinent…so the concept itself is interesting. Now, of course, it was the case with this concept that one plus one must be worth eleven. Because one plus one could also be one…in this context it could be a total benefit to the European side. This should not be the case…and Dii had as its objective a bad strategy…Dii's strategy was 100% commercial—it was European. And…the MENA region was only a tool for doing business, that's all. So, all must be added value (so one plus one is equal to eleven) and that the region benefits, be it through the creation of jobs, expertise, etc.….so personally I attended the meeting with Dii… where they said "and here we have a proposition, you will give us the best terrain in Morocco. And there, we will install the central power plants, we will take the electricity." So here is the proposition!...it can also be a form of colonization. I went, I took the best spot, I used it, *et voila*! That is it! And that's why I told you, there was a bad strategy or maybe there was not a strategy …and there was an amalgam. An amalgam between the Desertec Foundation, the Desertec concept, and the Desertec Industrial Initiative… This model is (I am sorry for the term, I will say it in English) bullshit. It's the right term….because the idea yes the idea is good, and it is maybe pertinent for both, for everyone etc., but the tool that was created because we thought it would help. On the contrary… it was not the right tool with the right strategy.

This quote illustrates that not all partnerships between Europe and Morocco are neocolonial and there is nothing intrinsically neocolonial about the Desertec vision itself, as I argued in Chapter 5. However, optimizing procedural justice is essential in north-south collaborations moving forward, especially considering the colonial past. He then expressed that what is really needed is global teamwork, rather than saying, “I decide and you provide.” Integrated projects are needed. This adds another layer to MASEN’s “integrated solar development” framing, in which North-South partnerships must be based on a just procedure and mutual benefit.

The head of the Sahara Wind company, a Moroccan wind organization, contrasted the initial use of the Atlantic trade winds in the Age of Sail, which brought together two continents— Europe and North America— in exploiting a third one (Africa) through the slave trade, to the more positive use of Africa’s renewable energy potential. The Atlantic trade winds, whose planetary circular movements over the ocean shaped its surface currents for millions of years, have pushed dead animal carcasses toward to coast of North Africa. These settled at the bottom of the Atlas Mountains. Their accumulation and subsequent sedimentation over time account today for 75% of the world's phosphate reserves.[165] He stated,

> By using the trade winds blowing over the Sahara desert to process their induced phosphate paleontological footprints into fertilizers, a new paradigm shift will occur in the ways natural resources are being accessed. Not only can fertilizers - essential to world food security- be decoupled from fossil fuels and their fluctuating price cycles, but resource transformation efficiencies can be tremendously improved. By generating local added-value in reaching out to the

165 US Geological survey commodity index summaries of 2013, 2014, 2015

> rest of the world's food plate, the remains of the world's largest predators transformed into fertilizers will have served a good revenge on our species' rather short-lived history of self-destructive planetary plunder.[166]

The interview was held on a day when images flooded the local news of sub-Saharan refugees who were trying to climb the fence from Morocco into its two Spanish enclaves while police beat them back. He highlighted the inequity between continents, stating,

> Ok. You're going to be exploited, through the slaves that are going to be taken and exploited in the U.S. and whatever resource you're going to have is going to be exploited by colonial powers, which will come thereafter. So with that hindsight, you have to see that those Atlantic trade winds mean a lot for mankind, and you do have to see that hindsight in order to improve the history, not re-write it but learn from it and say, ok. Are those winds just about two continents making fun of the rest of the world in exploiting its resources and peoples beyond limits? Or is there an opportunity to integrate another continent with a better story with a leadership that can look beyond... using perhaps a U.S. president that is black, and a new ambassador of the U.S. to Morocco that will be black…. And I think that you know, you cannot go into the 21st century with a doomed continent, a continent of people trying to climb a fence. You see that and you go like oh my God. You know this is the world we live in. And I don't think it's acceptable.

[166] Phosphates are mostly composed of large fish, essentially shark's and sea ray's remains.

While I argued in Chapters 4 and 5 that the Desertec vision is not intrinsically xenophobic, it could become so if people from both north and south are not treated as equals. Another energy expert said that as long as people think there are two classes of people within society, energy justice could not be achieved. Sahara Wind, which is funded in part by NATO, seeks to develop wind energy for Morocco and later for export through high voltage direct current transmission lines to Europe, as well as surrounding Maghreb countries.[167] Sahara Wind seeks to improve the access to the trade winds through integrative processes that will gradually make wind energy available for Morocco, Mauritania, and sub-Saharan Africa. Surplus energy would also be later used for export through HVDC transmission lines to Europe and surrounding Maghreb countries. Sahara Wind emphasized the importance of Moroccan, rather than European, ownership of these plans. In a postcolonial world, Morocco should be tied to Europe through a collaborative, equitable relationship rather than a coercive one. The director of Sahara Wind insisted this must come from Moroccan ownership of the process.

Unfortunately this is not how the process evolved in Morocco. After Dii and MASEN signed an MOU, the German Embassy held a press conference claiming the Ouarzazate power plants as Dii pilot projects. This created subtle animosity and led to

[167] Funding from NATO comes with the full recognition of the Sahara Wind Project's concept rights. It partners with the Moroccan and Mauritanian governments with the full recognition, co-funding and/or involvement of other multilateral institutions including: the United Nations Development Program (UNDP), the Global Environment Facility (GEF), the United Nations Industrial Development Organization (UNIDO), the World Bank, as well as academic partners and other companies including ONEE (with whom the Terms of Reference of the Sahara Wind Project's HVDC line have been established; ONEE provided co-funding for the study of the integration of the HVDC line into its grid and the subsequent evaluation of water treatment solutions using wind energy.) The Moroccan OCP Group's CERPHOS phosphate research center contributed to Sahara Wind's NATO research work. Other companies, such as the region's Telecom operators, provided access to their mast tower and other infrastructures. As the Sahara Wind Project involves applied research activities backed by governments and multilateral institutions, these institutions also endorse the intellectual property rights agreements.

significant media confusion between Desertec and the Moroccan Solar Plan. In contrast, Desertec's founder stated that even when foreign experts are consulted, Moroccans should take get credit for their work. "The less they give credit to others, the more it is their project and their responsibility, so I think this is the best that can happen…that they get the credit, even if it was inspired by someone else."

Considering these issues of capacity building involved in constructing a national system of innovation, Morocco's concept of integrated planning could be used to expand national learning systems theory. Viotti (2001) argued that processes of technological change in industrializing countries should be analyzed as national learning systems, not national innovation systems. Learning is the process of absorbing technologies, conducting incremental innovation, and diffusing the technologies (ibid). The Moroccan case study illustrates that this depiction of innovation may be overly combative. Technologies are neither absorbed nor transferred. Partnership and collaboration are involved as well as competition. As one interviewee expressed "no business will come to Morocco and transfer their know-how; this is merely false marketing. Working with foreign research teams is more likely to transfer know-how or to develop new knowledge." In the process of this collaboration the technology could be transformed to better meet domestic needs. The Moroccan depiction of integrated projects is a useful addition to national learning systems theory because it acknowledges the international exchange often involved in the process. It could also aid in thinking through how these partnerships could be improved to enhance north-south collaboration and improve the adaptation of technologies or the development of new technologies that aid in fulfilling the social promises made for electricity systems development. Capacity building in the area of industrial and R&D policy can help Morocco to avoid being coerced in north-south negotiations and technology-related partnerships. An integrated project would go beyond the “copy-apply” model to consider positive North-South partnership, the technology’s societal context, and the socioeconomic benefits.

Conclusion

In this chapter, I argued that energy plays an important role in political development in Morocco and other countries. The field of energy is not just technical but illustrates broader socioeconomic and political challenges in Morocco. These socioeconomic challenges are being integrated into an evolving social pact for electricity in Morocco. During the Protectorate, the social pact was largely negotiated between the Protectorate government and French colonists, which focused on providing benefits to French companies. Local access to electricity was not a priority and was in some cases forbidden in order to maintain the traditional characteristics of the medina for tourists. This lack of focus on energy for Moroccans, especially in the mountains areas, led to uneven development and inequities. After Independence, Moroccans sought to reclaim the state and consolidated the electricity sector under state power. King Hassan II continued the Protectorate’s dam building policies, interweaving agricultural and electricity policy. In the 1990s, as Morocco emerged from the Years of Lead, universal access was finally prioritized under the pact to address unequal access between urban and rural areas. Today, the pact is being renegotiated to address multiple socioeconomic problems facing Morocco, from rural exodus to the unemployment of skilled youth. Some Moroccans argued that a new concept of citizenship was needed to encourage citizen empowerment and participation in their energy future, which would move the pact toward being a contract with citizen consent. This will be further explored in Chapter 7.

A centralized electricity system has been viewed as the modern configuration of an electricity system from the Protectorate to the present. Distributed solar PV is framed as a technology for the poorest people in the country. This focus on centralized systems for Morocco fits well with the Desertec vision, which seeks to extend the centralized system logic across an entire region. Like Desertec Design I, Morocco also prioritizes building a centralized system based upon energy farming. This is because CSP as a solar farm delicately balances Morocco's agricultural past and present with a potential imagined future as a knowledge economy with a robust R&D and innovation sector.

To become a knowledge economy, Morocco is working to build capacity to ensure it is on a level playing field with European countries. Since Morocco's focus for CSP is on industrialization, MASEN frames CSP as an emerging technology in need of R&D, as opposed to Desertec's framing of CSP as a mature technology, in order to meet Morocco's specific needs under the social pact. Dii is hoping to speed toward an inevitable future of technological progress to develop technologies whose time has come in the present. In contrast, Morocco is balancing its past, present, and future within its electricity policy. Despite this, Morocco is supportive of the Desertec vision, as it aids in maintaining its centralized electricity system and providing energy security and reliability through regional integration.

The implementation of the Desertec vision would be more politically complex than has been appreciated, because it intersects with nation-states' social pacts for electricity, political development, and politics. The green electron is not a sufficient criterion for investment in North Africa as it is in Europe. Rather, individual countries' goals for renewable energy development must be considered in order to facilitate multilateral, or even bilateral, partnerships. The regulation of the system at a regional level is problematic, as the negotiation of electricity policy and standards is a matter of political development for individual nation-states. A Mediterranean regulatory body would be faced with navigating these varying goals and visions. This is true even though there is much more support in Morocco for regional electricity integration than I expected to find. Given Morocco's history of being torn by different dynamics as well as between its imagined future and storied past, Morocco views regional electricity integration as a desirable future, but not necessarily a feasible one given the sociopolitical complexity involved.

In the post Arab Spring context, Morocco is just beginning slowly to implement the Advanced Regionalization plan, which would decentralize governance to give more power to local governments. It is unclear whether this plan would affect electricity policy and begin to change the entrenched perception of a modern electrical power system as centralized, especially since the initial focus is on bringing greater regional control to Western Sahara. Chapter 7 will explore the discrepancies between national-scale plans and local-scale implementation and governance.

CHAPTER 7

PROSPECTS FOR LOCAL-SCALE GOVERNANCE OF TECHNOLOGY IN MOROCCO

This chapter expands upon the theme of how electricity development relates to political development. Until now, I have discussed political development in terms of nation building, national sovereignty, national identity, and the consolidation of the nation-state. Here, I expand my exploration of political development to consider how Morocco's political system might change in the future— especially as its relates to inequity— as gradual steps are taken toward the decentralization of governance and new modes of governance of technology. Morocco is considering continuing with its Advanced Regionalization plan to decentralize power, giving more authority and financial independence to regional and local governments and incrementally increasing democratization. Morocco launched the Advanced Regionalization process in 2010, and it entered its second phase in 2011. The current plan is under debate in the Parliament. According to King Mohammed VI, as quoted on the Moroccan Ministry of Foreign Affairs and Cooperation website, advanced regionalization

> is not "a mere technical or administrative arrangement, but "rather a resolute option for the renovation and modernization of State structures, and for the consolidation of integrated development." It will not be reduced either into "a mere redistribution of powers between the centre and the regions" (Kingdom of Morocco Ministry of Foreign Affairs and Cooperation, n.d.).

In this chapter, I consider the reciprocal shaping of governance in Morocco and technological development as Morocco considers increasing decentralized governance.

In order to understand the possible implications of the decentralization of governance and its effects on technological development, I discuss the public engagement process for the siting of Morocco's first CSP plant, which seeks to be more inclusive than the dam building projects of the past. These public engagement processes have implications for changing conceptualizations of citizenship and citizen participation in technology governance and, more broadly, political development in Morocco. In Chapter 6, I began to argue that new conceptualizations of citizenship have been developing in Morocco as it advances with plans for renewable energy. One is the participation of new voices in governance in Morocco, such as the MENA Policy Hub. The other relates to questioning whether the centralized model of electricity generation promotes effective citizen engagement. A financier I quoted in Chapter 6 stated, "What is important is to create the conditions for [everyone who benefits from new energy development] to become citizens." However, this chapter shows that various inequities and inequalities impeded the capacity of rural citizens to participate in decision-making. This chapter illustrates that just as Morocco as a nation has worked to build capacity to leverage a stronger position in R&D and political integration processes,[168] the capacity of local citizens and communities to participate in decision-making needs to be improved by addressing inequities in rural areas related to, for example, education, isolation, and gender disparities.

[168] See Chapter 6.

Conflict arose over the legitimacy of the public engagement process and the representatives selected to speak for the villages adjacent to the power plant site. At the same time, the local population articulated strong political legitimacy for the king and pride for national plans for renewable energy development. This illustrates a paradox in greater liberalization and democratization efforts. Greater local participation and decentralized governance is needed to increase democratic participation and citizenship, but the local representation lacked legitimacy while the king had strong legitimacy at the national level. Given this paradox, what are the prospects for the governance of technology in Morocco, especially considering the local-scale inequities that affect the capacity of rural citizens to participate in decision-making and the structural problems with participatory procedures? How are rural citizens viewed and how do they view technological governance in the post-Arab Spring era as Morocco imagines a future as a knowledge economy with more decentralized, democratized governance?

As Morocco considers increasing decentralized governance, I compare nationally-led integrated CSP development to locally-led integrated development projects in the Ouarzazate region. I explore their benefits and challenges and their relationship to decentralized governance, citizenship, and integrated development. Integrated development explicitly ties electricity policy to matters of inequity, water, poverty, education, and industrial capacity. Through integrated development projects, Morocco explicitly seeks to align technical ends of technological development (i.e., the provision of electrons) with its societal goals (e.g., jobs, rural development, education).[169] As I have argued throughout the dissertation, electricity is being called upon to meet complex

[169] see Chapter 6.

sustainability challenges in the 21st century that go beyond providing heat and light. The ability of electricity to deliver upon these promises depends upon effective technological governance processes designed to include local citizens in shaping technologies meant for local benefit.

In the context of this broader dissertation on the Desertec vision for Mediterranean electricity systems integration, this chapter illustrates the possible implications of the Desertec vision moving from the visioning to the construction phase through the first CSP plant built under the Moroccan Solar Plan. While Noor is not Desertec's project, it is an example of CSP development in Morocco and is intended here to be taken as a thought experiment for understanding the multi-scalar implications of the transnationalization of electricity. A transnational electricity vision like Desertec illustrates both the scale up of renewable energy technology and the connection of the multiple scales of justice (from local to global) in this massive imagined sociotechnical system. In Chapter 1, I recounted sitting along the Friedrichstraße in Berlin wondering what the ramifications would be of powering the street with renewable energy generated from power plants next to small villages in Morocco that lack clean drinking water. I asked: what will the outcomes be for social justice if the electricity system were globalized to bring together these disparate places—the commercial present of Berlin with its storied past and the future of a small village at the door of the Sahara that currently lacks clean drinking water? Will premium-networked spaces be expanded or will locals shoulder the burdens of energy development without gaining the benefits? These scales of justice relate to trade-offs and uncertainties in decision-making as construction begins. In Chapter 5, I illustrated how Desertec Design I aimed to address the energy-water nexus, which was excluded later from Design II. When CSP shifts from the visioning phase to the construction phase in local, water-scarce desert landscapes, the energy-water nexus again rises to the fore. Furthermore, Desertec as a regional system would be tied to these thorny issues of political development, national sovereignty, and citizen engagement discussed in this chapter.

The chapter begins with an overview of the inequities in the Ouarzazate region and Morocco that affect the capacity of citizens to participate in decision-making. I extend the comparison made in the last chapter between the dam building policy under King Hassan II and the Moroccan Solar Plan. The dam building policy provides a benchmark against which to compare the Moroccan Solar Plan and its effects on the local community. What differs is that while dam building generally did not benefit the affected public, the Noor process seeks to engage the local community and to provide them with benefits through an integrated development plan. This could be a significant departure from the past, because it would need to address the inequities of rural people living in the region of Ouarzazate. After that, I describe the siting process as an example of public engagement in technological governance. Local people wanted a say in nationally led integrated development plans. However, participation was impeded by the lack of capacity of the community to participate due to inequities, as well as the structure of the process and the greater legitimacy given to the king over local representatives. The chapter then compares the benefits and drawbacks of Noor versus local development projects initiated by NGOs. It concludes with the future prospects for technological governance in Morocco.

Social CSP report. As described in Chapter 2, I made five trips to Ouarzazate throughout the course of this research—two on my own, two as part of an ASU study abroad trip, and one as a participant in a portion of a broader research project headed by Boris Schinke and a team of German, Egyptian, and Moroccan researchers (funded by the German government). This project sought to understand how the siting, construction, and operation of the Noor solar power facility would affect communities living in the region. The extensive report—*Social CSP*—describes the development context of the Ouarzazate region and the existing and projected social impacts of Noor. I helped to author this report but did not participate in all of the research. I seek not to duplicate this report but to add to it by addressing the contributions described above. Readers are encouraged to read the full report, published in May 2015. I use some data from this study as clearly cited below, as well as data I collected during other trips. Any errors or misinterpretations are my own. I am deeply grateful for this research partnership, and I give credit to Boris Schinke in heading this project and to our Moroccan translators and research assistants for their exemplary work.

Social Inequity at Different Scales in Morocco

The first solar power plant under the Moroccan Solar Plan[170] will be constructed in Ouarzazate, Morocco. The plant, called Noor, is expected to be a 500 MW power plant for proof-of-concept of trough and tower CSP technologies, as well as roughly 50 MW of large-scale PV (see *Figure **55***). When I visited in 2014, the first phase—160 MW of wet-

[170] See Chapter 6.

cooled solar trough with three hours of storage—was well under construction. The project developer is ACWA Power, a Saudi company described in Chapter 6. The plant is being financed with concessionary financing with loans from eight banks and governments.[171] A thorough description of Noor can be found in the SocialCSP report.

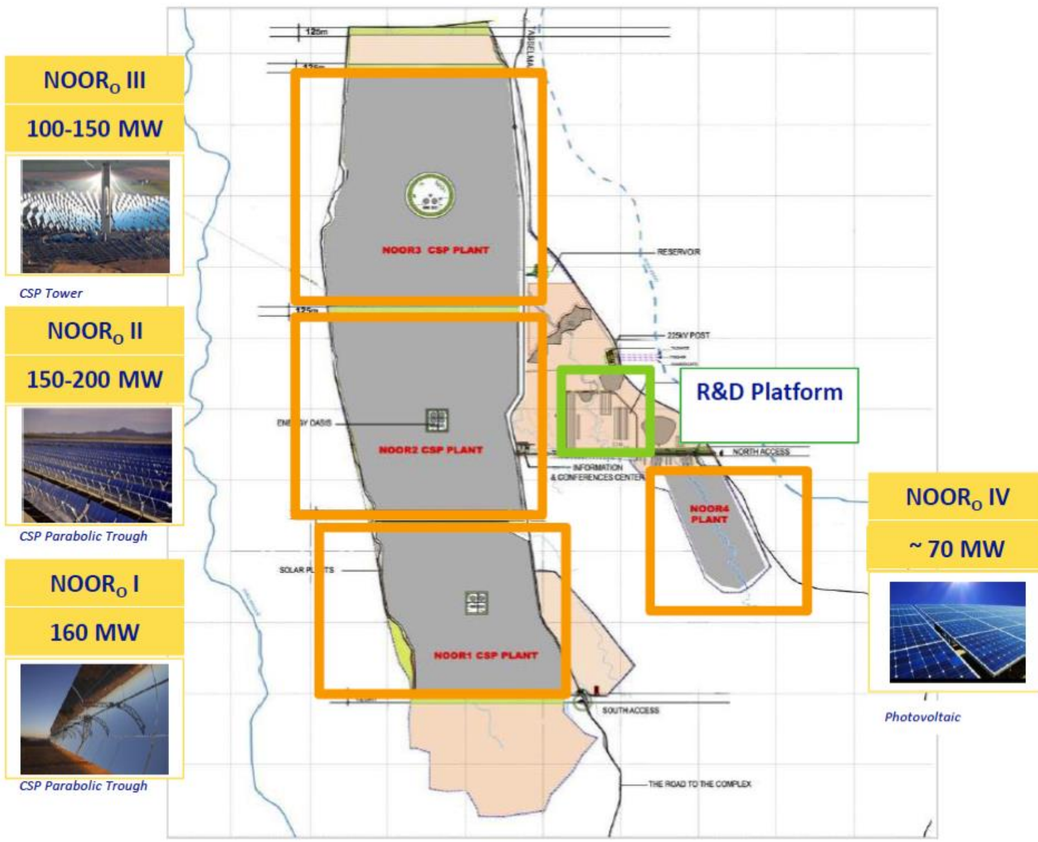


Figure 55. Noor Power Facility. (Wuppertal Institute; Germanwatch, forthcoming).

Unlike the European imaginary of Saharan technological systems built in the middle-of-nowhere described in Chapter 3, Noor is intentionally being built in populated

[171] The World Bank, the International Bank for Reconstruction and Development, the African Development Bank, the French Development Agency, the European Investment bank, the KfW Development Bank, the European Neighborhood Investment Facility, and the German Ministries of Environment and Development Cooperation. The electricity from Noor I is estimated to cost 18.9 US cents/ Kwh. Depending on their usage levels, consumers in the Ouarzazate Province pay between 0.9 Moroccan cents per kWh to 1.44 cents per kWh (Wuppertal Institute; Germanwatch, forthcoming).

areas so that local people will benefit from its development. The population of Ouarzazate city is 69,364, and the population of the broader Province of Ouarzazate is 292,000. Ouarzazate is one of the doors to the Sahara, which Bisson (2003) described as populated areas on the outskirts of the Sahara desert that indelibly shape and are shaped by it.

The Ouarzazate region reflects broader development trends and inequities in the Mediterranean region and therefore provides a useful case study for understanding not only the development of CSP in Morocco but also the possible implications of the development of CSP in other parts of the Mediterranean for an integrated electricity system and integrated development. Specifically, Roux (1997) described the Mediterranean overall as a region with wealthy coastal areas with higher rates of economic and population growth that receive the majority of the attention, in contrast to its interior characterized by depressed mountainous zones with weak economies and dilapidated infrastructure (called *le Maroc inutile* during the Protectorate, as described in Chapter 6). He argued that this dynamic poses even greater inequities than the inequities between the North and the South of the Mediterranean. The previous chapters of this dissertation suggested that these North-South inequities and political disagreements are significant. However, Roux's point illustrates that there are many layers of inequity within and across the Mediterranean that would affect energy justice for a Mediterranean-wide electricity system.[172] A view from the mountainous Ouarzazate region of Morocco provides generalizable lessons about the inequalities and inequities that would affect the energy justice calculus of a regional Mediterranean electricity system. Additionally, the

[172] See Chapter 8.

description below of inequities in Morocco will provide context for evaluating the integrated development process and will also aid in testing the energy justice framework in Chapter 8. (For a detailed description of the social situation in Ouarzazate, see the Appendix of the SocialCSP report).

Layers of inequality and inequity. Inequity and inequality in Morocco are important to its political development in terms of the capacity of citizens to participate in technological governance and how the view of the citizen might evolve in rural areas. As described in Chapter 4, equality implies sameness (e.g., everyone has access to the same quantity of electricity at the same price), while equity requires fairness (e.g., everyone has access to electricity that improves their human capabilities at an affordable price). I argued in Chapter 4 that energy justice implies a higher standard than energy equality.

Electricity development is viewed as a boon for equalizing Morocco's inequalities, yet electricity alone is insufficient to the task of addressing inequity. Rida Lamrini's 2006 book *Is there a Future for Morocco, Yasmina Asked Me*[173] reflected upon the effects of social inequity on Morocco's political development. The first time Yasmina asked Lamrini whether there is a future for Morocco, he mulled over the evidence that would indicate that there is a bright future for Morocco. He considered the improved development statistics since the efforts of the 1990s. Foremost, he pondered whether nearly universal electrification rates might imply a promising future stating "the countryside has rejected the mantle of darkness that enveloped the evening to offer an

[173] *Y a-t-il un avenir au Maroc, me demanda Yasmina*

electrified spectacle of starry constellations."[174] However, he was, in the end, cynical about Morocco's future due to a combination of state dysfunctions—e.g., corruption, lack of competitiveness compared to other emerging economies, and a lack of political will—as well as the indifference of the citizens—i.e., Moroccan youth eyeing emigration rather than staying to improve the country. As he contemplated how he would respond to Yasmina's question, she was in a car accident, and Lamrini visited her in a hospital in Casablanca. There, he witnessed poor people lined up in the hospital hallways waiting hours, or even days, for treatment. Noting the concern on his face, the doctor assured him that he would never have to wait like this because he is not destitute. This did nothing to allay Lamrini's fears, as he wished to live in a society where such inequities did not exist.

I reflected upon these inequities as I sipped espresso with a professor in a comfortable café in Rabat across from Mohammed V University, one of the top universities in the country. He stated, "the first danger for men is men. There are people who think there are first- and second-class people—that's a problem. It's not a lack of resources [Morocco suffers from] but a lack of respect." He went on to argue that Morocco must valorize people before natural resources in order to develop renewable energy. This conversation illustrates that a large segment of the population—these second-class citizens—are not empowered to participate. The Ouarzazate region embodies these tensions between different classes of people in Morocco's political and social development as described below.

[174] *"Les campagnes ont rejeté le manteau de ténèbres qui les enveloppait le soir pour offrir au regard le spectacle féerique des constellations étoilées."*

Social inequality and inequity between the rural Ouarzazate region and major cities like Marrakech stems partly from isolation. To use the metaphor from Chapter 4, it is “islanded” in that it is remote, cut off, and lacks economic diversification—the opposite of the characteristics a premium-networked Mediterranean grid would seek to provide it. Ouarzazate is situated on a plateau between the High Atlas Mountains and the Anti-Atlas Mountains. It can only be reached by a winding, treacherous road through the Atlas Mountains from Marrakech, which is 120 miles away but takes about five and a half hours to reach by charter bus (see *Figure **56***). The Tichka Pass is one of the most dangerous stretches of road in Morocco. During the winter, it is sometimes snowed in and buses from Marrakesh must simply turn back. This isolation affects the area’s economy in multiple ways. For example, when I visited the Noor power plant during construction, the workers told me that the first shipment of mirrors arrived broken due to bad roads. I also talked to small-scale producers of olive oil in rural areas who explained how difficult it is to transport their oil to Marrakech. People in Ouarzazate viewed this isolation as a cause of their disadvantages.

Figure 56. The Tichka Road. Photo by Author.

One of the results of social inequality and inequity between rural areas and major urban centers is rural exodus driven by desperation rather than a genuine desire to relocate. About an hour and a half from Ouarzazate, I visited the town of Agdz with researchers from the Germanwatch group. I asked one of our researchers about economic opportunities in the town. She explained that since there are no large businesses or factories in the area to employ people, many young men emigrate from rural areas to the cities of Casablanca or Rabat looking for construction jobs. They pay 2,000 dirhams ($210) per month to rent an apartment, including electricity and water costs, and must share it with several other people. If they get married, they do so in the rural area and only see their family on several major holidays per year, which she viewed as a threat to social cohesion. This is a challenge that integrated development projects seek to address.

While urban-rural inequalities are stark in Morocco, the tendency to focus only on this dividing line overlooks numerous other layers of inequality that relate to the capacity of the community to participate in decision-making. First, there are inequalities even within cities. For example, in the outskirts and poor neighborhoods of Ouarzazate city, people lack water and sanitation services (Wuppertal Institute; Germanwatch, forthcoming). Additionally, many rural immigrants live in slums in the outskirts of major cities. Second, as Lamrini illustrated, there are major inequalities in access to and affordability of healthcare. People in Ouarzazate who can afford it often travel 4.5 hours over the Atlas Mountains to Marrakech for healthcare, as specialists and hospitals are lacking in the Province of Ouarzazate. Third, there are two Moroccos in terms of gender.[175] Moroccan women do not enjoy equal access to rights and education, as evidenced by the 84% female illiteracy rate in the Province of Ouarzazate, compared to 67% for men (Wuppertal Institute; Germanwatch, forthcoming). According to the head of a local NGO I interviewed, girls often cannot attend school because their family needs them for domestic chores, the families see it as unsafe to travel long distances to school, and school sanitation services are sometimes lacking making attendance untenable for girls after puberty. These multiple layers of inequity affect the capacity of citizens to become full citizens in energy development.

Noor relates closely to these inequalities and inequities, as it is sited near marginalized rural villages within the rural Commune Ghessate. According to the Commune's president in an interview with me, the Commune includes 44 villages and 10,000 inhabitants over 1,034 kilometers of land. Many improvements have been made to the Commune since 2002. According to the president, reaching a 99% electrification rate was very important to its development (ibid). However, the villages adjacent to the power

[175] Note also that I worked with and met many articulate, intelligent, and assertive women. It is important to avoid the stereotypes of Muslim women as passive and meek, as bemoaned by Arab feminists like Joumana Haddad.

plant suffer from inequalities compared to the rest of the Commune, such as unequal access to education and water. Tasslemante, the closest village to Noor, which is only a matter of yards from where construction is underway, has a population of 326 people in 40 households (as of 2008) (ibid). Most significantly, Tasslemante lacks clean drinking water. Water is available in the village through several wells, but these wells provide only salty water fit for washing but not human consumption (see *Figure **57***). When our group from ASU visited the village, we were asked to bring our own bottled water for boiled tea so that no one from our group would become ill. Additionally, some people reported that several households in adjacent villages lack electricity, and these households will now be living in the shadow of a major energy facility (although it is unconfirmed whether this is true). For Noor to be part of an expansion of premium-networked spaces, it would need to address inequities in water and energy access.

Figure 57. Well in Tasslemante, with two Researchers and a Woman Doing her Laundry. Photo by Author.

Energy inequity and capabilities in Ouarzazate. Inequities in energy access exist within Morocco and across the Mediterranean. Almost 96% of households in the Ouarzazate Province have electricity access (Wuppertal Institute; Germanwatch, forthcoming). The interviews from the SocialCSP study showed that people used electricity primarily for lighting, as well as TV, cooking, and in some cases heating and cooling. While the hope is that electricity access will improve people's capabilities, the Executive Director of the High Atlas Foundation, a development NGO headquartered in Marrakech, argued that electricity has in fact harmed development because it has greatly increased TV use, threatening social cohesion as people spend less time on community activities and looking for employment and more time on entertainment. (TVs, however, can bring better access to diverse news outlets, see the capabilities section in Chapter 8). Furthermore, he said that villagers have trouble paying the bills, and the electricity is not reliable. However, the Social CSP interviews found that the majority of people could afford their electricity bills, although they complained about the price increasing.[176] The results are mixed about whether electricity has improved citizenship in the community and more fine-grained data is needed to accurately judge.

Unlike in premium-networked spaces, energy usage is not invisible in the Ouarzazate Province. For example, villagers trek to the city and haul butane bottles back over treacherous roads on donkeys to power agricultural water pumps. Butane is important for capabilities; it heats water and fuels portable stovetops and refrigerators. This allows people to have a higher quality of life with hot showers and with a cleaner

[176] Electricity in the area is purchased through pre-paid charge cards instead of being metered and billed at the end of the month.

fuel less likely to burden women with lung disease. It also provides for irrigation through gas water pumps. When our group from ASU stopped for lunch in rural Morocco in 2013 a shopkeeper charged our students a high price for water. When they questioned the price, the shopkeeper, who did not speak English, drew us away from our Western energy-wealthy mentality by gesturing toward the bottle of butane running the refrigerator. Our drink was not cold for free.

Some traditional fuels are used in the region; I often saw hunchbacked Berber women plodding along the highway with large bushels of firewood on their backs. The firewood is used for cooking and heating—it is a cheaper fuel source but puts people at risk for lung disease. Traditional bread (*tafernet*) is cooked in ovens with these traditional fuel sources. Figure **58** illustrates the soot from such a stove, which fortunately in this case is located outside.[177] In terms of improving local capabilities, the High Atlas Foundation said that subsidized solar water pumps are the most demanded renewable energy technology in rural areas, because they allow people to avoid the trek mentioned above for butane bottles.

---

[177] Further, charcoal, which is detrimental to health, is still used in both urban and rural areas of Morocco, especially for culturally important rituals. For example, the sheep slaughtered during the Eid-el-Kabir holiday are cooked using charcoal grills that choke the stairwells of apartment complexes with smoke.

Figure 58. Traditional Oven in Tasslemante, Morocco with a Transmission Line in the Background. Photo by Author.

***La politique des barrages* and the future of inequity and energy development.** The Moroccan Solar Plan will change the geography of energy and the distribution of its effects on inequity. As an interviewee from MASEN explained, thermal power plants were built traditionally on the coasts and the transmission lines were the veins that injected energy into the country. The areas of the country that have the most sun are also the poorest areas. For example, Ouarzazate is a poorer region with an agrarian economy. Its main economic activities include agriculture—which is mostly subsistence agriculture with only a few cash crops—tourism, and small handicrafts (e.g., textiles, rugs, ornamental daggers) (Wuppertal Institute & Germanwatch, forthcoming)[178] While these agrarian rural areas generally do not host thermal power plants, they have long been the focus of dam building. As discussed in Chapter 6, Noor and its integrated

[178] Despite the agricultural focus only 2% of the land is cultivated due to the arid climate (ibid). There are also several important mines (manganese, cobalt, and copper). Ouarzazate is called the Morocco of Hollywood and has a movie studio it seeks to grow. Increasing international competition had hurt the sector, but business has improved recently (ibid).

development plan balance traditional and modern views of Morocco's political development dating back to *la politique des barrages* (dam policy) from King Hassan II.

La politique des barrages provides a benchmark for understanding political development and local participation and benefit under the Moroccan Solar Plan. There are many similarities between *la politique des barrages* and the Moroccan Solar Plan. Therefore, while CSP appears to be a novel development project, it is also a dream whose time has come in terms of achieving large-scale farming in Morocco and exporting the harvest to Europe. CSP has been framed as a farming and irrigation technology since its invention in 1866.[179] Today CSP is a new type of farm integrated into a modern electricity system for Morocco. The Mansour Eddahbi reservoir near Ouarzazate was built under *la politique des barrages* to irrigate 19,000 hectares, to contain flooding, and to provide electricity. It was completed in 1972 along the Draa River with a height of 70 meters and an initial reservoir capacity of 560 million m^3 (Swearingen, 1998). The latest bathymetry in 1998 indicated a capacity of 433 million m^3 (Diekkruger et al., 2010) Soon it will provide cooling water for Noor I. CSP development seeks to make use of land that was ill-suited for agriculture to harvest electrons, and the Mansour Eddabhi dam will irrigate this CSP farm. This discourse balances between the vision of Morocco as a traditional agricultural society and a future knowledge economy through integrated solar development.

The possibility of generating green electrons as a major export commodity to Europe also fits into *la politique des barrages* discourse as described in Chapter 6. Just as dam building and irrigation sought to provide for the nutritional needs of the country,

---

[179] see Chapter 3.

CSP seeks to provide for electricity needs. Dam building promoted regional development to raise the rural standing of living and stem rural exodus to the cities, very similar to the goals for CSP. Finally, just as King Hassan II hoped that agricultural projects made possible through extensive irrigation would develop major cash crops for export, green electrons are seen as a potential export commodity. Interviews conducted for the Social CSP study with people living in Ouarzazate Province indicated nearly unanimous support for exporting the electricity to Europe, provided local people benefit. According to these interviews, they viewed electricity exports as a source of "earning foreign currency," the same discourse as agricultural exports under the dam policy.

Despite these similarities, the stipulation that local people must benefit will require a rethinking of the dam policy of the past. Under *la politique des barrages*, the community living near the Mansour Eddhabi dam was displaced and harmed by the project rather than experiencing development benefits (Wuppertal Institute; Germanwatch, forthcoming). These disadvantages from energy development have lasting effects, as was illustrated when I visited the village of Idelsane near the Mansour Eddhabi dam as part of the Germanwatch study. There, villagers viewed themselves as still being disadvantaged after being displaced by the dam in the 1970s. They knew little about the CSP plant but were concerned mostly about their precarious water situation. Despite living near the dam, they must walk one kilometer up the road to reach drinkable water, as the water quality of the reservoir is poor. They have tried to dig wells only to reach brine. After the interview, we walked to the Mansour reservoir. There was no path, and it was a challenging and dirty trek. The water in the reservoir is low due to years of drought. The outskirts resemble an estuary—the ground is coated with white powder and cracked, salty mud. The water in the lake is green from algae blooms, which have reduced the water quality. The reservoir was not designed to provide drinking water (Swearingen, 1988) even though it is a crucial need. Since people in the area lack access to drinking water, they attempt to drink water from the reservoir even though it is dirty. This story illustrates how important it is to avoid replicating the past problems caused by centralized energy infrastructure when constructing new renewable energy systems and to meet the needs of the local community with new infrastructural development.

The new social pact for electricity in Morocco discussed in Chapter 6 seeks to ensure local social benefit from integrated development. The Noor power plant is viewed as part of a plan for integrated development in Morocco and MASEN as an animator for local development. MASEN stated that their projects should have an impact from kilometer zero to kilometer 1,000—the entire country. The main development requirement for Noor is to source 30% local content for the power plant in order to grow supply chain industries and to foster small enterprises that provide services such as maintenance and security. Additionally, MASEN is building the Institute for Training in Renewable Energy and Energy Efficiency (IFMEREE-Ouarzazate or *L'Institut de Formation aux Métiers des Energies Renouvelables et de l'Efficacité Energétique d'Ouarzazate*), which it hopes will become an R&D platform similar to the Solar Plataforma. ACWA Power had hired 1,200 to 1,600 construction jobs for Noor I by September 2014. About 80% of the jobs went to low-skilled laborers, 10% to semi-skilled, and 10% to skilled (ibid). These benefits are expected to endure as entrepreneurship and economic growth is expanded in the region.

If exports were pursued under the Moroccan Solar Plan, *how* would people expect to benefit and *how much* benefit would they view as sufficient? Two common views about energy exports from North Africa are espoused in Europe. One is that exporting electricity is fundamentally neocolonial, as it will drain electricity out of North Africa.[180] This was surprisingly not how local people in Morocco viewed the situation. Second, the perspective from institutions like Dii is that North African countries want to export electricity and that socioeconomic benefits will automatically trickle down to the local population. The case study of Noor illustrates that while there is potential for such benefits, they are not automatic and relate to existing inequities in Morocco and the Mediterranean. As described below, local people wanted some say in how they would benefit from Noor, which suggests that they would also want some say over how they would benefit from the potential export of the electrons. Furthermore, this local benefit is essential to avoid tying inequities in Morocco with energy wealth in Germany and linking a premium-networked space with a depressed Mediterranean zone.

Citizenship and Representation: The Noor I Public Engagement Process

The inequities described above are tied to the evolving social pact. In Chapter 6, I argued that Morocco's promises for the benefits of electricity generation reflect a social pact, rather than a social contract, because it lacks citizen consent. While the social pact addresses the distributive *outcomes* of electricity, it does not require a *process* for consent

[180] as described in Chapter 5.

that would allow local people to become empowered citizens in this process. The Noor siting process is an opportunity for understanding an early effort made to include citizens in the process of the governance of energy technologies under an evolving social pact for electricity in Morocco. Effective citizen input would improve the procedural justice aspects of energy planning and policymaking.

This siting process was in part an instrumental action taken by the state that could be witnessed by the public, through what Ezrahi (1990) called "visual attestive culture." Ezrahi (1990) defined visual attestive culture as a process in which a community of free and rational individuals witnesses government actions, promoting governmental transparency and accountability, and preventing arbitrary uses of power, at least in appearance. He viewed visual attestive culture as fundamental to the workings of liberal democracies.

The engagement process for Noor reflects a tension between the use of visual attestive culture and what Ezrahi (1990) called the visual celebratory culture of a monarch. The visual celebratory culture can be seen in infrastructure projects across the country including Noor. For example, *Figure **46*** in Chapter 6 shows the king inaugurating the Ain Beni Mathar natural gas-CSP plant. Similarly, an online video shows the king commemorating Noor to dancing, singing, and overall celebration of the Kingdom's accomplishments in renewable energy, reflecting the "king as builder" tradition (Elsheshtawy, 2008).[181] In contrast to this visual celebratory culture at the plant's commemoration, the siting process reflected an attempt to foster a visual attestive culture and at least a partial effort to gain the consent of the local population.

[181] see Chapter 6.

Paradoxically, the two coexist in Morocco as it takes incremental steps toward democratization.

Below I provide an overview of the siting process; readers can refer to the Germanwatch Social CSP study for a detailed description and assessment of the siting process. The spirit of the law has recently given citizens the opportunity to be engaged in sustainable development projects that did not exist under King Hassan II. (Law 99-12, *Charte nationale de l'environnement,* allows for adequate information provision and participation on sustainable development projects, and Article 12 of the new constitution allows for the public participation of civic groups— see the baseline appendix of the Social CSP study). Siting included a public engagement process that was in compliance with legal regulations (Wuppertal Institute; Germanwatch, forthcoming). The World Bank and contractors conducted a full environmental and social impacts study, along with numerous other studies by MASEN, which made legible the anticipated impacts of the power plant. Three public meetings were held about the project in November 2010, March 2010, and November 2012 (ibid). The rural Commune Ghessate (described on p. 420) collectively owned the land near the site. This rocky land was used for some grazing and for gathering of rocks for building materials and sticks for firewood (ibid). Proceeds from the sale of this land were deposited into a compensatory fund called the Social Development Fund (ibid).

The Social CSP study identified several major drawbacks in the public witnessing process. In my interpretation, the process paired structural drawbacks with a lack of capacity of the community to participate as witnesses. First, the meetings were held in a hotel in Ouarzazate, which was difficult for villagers to travel to and an intimidating location to visit. Second, the documents explaining the project were available only in French and Fus'ha (formal Arabic), while many people in the villages speak only local dialects of Arabic and Berber and are illiterate. Third, some people, especially women, thought they were not educated enough to participate in the process. One rural woman interviewed at home during the Social CSP project, said she did not know of such things because "these walls are my frontiers." In short, even though there was a participatory process available, the multiple inequities in the community—illiteracy, gender issues, lack of transportation, and isolation— resulted in a lack of capacity to participate meaningfully.

Recognizing that they were building in the poorest areas of the country, MASEN did, in fact, seek to improve the capacity of the community. In addition to the industrialization goals previously mentioned, MASEN undertook "charity work" in the region to improve its resilience and MASEN's license to work there. For example, they have funded entrepreneurship classes, a dormitory for young women to attend school in Ouarzazate, eyeglasses, dentistry, Internet, buses, and bicycles for children to ride to school. The charity framing is admirable and goes beyond simply preparing the region for economic investment to addressing the community's lack of capacity. However, under the "charity framing" of local development, villagers were not viewed as true participants in deciding what projects were needed under the Social Development Fund financed by the land sale. Taken together, the inequities in the region illustrate a lack of capacity in rural citizens to participate substantively in decision-making, even though they have important ideas, opinions, and knowledge. Just as capacity-building needs to occur at the national level to put Morocco on a level playing field in international energy negotiations and R&D with Europe,[182] capacity-building exercises for local citizens are needed to improve capabilities to participate in decision-making.

From a structural standpoint, the process did not allow for direct witnessing at all stages. In some cases representatives from the community were called upon who suffered from a lack of legitimacy. Early social contract theorists saw representation as acceptable instead of direct democracy because citizens agree on the original contract and then select representatives to speak for their needs (Brown, 2009). In this case, both initial consent for the social pact and legitimate representation were lacking. Six representatives from the Commune and nine governmental authorities from ONEE and MASEN approved the land sale for 1 Moroccan Dirham per m^2, or 30.5 million dirhams ($3.2 million). During a focus group conducted under the Germanwatch study, people complained that their representatives in the sale did not consult the location population, or that the representatives did not truly represent the population.

Villagers had to sell their sheep that they used to graze on the land, and they could no longer gather firewood and rocks from the site (Wuppertal Institute; Germanwatch, forthcoming). Additionally, construction encroached upon the perimeter of the village, much closer than villagers said they were originally promised (ibid). Furthermore, the benefits from the land sale largely went to the center of the commune some 10 kilometers away instead of to those who had lost capabilities from access to the land. As such, CSP is resulting in uneven development in the Ouarzazate region as those villages most affected are reaping fewer benefits. The villages closest to the power plant site lack access to clean water but will now live in the shadow of a major energy facility.

---

[182] see Chapter 6.

The Social CSP findings indicate that the citizens wanted to be involved as public witnesses to the process, but the process was partly captured by elites. Catusse, Vairel, & Bono (2010) argued that there are systemic issues with a lack of legitimate representation between villagers and elites in Morocco, in which the elites capture the benefits. The representatives do not necessarily share the same interests as the local population—a fact that is often masked by the assumption that the main disparities in Morocco are between urban and rural areas. The lack of capacity of the local citizen combined with problematic representation led to conflict. Villagers from Tasslemante and Tidgheste protested several times against what they perceived as a lack of fair compensation and some were even jailed.[183]

The visual attestive witnessing process failed to a certain extent. The view of who counted as a witness was at times constrained to the local elite rather than based upon popular sovereignty. It did not fail because there is no civil society in Morocco, as some scholars suggest. There was an engaged civil society that wanted to participate but did not have the ability due to inequities impeding the capacity of the citizen to participate and issues with representation and procedure.

The Solar Haj: Local Pride and National Legitimacy

While there was dissatisfaction with the process and compensatory measures, the opposition had little to do with the technology itself. The centralized state's decision to

[183] The World Bank halted construction for several weeks while it investigated the conflict. The villagers were released from jail after community members paid fines on their behalf.

pursue a particular technology, instead of letting the free market or local population decide (as described in Chapter 6), was not a source of conflict. In fact, participants in the Social CSP interviews expressed strong patriotism for the project, which they were proud to have in their backyards. This differs from the siting processes I have studied for CSP in the United States, in which citizens were opposed to the technology itself as well as disappointed in the engagement procedure. CSP is perceived and interpreted differently in different political contexts, which would need to be accounted for in a transnational electricity system.

In Chapter 6, I argued that solar power has become part of national pride and nation-building. This discourse was strong enough to have permeated the local level. In 2013, I gazed out of the window, driving from rural Zagoura to the village of Agdz, an hour and a half southeast of Ouarzazate, Morocco. We passed a faded ONEE sign on which someone had scrawled *allahu akhbar* (God is good). We drove through winding roads with canyons covered only with rocks and shrubs, free of visible technological infrastructure other than the road ahead and high voltage transmission lines. The lines took sharper turns and dives than the treacherous road, draping across the road and down canyons. They crisscrossed over hills with the words printed in white “God, Country, King.” I was reminded of the ONEE logo (see *Figure **59***), in which a transmission line resembles the shape of the star on the Moroccan flag. The transmission lines therefore stood out as symbols of national pride etched out on a landscape free of other human infrastructure. This scene reflected both the region’s remoteness coupled with its unusually high electrification rate compared to rural areas of countries to the south. These lines are symbols rural Moroccans see every day—technological feats that have been imprinted on the local conscience since Morocco's Rural Electrification Program launched in 1996. This program laid the groundwork for the rural electricity system and local pride in a centralized electrical power system that reaches nearly every Moroccan village.

Figure 59. ONEE Logo

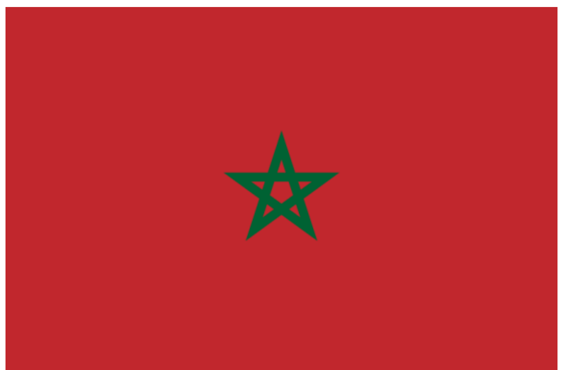


Figure 60. The Moroccan Flag (public domain image)[184]

One Social CSP interviewee said, "All in all, the CSP project is good for the region, it gives a certain honor to our area, and we would say that it is not only a local project, it is a national project." Members of all communities associated the development of Noor I with an intensified local pride and improved reputation for the Ouarzazate region. When I interviewed the President of the Commune Ghessate he expressed hope

184 "Flag of Morocco" by Denelson83, Zscout370 - adala.justice.gov.ma (Ar). Licensed under Public Domain via Wikimedia Commons - http://commons.wikimedia.org/wiki/File:Flag_of_Morocco.svg#/media/File:Flag_of_Morocco.svg

that the Noor project would lay the foundations for Ouarzazate to become the site of the Haj for solar energy.[185] He emphasized that, unlike a movie, CSP was a long-term project for the region, which would attract foreign companies and collaborators to Ouarzazate.

Not only was there national pride for the Noor project but also villagers gave strong legitimacy to the king, despite problems with local representation. One participant in the Social CSP Tasslemante focus group in February 2013 stated

> The sale procedure should have been more transparent and clear. If the local authorities had told us clearly that they would want the land for the solar project, and especially that his majesty is involved, we would not have sold the land, we would have given it for free.

The *makhzen* (state/ king) actually espoused more legitimacy than local representatives. Consent to rule existed at the national level but not at the local level. The solar siting case shows that there has not been a modern, linear transition from the visual celebratory culture of the king to the visual attestive culture of a liberal democracy. Both co-exist and depend upon one another.

Amster (2013) explained this longstanding legitimacy of the *makhzen* but also argues that it is hybridized with French technocracy.

> The 1912 Treaty of Fez decapitated the Muslim body politic and replaced its makhzan state with a French technocracy, a regime of science imposed over and

[185] The Haj is the Muslim pilgrimage to Mecca.

> against the Muslim body politic. In the king, Morocco retains an Islamic sovereignty reembodied. In the Moroccan postcolonial state, a positive technocracy nationalized and Islamicized (Kindle loc. 281).

In the United States, representation in a visual witnessing process would come partly from technocratic experts, as in Hecht's story about nuclear power in France (2009). Experts were starkly missing in the visual witnessing process for CSP siting. I argued in Chapter 6 that expert participation in the Moroccan state has been highly constrained and that experts are often missing in decision-making. Brown (2009) interpreted Rousseau as having said that consent is less important than the social contract that privileged expertise rather than divine rights. Privileging of experts is lacking in the Kingdom of Morocco.

In place of experts, local elite played a role in witnessing the process, but the local community contested whether they represented the population. This controversy between illegitimate representation and the visual witnessing of the siting process reflects what Brown (2009) termed "the tension between public witnessing and elite method" (p. 85) and representation by experts and elites versus popular sovereignty. In Morocco, sovereignty is generally embodied in the king himself rather than in experts or the public. Attempts to develop popular sovereignty have had mixed results; voter turnout in the 2007 Parliamentary election was only 37%, as the parties did not address the concerns of the citizens (Tozy, 2008) and failed to prioritize anti-corruption measures. The tension in Morocco's hybridized process between visual attestive culture and visual celebratory culture, is who gets to be a witness—regional governments, villagers, local experts, or local elites?

The lack of local legitimacy of representation is a challenge for the Advanced Regionalization Process, especially when coupled with the lack of resources facing regional governments. As Morocco continues with its advanced regionalization project to expand regional governance, the *Maghreb Arabe Press* quoted King Mohammed VI as stating in July 2014,

> "In any case, we shall not put the region's future at risk. That is why we shall carry on with development and modernization projects there, particularly through the implementation of the development model for our southern provinces", HM [His Majesty] the King said, adding that this model is "based on a participatory approach, on good governance and on cohesive, multidimensional programs aimed at achieving integrated development" ("Morocco: HM King Mohammed VI", 2014)

First, in the quote above, the king advocated for centralized, large development projects based on the dam building model that is nearly a century old. Then he argued for an integrated good governance approach, a more recent discourse that has been associated with the spread of liberalism across the globe. The success of the inclusion of the local people is essential for political development from *la politique des barrages* toward a participatory integrated development model.

These issues are also significant for Mediterranean electricity politics, because if the system were integrated these national political development challenges would be tied to the regional level. It may also be the case that this nationally embodied sovereignty for the project would be necessary for lending legitimacy to the export of electrons to Europe, as the king would retain sovereignty as the "builder" of the project, even as grids become interconnected. The push toward ceding more governance to the regional level through the TSO (described in Chapter 5) could therefore result in conflict.

In a separate study, I found that the siting process for CSP in the United States also suffered from significant drawbacks. Put differently, the visual attestive process also faltered in the mature liberal democracy of the United States. If it is true that the democratic public engagement process was unsuccessful in Morocco, then it is significant to note that it failed in the United States as well and does not necessarily illustrate a lack of hope for decentralized governance in Morocco. The shortcomings of such processes, in part, illustrate the complexity of the trade-offs entailed in siting renewable energy, especially because integrated sustainability challenges are at stake.

Integrated Challenges and Win-Win Solutions

As construction begins on CSP plants in North Africa, it illustrates some of the trade-offs entailed in local-scale development. All three design of the Desertec vision were framed as a win-win. McShane et al. (2011) criticized sustainable development discourses that set unrealistic expectations for win-wins across the triple bottom line (people, planet, and profits). Instead, they recommend evaluating a project's difficult decisions, value conflicts, conflicts between social goods, strategic choices, and problem frames. For example, elites in Europe and Morocco may benefit from the system while Moroccans in Tasslemante are negatively affected and bypassed by benefits. Global climate change may be mitigated, but construction may damage the local environment. There may be instances in which the trade-off does not become apparent until construction begins or in which trade-offs are masked by value judgments concealed in a discourse of technological and market determinism. Furthermore, the Social CSP study in effect nicely illustrated that wins are a matter of the perspective of the winners and losers not simply objective, measurable facts. (See for comparison the discussion in Chapter 4 about the perspective that the landscape near the CSP plant in Egypt was unpopulated, versus my observations that it was populated.)

One local trade-off that is being insufficiently considered in the discussions on Mediterranean electricity integration is that between energy and water usage. As explained in Chapter 6, Morocco has capricious water sources that are unevenly distributed across the landscape and highly variable, and it suffers from long periods of drought. The Province of Ouarzazate is water scarce, with 360 m^3 per person of water available per year, versus 700 m^3/year nationally, and 1,000 m^3/year as the definitional threshold for water scarcity (Wuppertal Institute; Germanwatch, forthcoming). Around 98% of the population has water access, but there are huge disparities in the quality and quantity of water, even within Ouarzazate itself as well as within the Province (ibid). Water in the region naturally has high salinity and is worsening as groundwater resources are overdrafted (ibid). Irrigation from the Mansour Eddhabi dam continues to be critical for supporting subsistence and other agriculture in the region (Wuppertal Institute;

Germanwatch, forthcoming). Due to this water stress, local people are concerned about new demands on water in the region, including Noor (ibid).

The future of water resources in the Ouarzazate Province is critical, highly uncertain, and under-researched. Noor I will use 1.75 million m^3/year (5 Capitals, 2012:83), but it is not clear whether it will significantly affect future water stress in the region because no one has studied this complex issue. The following stages will use dry-cooling technology, which will significantly reduce water usage (up to 90% is a often cited industry figure.) Diekkruger et al. (2010) illustrate that data on the future of water resources in the Draa Valley of Ouarzazate are lacking and crude where available. They also argue that future water availability is highly dependent upon uncertain future social and governance choices and inequities, as well as climate change. Reactions to the Noor power facility are related to decision-making under uncertainty and the perceptions of people living under an already precarious water situation. Reciprocally, if the water from the dam were to run out, Noor would be unable to function without it.

Some uncertainty is entailed in the development and trade-offs of sociotechnical systems in a multi-scalar world. One interviewee expressed to me that no one even at the local level wanted to discuss the trade-offs entailed in the Noor power facility. He said that discussing the negative aspects of the project could bring *hushuma*—a somewhat karmic concept of shame important in Moroccan culture—on the elites in the area. He compared it to a marriage contact in which no one wants to mention divorce enough though it is a possibility. Yet it is important to discuss these issues because they illustrate the complexity of the Desertec vision— and other visions for transnational sociotechnical energy systems— and can become intractable challenges as construction begins.

Exporting electricity would likely *de facto* export water; this would vary greatly based upon the generating technology used, with around 90% more water for wet-cooled than dry-cooled CSP and very little water for PV or wind (Miller & Moore, 2011). (This issue is not specific to electricity and, while it is overlooked, applies to agricultural and other exports as well.) Dasgupta (2010) refers to these as "implicit subsidies" on exports. Without taking these implicit subsidies into consideration, even renewable energy could deplete a country's natural capital (see also Chapter 4). These integrated challenges would tie the commercial streets of Berlin to the challenges of integrated development in small Moroccan villages. Future water management in Morocco would then affect future electricity policy in the Mediterranean in highly complex and unpredictable ways. These trade-offs ought to be decided through a good procedure.

As described in Chapter 6, Desertec Design I included a vision for integrated solutions, which combined water desalination with electricity generation. Design II lost the focus on integrated solutions, especially in relationship to the energy-water nexus, the problems of which are illustrated with Noor. As the vision moved toward construction, the energy-water nexus indeed reemerged. The Desertec Foundation posted a picture on Facebook of Noor I under construction. It used the technique described in Chapter 6 of framing the future as proximal stating, "the future has begun…help to spread the word: Energy Transition is possible!" Several people responded in the comments, saying that the word that should be spread is that water stress is possible in the MENA region. The future is not here for Morocco if it means people at the local level will not have access to water, which is an issue that was neglected in Desertec Design II.[186] Below I will compare the Noor project to locally-driven integrated development solutions at the nexus of water and energy.

Figure 61. Noor I under Construction on the Desertec Foundation's Facebook Page. Screenshot by Author.

Decentralized integrated development. An energy scenario study developed by the Moroccan government in 2006 asked what Morocco's priorities should be between energy activities (like rural electrification) and other social activities with a redistributive effect (Royaume du Maroc, 2006). What is the capacity of Noor to redistribute the social inequities discussed at the beginning of the chapter versus the integrated development activities underway at the local scale? In Chapter 6, I discussed a distinction made by a Moroccan research organization between Champions League technologies and local technologies. Noor is clearly in the Champions League, as Noor or a similar project could provide the capability for exporting green electrons to Europe, and Noor seeks to improve

[186] see Chapter 6

Morocco's national energy security and to ensure multiple, ancillary benefits under the social pact discussed in Chapter 6. However, CSP is not necessarily redistributing social goods and is resulting in uneven development as benefits fail to go to those communities most affected and most in need.

As I will discuss in Chapter 8, the goal of electricity development from an energy justice and socially redistributive perspective is that it will improve people's capabilities to live out rich and fulfilling lives to address the inequities described in this chapter. The energy justice framework in Chapter 8 emphasizes the capabilities electricity access provides citizens, rather than just accounting for electrification rates. Below, I compare Noor to integrated development challenges led by local NGOs in terms of their ability to improve energy capabilities. This comparison will also aid in evaluating multi-scalar justice issues using the energy justice framework in Chapter 8.

The integrated development initiatives stemming from the local level seek to address the lack of local capacity of citizens and inequities. A local NGO called the Association Tichka provides local community development services for the Ouarzazate Province through a model that conceives of the citizen as sovereign. Tichka is run by Moroccans for Moroccans, which has been shown in the development literature to be more successful than when foreigners lead these projects.

Tichka engages the citizens of the village and seeks to avoid paternalism. The villagers come to Tichka with a proposal for a technology. Often local people ask for a small hospital but the core problem that is making people sick is dirty water. The Association then asks them to look critically at the root of the problem the technology is trying to solve, which Tichka finds typically relates to water and sanitation services. This is done through a process to engage the population early rather than to wait until the project execution stage. The villagers ultimately decide whether they want the water filtration system or the hospital. Then they prepare a contract with signatures from everyone in the village for local buy-in, to define everyone's roles in the contract to avoid top-down administration and future problems. They give the document to each household to read and decide what their contribution will be, as the population provides the workforce for the project. This model is bottom-up, not focused on the charity framing but on a public engagement framing, and it seeks to improve quality of life on an incremental, practical level.

To observe Tichka's version of integrated development, I visited the village of Zaouite Sidi Ahmed in late 2013. The local population had struggled with previous development projects, and many young people were leaving the village for urban areas. There was latent capacity in the village—ideas, people willing to volunteer, a cooperative, and an association—but insufficient resources. They planted trees, but they experienced mechanical problems with their butane pump used for pumping groundwater, and the trees died from a lack of water. Funding from Tichka allowed the villagers to install 85 solar panels for solar water pumping. They grew new olive trees. As an integrated development project, they also purchased an olive press so that they could press the olive oil themselves to sell higher quality oil. They even rent out the press to nearby villages; otherwise villagers must take the olives to Marrakech to be pressed. They purchased livestock for a continual source of income; the chickens can be sold quickly, and the dairy from the cows is used to make cheese. Additionally, they began growing a type of algae—spirulina—that is a popular health food in France and is exported. This local-scale integrated development is advantageous in terms of bottom-up participation, improving capabilities in the near-term to improve resilience and community buy-in.

Considering these benefits, it would be easy to assume that local-scale initiatives are fundamentally more just. Brown & Purcell (2005) call the privileging of the local scale “the local trap” because there is nothing “intrinsically more desirable [about the local scale] than other scales” in terms of their outcomes for sustainability, justice, and democracy. The local trap often encompasses a false assumption that localized decision-making will always be more democratic (Purcell, 2006). Similarly, localism has long been viewed as central to the democratization of technology. For example, in his iconic work on technology and democracy, Sclove (1995) recommended developing technologies that promote local self-reliance. Furthermore, the local-trap is prevalent in the envisioned transition toward distributed energy systems. While the local trap implies that local autonomy and decision-making are more just, local people themselves frame Ouarzazate as disadvantaged because of its isolation, lacking interconnections to the rest of the country and Mediterranean region. A focus on local independence and self-sufficiency overlooks the benefits to reducing isolation and building interdependencies, as this dissertation has illustrated in other chapters. Each region has comparative advantages and complementary attributes that could provide benefits through integration provided, as this dissertation has illustrated, that just political integration processes are developed.

Another issue with local-scale development is that it is not of sufficient scale to address the goals of transitioning Morocco as a nation-state into a future knowledge economy. Local and nation-scale development relate to different timescales and must occur simultaneously to fulfill Morocco's social pact for electricity. Tichka's development effects are immediate whereas Noor is geared toward a long-term vision for the country. It is more difficult to gauge the trade-offs for a larger project over a longer timescale, especially since the lack of capacity of the community impeded participation and the achievement of benefits from Noor.

An additional issue is that the focus on the local-scale often overlooks the governance of existing centralized systems. To construct democratic technologies, Sclove (1995) recommended building new, small-scale, decentralized technologies without focusing on how existing infrastructure would have to be refurbished and transformed. Over the course of my fieldwork, even these small-scale technologies came to be viewed as an important part of the centralized system. As Morocco's grid is strained, ONEE has begun to view rooftop PV systems in villages as a load balancing measure. Furthermore, there are advantages to being connected to centralized, large-scale power sources—for example, such sources can power factories that create jobs, while a solar PV panel is better suited for providing light and small-scale household uses, which are equally important to improving human capabilities. In Chapter 4, I quoted a Desertec stakeholder who explained that access to infrastructure in North Africa is better than access in sub-Saharan Africa because without infrastructural and social connectivity in the desert humans cannot survive. The Desertec vision's proponents view areas not connected to premium-networked spaces as isolated islands that do not benefit from the reliability and large-scale power sources of a centralized grid.[187] (Chapter 8 further discusses the justice aspects of centralized versus distributed energy systems.)

To achieve even development, a balance between local and national governance and development is likely needed. Local capacity-building initiatives should be combined with larger-scale projects for Morocco's political and social development. Noor I did not align with the capabilities of the workforce in neighboring villages, such as Tasslemante. National projects should align with the needs and capabilities of local people to address the inequities outlined above. Simultaneously, decentralized development is needed to improve the capabilities of the community, such as electrifying all homes and ensuring a clean supply of water in order to reduce the marginalization of local communities (this discussion is continued under the capabilities justice section in Chapter 8.)

Conclusion: The Prospects for Political Development & Technological Governance in Morocco

The Noor case fused new attempts at local governance with big projects traditionally run by the government. This process suffered from issues of legitimate local representation and uneven development, as a small village that lacks clean drinking water will now live in the shadow of a major energy facility. Rescaling governance in Morocco faces the paradox of greater legitimacy given to the king than local representatives, even as attempts are made to increase participation at the local level. Considering this paradox in the legitimating principles of power, what are the prospects for political development,

[187] see Chapter 4.

or more specifically an evolution in technological governance, in Morocco? The transition toward greater local governance as part of Morocco's political development would be rocky, but there are hopeful possibilities for a transition toward more local empowerment and political participation.

Some Moroccans I met prioritized the status quo in governance because of its stability, hoping to avoid the turmoil that has resulted from the Arab Spring in other countries. Yet, given the pressures of the Arab Spring, it seems unlikely that the status quo will be completely maintained. Activist youth are demanding radical change (i.e., doing away with the monarchy for fully elected representation) including the 2011 February 20th movement during the Arab Spring. For example, young artists and songwriters have been at the forefront of demanding change. A 17-year old Moroccan rapper, aka "Mr. Crazy," was jailed for three months in 2014 for offending the state with lyrics about the lives of unemployed young people living in Casablanca. Rapper El Haqed ("the Enraged One") has been imprisoned multiple times. While the most radical protests of 2011 have subsided, young people are continuing to stand up to the government to demand political change.

The most likely prospect for future governance would be gradual changes in representation and who gets to participate in technological governance as Morocco combines new participatory processes and visions for what the country will become. For instance, the government is accepting citizen comments on regionalization in the Sahara on a website called *Al Moubadara Lakoum* (the people's initiative), which is an example of public witnessing. New voices in governance range from the MENA Policy Hub discussed in Chapter 6 to new community associations composed of young people who want to improve the quality of life in their communities. Allowing for experts outside of the government to participate in the policy discourse could provide for a more neutral connection between the local community and the government. This input would be less threatening to state than activism. Increasing the capacity of experts is one possible component of good governance, although not a perfect solution, especially if the experts do not represent local people's interests.

Both equity of process and outcomes should be considered in this potential political development transition. I have discussed multiple inequities in Ouarzazate in terms of the socioeconomic status and geography of the region. For public participation to be successful, capacity is needed to address these inequities and foster popular sovereignty, not just royal sovereignty. This is a chicken or egg problem. On the one hand, measures could be taken to improve the capacity of the community to participate while participatory processes are delayed. On the other hand, participatory processes could be implemented today to include new voices to empower them to participate. The comparison could be drawn to whether transmission lines should be built before or after power plants with export capacity. A working group convened in Morocco by the NGO Germanwatch in February 2015 in Rabat, Morocco found that representatives of government, industry, and academia wanted to see more opportunities for civil society participation in renewable energy development and more mobilization of NGOs to participate on these issues. They also found that additional measures beyond CSP are needed to reduce the economic marginalization of southern Morocco (Schinke, 2015).

In the meantime, local NGOs like Tichka are taking on these capacity building efforts. In 2014, several young Moroccan researchers who participated in the

Germanwatch research project started a new NGO called the Human Touch. After interviewing numerous people in their community, these young women noted that "people are suffering too much in this region" and created an NGO to try to alleviate this suffering. They are part of the large unemployed but educated youth demographic that is taking on their responsibility as citizens to contribute to society. They offer hope that there is, in fact, a bright future for Morocco.

If Mediterranean regional electricity systems were integrated to the extent envisioned in Desertec Design II, these political development challenges would be connected to regional electricity governance. Additionally, the inequities in the Ouarzazate region would be linked to premium-networked spaces in Europe if electricity were exported, although there are benefits to be gained from these exports if a just processes free from coercion guides the development of the exports.[188] Through export these inequities could be improved, remain the same, or worsen; regardless they would be connected across space and nation-states. While it is often assumed that the benefits of large-scale development will trickle down to local citizens and communities, this chapter showed that the development of energy infrastructure in a particular locale does not automatically link it to the infrastructural and development benefits of premium-networked spaces. These areas will not *de facto* win but could be harmed or bypassed in technological development; long-term efforts must be made to address local-scale inequities in order for local citizens to benefit, as Morocco is working to do through the integrated development model. Chapter 8 will aid in thinking through issues of just processes and outcomes more systematically in complex, multi-scalar energy systems.

---

[188] This is further discussed in Chapter 8 under the sovereignty and freedom from coercion section.

CHAPTER 8

A NEW FRAMEWORK FOR ENERGY JUSTICE

Introduction

Complex energy systems impose myriad injustices from how energy is supplied to how it is consumed and finally how energy technologies are disposed. Furthermore, transformations in these energy systems, such as those addressed in this dissertation, have the potential to reconfigure and maximize just outcomes for vulnerable populations. Currently, even though energy access could improve the livelihoods of the vulnerable, the development of energy services for the world's poor has been systematically neglected. On the demand side, a staggering 1.3 billion people worldwide lack any access to electricity (Practical Action, 2012), and up to 3 billion people lack "sufficient" access to electricity (Guruswamy, 2011). Without substantial policy changes, the rate of sub-Saharan Africans with access to electricity is set to improve by a mere 10% by 2030, while the absolute number of those without power will increase (Practical Action, 2012). Supplying energy also imposes injustices. Worldwide, impoverished communities live near polluting, unsightly, and dangerous energy facilities, often shouldering the burdens of production while communities elsewhere benefit from using the energy. For example, communities in the oil-rich Niger Delta bear immense burdens, including the industrialization of their lands, water pollution, and a lack of personal safety (Amnesty International, n.d.). Even the low-carbon CSP plant in Morocco evaluated in Chapter 7 resulted in drawbacks for local communities. This energy justice challenge crosses scales in a globalized world, as, for example, benefits from burning Nigerian fossil fuels are largely reaped overseas, and monetary compensation typically goes to the national government rather than the local people (ibid).

The challenge of energy justice is substantial, complex, and multi-scalar. Changes and innovation both in the system configuration and the technologies are needed that go beyond prioritizing the typical standards of low cost for current generations and reliability. In order to maximize societal benefit for energy systems undergoing transformation, energy system innovation and investment need ethical guidance throughout the visioning, designing, planning, construction, operation, and decommissioning stages based upon the principles of justice. The urgency is increased by the fact that decisions made in the energy sector today will have significant effects on justice outcomes for decades to come. Power plants last for 30 to 40 years and are integrated into entrenched and obdurate system configurations that distribute the benefits and drawbacks of supply and demand. As this dissertation illustrated, energy systems are not being built from scratch but are being integrated into these existing systems in an attempt to refurbish them. This process will have enduring effects on justice outcomes and trade-offs for both current and future generations. Therefore an operationalizable framework on energy justice is needed today to guide this systems change.

Current colloquial and scholarly approaches to energy justice, while important and useful, are also scattershot and often narrowly framed with a focus only on the demand side, largely relating to whether people lack access to electricity. A more comprehensive conceptualization of energy justice is needed to weave together various definitions of energy justice and empirical material from this study with a plurality of theories of justice. Framing energy justice only as equality of access is problematic because reaching a kW/person target will not ensure just outcomes. Energy justice is a multi-dimensional and ambiguous concept that—like sustainability—suffers from definitional issues. Just as it is easier to diagnose unsustainable practices than it is to depict a sustainable society, it is easier to identify energy injustices than to envision just energy systems without resorting to utopianism and unrealistic win-win discourses. A more comprehensive understanding of the term should be developed.

Contemporary justice theory could aid both scholars and practitioners in developing a new conceptualization and framework for energy justice to aid in designing and evaluating energy system transformations. Nussbaum (2007) argued that theories of justice should be sufficiently abstract to apply to a range of social problems but be specific enough to offer useful guidance on real-world problems like energy. Hence, this paper interweaves various theories of justice to develop principles and guidance specific enough to aid in building just energy systems but abstract enough to allow for generalizable thought across energy case studies. Sen and Nussbaum's capabilities approach, for example, illustrates that energy's worth must be measured not simply using electrification rates and usage per capita, as was often done in Morocco, but in the ways that electricity improves quality of life and helps people secure their rights. Furthermore, since sociotechnical systems play an important role in distributing just and unjust outcomes, the sociotechnical systems approach can also contribute to justice theory. Specifically, the findings from the Desertec sociotechnical systems case study illustrate how the theoretical categories of justice relate to complexity and to how energy systems affect people differently at local, regional, national, and international scales, as will be explicated below. It is necessary to draw together the key issues from the case study with relevant theories of justice, to address how these theories are applicable but incomplete, in order to develop a comprehensive conception of energy justice that can be put into practice.

This chapter begins by overviewing the complexity of the energy justice challenge based upon findings from this dissertation. Then it surveys existing conceptualizations of energy justice from the scholarly and grey literature, followed by a review of the justice literature. Based on this literature, it presents a preliminary energy justice framework to improve upon the conceptualization of energy justice and to diagnose energy injustice. Finally, it applies the framework to the empirical material from this dissertation, finding that it is useful for diagnosing injustice but needs to be revised to address foundational inequities, trade-offs, energy security, and multi-scalar systems-level inequities and injustices. Overall, this chapter ties together the dissertation's main arguments through the lens of justice, fulfilling the dissertation's normative goals outlined in Chapter 1. Current policy discourses on sustainability often close down and narrow discussion and debate (Leach, Scoones, & Stirling, 2010), especially in the energy sector in which decisions and imaginations are often constrained based on existing, path dependent systems. The pluralistic and comprehensive framework on energy justice presented below could help to open up new "pathways to sustainability" (ibid) for energy systems that both power and empower communities for a more just energy future.

The Complex Challenge of Energy Justice

This dissertation has illustrated how an energy technology's politics are dependent upon the system context in which they are embedded. Furthermore, a technology's success is dependent upon sociopolitical complexity, as well as the system complexity into which emerging technologies attempt to take root. Therefore, the challenge of energy justice is not simply a matter of designing socially robust technologies but is an even greater challenge of rebuilding complex sociotechnical systems spanning local to global scales. There are no simplistic, win-win solutions to providing electricity and fuels in sustainable and equitable ways across these complex sociotechnical systems. Below are some examples of the complexity of energy justice identified from this study that ought to be considered when drawing boundaries around the energy system to be evaluated and when evaluating energy justice procedure and outcomes.

System transition complexity. It is important for energy policy in the 21st century to consider emerging technologies within the context of the complexity of the existing sociotechnical systems landscape and how this landscape is managed and governed. As this study has illustrated, electrical power systems are not scale-free and are generally centrally managed. Mediterranean electricity system imaginers framed a modern energy system not based upon radically innovative technologies but on a somewhat different system configuration and its management. Even subtle changes in this management can be complex. Electrical power grids can only accept a relatively small portion of the total generating capacity from intermittent energy sources before experiencing significant challenges with grid management; this is the impetus for integration across nation-state lines. For example, grid managers in Spain prioritized electricity from coal in the system because it is very difficult to temporarily shut down a coal-fired plant but easy to stop wind turbines. As described in Chapter 5, a Mediterranean TSO would be needed to manage a regional power system. Whether the Desertec vision is pursued or not, Europe will have to make major system-level electricity transformations.

Sociopolitical complexity. The Desertec case study illustrates the sociopolitical complexity of energy transformations. Energy transformations are not simply technical but are sociotechnical and political. As this dissertation has argued, the development of electricity regulatory institutions has long been a political development challenge specific to individual nation-states. Each of the 44 countries within the Desertec vision have an individual social contract or pact for electricity system development, which would have to be ceded in favor of multilateral, regional political planning. This sociopolitical complexity was also illustrated by how Morocco's domestic energy system was torn in various directions by numerous, complex sociopolitical influences and dynamics. In another example of sociopolitical complexity, Spain failed to sign the Desertec trans-continental transmission agreement for a variety of sociopolitical reasons including geopolitics, security of supply, and the economic crisis, whereas Moroccan officials saw European politics as interfering with the Desertec vision's progress. The idea of a copper plate for energy generation in the Mediterranean region trivializes the significant sociopolitical complexity of the region. Overall, this sociopolitical complexity illustrates that the Desertec system—and other visions for energy transformations— would not be built from scratch but within a complex context that shapes the social justice outcomes of the system.

Temporal complexity. This dissertation illustrated the temporal complexity entailed in energy system transformations. Temporal complexity is particularly salient for transformations to renewable energy systems due to intermittency; supply and demand must be balanced at every second, otherwise blackouts and wasted electricity result. Unlike with oil markets, temporal complexity is related to energy security in renewable energy systems because generation withheld for political reasons would be wasted and could not be stored and sold later on.[189]

Providing for both supply and demand requires planning across timescales that are staggering. Investment cycles in the power sector last up to 50 years, which is the time it takes to plan, build, operate, and decommission a single power plant. Temporal complexity relates to the sociology of expectations, as different stakeholders involved in the vision for an integrated renewable energy system in the Mediterranean had vastly different expectations for how quickly the first projects could be built and the exports could be achieved. These disparate timescales relate to rapidly changing technological and social contexts, making electricity system planning particularly challenging and complex. Even minor changes in the existing energy landscape affect plans for future energy systems.[190] Long timescales associated with energy planning, as well as wildcards that disrupt plans, lead to uncertainty in decision-making and challenges with predicting factors ranging from cost to cultural effects. Morocco, for example, worked to mitigate

[189] See Chapter 5.
[190] See Chapter 5 on the change in the price of solar PV.

this uncertainty by using statistics (*les données*) to inform policymaking, which could be reductionist and mask important social issues.

Urgency also plays a role in energy policymaking, and actors use temporal tactics to frame and control the future in an attempt to speed up their desired outcomes. Today's system imaginers are acting not as inventors but as project accelerators working to situate technologies viewed as already ready in an inevitable future. This attempt to speed up technological development could be problematic for procedural justice as stakeholder engagement procedures could be neglected. Adam (2003) pointed out that there are no organizations that manage the governance of time. This lack of temporal governance is magnified because the inequalities established in the design phase could be perpetuated for decades, as Winner (1980) illustrated. Therefore, temporal complexity is closely related to intergenerational justice, because decisions made today will affect future generations.

Another aspect of temporal complexity that illustrates its enduring consequences relates to lifecycle analysis. The lifecycle approach of analyzing energy technologies is essential to understanding the effects of energy technologies from cradle to gate, including their anticipated consequences for society (Wender et al., 2014). For example, a higher efficiency solar PV panel could be less energy efficient over the lifecycle because it requires much more energy to manufacture than a traditional PV panel. Household electricity consumption is not the end of the lifecycle, as energy generation technologies must later be decommissioned and disposed of or recycled. Even solar photovoltaic panels pose environmental risks if improperly disposed instead of recycled (Silicon

Valley Toxics Association, 2009). Therefore, lasting consequences can be observed relating to ecological justice even for renewable energy systems. The first design of the Desertec vision, described in Chapter 5, included lifecycle analysis to ensure that sufficient materials were available in a finite world to construct the envisioned system by 2050. This was lost in Design II.

Geographic complexity. A power plant would be better sited on a brownfield than on pristine land, but the brownfield site could require the construction of a new transmission line, thereby disrupting the landscape and having negative environmental effects. As such siting conflicts grow in the Western world, the burdens of electricity generation could be pushed onto the developing world. In a transnational electricity system, energy usage in one country shapes the landscapes of another. As this study illustrated, the design for an integrated Mediterranean electricity system was shaped by various geographic representations and framings of the region; these representations also affect its possible energy justice outcomes.[191] A constructivist perspective on geography is important to understanding the interplay between the landscape and the technological system. This interplay has outcomes related to the category of recognition justice described later in the paper, as populations that are written out of the landscape do not receive benefits from the system.

Socioeconomic complexity. The socioeconomic and economic complexity of electricity system transformations is more commonly acknowledged. This study illustrated how Morocco expected more than electrons from its new energy system; it

---

[191] See Chapter 4.

also expected multiple, ancillary socioeconomic benefits. In other cases, energy transformations can disadvantage vulnerable populations who benefited from the old system. For example, efforts to shut down the heavily polluting Navajo Generating Station in Arizona faced stiff resistance from workers whose livelihoods depend on the power plant. Similarly, communities on the Gulf Coast resisted a moratorium on deepwater drilling following the Deepwater Horizon oil spill that was intended to give regulators time to understand what happened and to mitigate future risks.

The economics of electricity transformations are also complex. New technologies in the power sector, such as solar PV and electrical storage, must compete with older technologies that are integrated into obdurate systems and supported by a subtle web of subsidies. Subsidies for renewable energy became unpopular in Europe during the financial crisis. In Morocco, subsidies are important for the affordability of energy but challenge the financial health of the state. Additionally, because of the timescale involved in Mediterranean regional power systems development, it was difficult to determine how much added cost would result from a 100% renewable energy future in the Mediterranean since much of the existing infrastructure would need to be replaced by 2050 anyway. In other cases, economic factors trivialized the complexity of energy transitions; for example, Dii focused on low cost above other factors, but other problems like the energy-water nexus could become intractable over time.

Environmental complexity. Transitions toward renewable energy in Europe primarily seek to address climate change through significant mitigation measures. However, there are no simple fixes to environmental challenges across the lifecycle due to complexity and long timescales. All energy systems result in environmental harms of some kind. For example, green energy technologies that emit little to no carbon during energy generation do not necessarily fulfill the social and environmental pillars of sustainability and may harm the environment in other ways, such as avian deaths from wind turbines and solar power plants.

Supply and Demand

Supply. Even though energy justice typically focuses on demand-side issues of access, the complex, system-level challenge of energy justice ranges across the lifecycle from how energy is supplied through to its end uses. Most prominently, issues of energy supply relate to land use, siting, and energy geography. The field of environmental justice has illustrated how power plants, refining facilities, and transmission lines are often sited in the backyards of marginalized populations who are often not recognized and given a voice in the process. In energy development projects across the globe, communities are often neither sufficiently involved in the siting process nor fairly compensated. For example, the community in the Democratic Republic of Congo whose land was flooded for the Inga Dam project was not recognized as having legitimate claims to the land. They became energy refugees living in tent settlements with transmission lines running overhead to transmit power to a copper mine (Lustgarten, 2009).

Justice issues in energy supply are not limited to siting. They are also multi-scalar, as complex energy supply chains interweave justice issues in disparate locations. For example, PV panels on rooftops in Arizona may be tied to rare earth metal mining in China where workers have insufficient protection from hazards. Inequities in the village of Tasslemante could be tied to the streets of Berlin through the envisioned Desertec system. The supply of electricity also poses integrated challenges. As the Tasslemante case study discussed in Chapter 7, electricity is tied to sticky integrated challenges relating to water and other environmental resources, as well as to socioeconomic outcomes.

The drawbacks of energy supply are often neglected in the Western world until disaster strikes, resulting in an "attention-neglect cycle" (Bryne, Toly, & Young-Doo Wang, 2006). Forms of supplying primary energy are becoming riskier as fossil fuel supplies dwindle, from hydraulic fracturing (i.e., fracking) to deepwater drilling. From 1992 to 2006, deepwater oil production rose 820% in the United States (Minerals Management Service, 2008) and by 2008 15 rigs in the Gulf of Mexico were operating in ultradeep water, meaning below 5,000 feet (ibid). Yet regulations are lacking to cope with the systemic risks and lack of scientific understanding of high pressure and high temperature environments. In another example, nuclear power poses the risk of "normal" and catastrophic accidents (Perrow, 1999), and the recent accident at the Fukushima Daiichi nuclear plant following the tsunami in Japan led Germany and other countries to phase out their nuclear power plants. Additionally, power plants also pose health risks; in the United States power plant emissions are indirectly tied to roughly 13,000 deaths each year (Schneider, C. & J. Banks. 2010) in addition to their effects on climate. This underscores the need to consider energy risks and the principles of justice early in the design of energy supply chains rather than only in times of crisis, especially so that vulnerable populations do not shoulder the risks disproportionately.

On an international level, energy supply is also linked to complex geopolitics and international relations, because oil and natural resources are global-scale markets and resources are unevenly distributed. Oil rich rentier states lack accountability to their populations as they rely upon rents, or revenue, from the state oil sector rather than taxes (Ross, 2001). Rentier states struggle with economic diversification and authoritarian governments, and relations are often tense with Western countries that purchase their fuels. The more recent trend toward the internationalization of electricity poses some risk that countries could become dependent upon electricity exports, just as rentier states are dependent upon oil exports. It also raises questions about who benefits and loses when electricity is transmitted over long distances and potentially across power disparities. Poorer countries integrated into regional systems may shoulder a greater risk in disruptions of the supply of electricity, as they will be more likely to suffer from blackouts than wealthier countries should a failure occur. However, regional integration also offers benefits such as economic opportunities from electricity and technology exports, the exchange of know-how, and North-South research collaborations.

Demand (Energy Poverty and Wealth). On the energy demand side, existing energy justice conceptions focus on those populations that completely lack access to electricity worldwide, which are not connected to premium-networked spaces. Some other populations have access, but it is insufficient to meet their needs. Many of these energy-impoverished populations also shoulder a disproportionate share of energy's supply burdens. Furthermore, energy poverty exists—and could grow—even in countries with full electrification rates. In MENA, losing access to reliable 24/7 electricity where populations have become dependent on it is problematic for equity and quality of life.

Access to electricity itself is an insufficient criterion for energy justice and must at least be considered along with access to the devices that use it. Households must be "electrically modernized," or wired for electrical lighting, outlets, and appliances to make full use of the electricity (Tobey, 1996). The key question, which often goes unaddressed, is whether the benefits provided by the electricity improve quality of life. Some development NGOs in Morocco complained that electricity merely powers TVs for entertainment and worsens social relations,[192] although these TVs could also bring access to information through independent media sources where only state-run press was available before. Energy system builders should take such factors into consideration when designing energy systems.

In contrast, premium-networked spaces benefit from profound energy wealth even in unseen ways. For instance, energy is embedded in all of the products that Westerners use from manufacturing to shipping. Energy-consuming servers, which are placed out-of-sight, power Internet searches (Google, 2009). People in premium-networked spaces plug in computers in public places without giving a moment's thought to who pays for the electricity. Because Western countries have become so dependent upon this instantly available energy wealth, the principle that dominates these planning processes is typically reliability. For example, U.S. utility companies will often say that they sell the service of reliability rather than electrons. While maintaining reliable supplies of electricity and energy to meet demand is crucial, this goal often overtakes other priorities. Efforts across the globe seek to expand the principles upon which electricity is built. For example, the Africa-EU Energy Partnership aims to build power systems that are reliable but also

[192] See Chapter 7.

affordable, accessible, and sustainable. Efforts to expand the principles and priorities involved in energy planning could be informed by energy justice theory, as described below.

From mining to generation to transmission to usage, energy poses challenges for just process and outcomes. This energy justice challenge is highly complex and crosses multiple scales in a system context. The energy justice challenge goes beyond designing individual technologies to understanding how they fit into complex sociotechnical systems and anticipating outcomes for society that will last over decades. Not only are the outcomes complex, the upfront visioning and design process is also complex due to the sociopolitical and other factors discussed in this dissertation. Energy also challenges justice theory because in order to diagnose injustices wider boundaries must be drawn to encompass the broader, multi-scalar system. Justice theory is only beginning to address these multi-scalar, transnational issues. As described in the framework below, injustices in sociotechnical energy systems cross different categories of justice and pose new considerations ranging from sovereignty to trade-offs.

Existing Conceptions of Energy Justice

This section reviews the scholarly and colloquial conceptions of energy justice, in order to collate the scattershot conceptions and use them as a starting point for the framework. As useful as these conceptions are, the theoretical concept of energy justice needs to be expanded from the demand side issues of energy poverty to consider supply side and multi-scalar justice issues. This section also illustrates that energy justice matters to a diversity of groups across the globe—from religious institutions to development banks to Native Americans—and that an energy justice framework could be useful to them.

In the United States and Canada, the term energy justice often focuses on technology choice and is used to advocate for the use of renewable energy over what many environmental NGOs see as polluting or risky energy technologies—primarily coal, but also natural gas sourced from fracking, nuclear energy, and even hydropower. The organization leading these efforts is a U.S.-based 501(c)3 grassroots nonprofit organization called the Energy Justice Network. Their website includes a map of the "dirty energy and waste" facilities in the country. It makes visible technologies, not actual inequities, meaning that the facilities are not correlated with data on race, income, gender, Superfund sites or other industrial uses, or other baseline indicators of environmental injustice.

Supply-side issues of energy siting attract a variety of community groups. Few explicitly use the term energy justice with the exception of several Western religious organizations. The U.S. National Council of Churches, an ecumenical organization, has an eco-justice movement, which themed 2012 the year of the ethics of energy. Their work is grounded their 1978 "Proposed Policy Statement on the Ethical Implications of Energy Production and Use," which emphasized stewardship over environmental resources rather than the domination of nature, based on an energy technology's ability to build shalom, or "wholeness and harmonious relationship in creation and in community" (Birch, 1978). They also emphasize ecological justice, defined based upon the principles of sustainability, equity, and participation, rejecting the dichotomy between social and environmental issues. This is one of the most comprehensive colloquial discussions on energy equity issues. The 2012 year of energy ethics included six webinars on energy stewardship issues for Sunday school on Earth Day. In another religious example of energy justice efforts, the Canada Mennonite Central Committee on Energy Justice evaluates the energy justice aspects of Manitoba's hydroelectric systems. They challenge the image of hydropower as clean, and their protest is grounded in a belief in the spiritual value and sacredness of hydroelectric power systems. They recommend that spiritual impact assessment be included in environmental impact assessment for new generation facilities.

Catholic theologians have also written on energy justice. Ivan Illich, a Roman Catholic priest, wrote the only existing book on energy ethics, which is discussed below. Jose Ambrozic, Chairman of the Board at the Universidad Catolica San Palo, argues that Catholic social justice theology can address the shortfalls of Rawlsian justice theory (Ambrozic, 2010). Ambrozic argues the solution to the energy crisis is "not technical, but moral" (p. 393). He objects to the Rawlsian assertion that the principles of justice should be decided only in the political sphere. Since Catholic theology sees humans as reflecting the divine image, humans' spiritual and material dimensions, including energy needs, should be addressed as well. Christian freedom, he argues, is having the capacity to fulfill duties to love and work for justice. Energy is a basic need that Christians must aid in providing through international development as a vocation. A full exploration of the relationship between religion and energy justice is beyond the scope of this paper but is an area ripe for future exploration.

Relevant to both the supply and demand sides, one strand of social justice theory applicable to energy justice is that of recognition justice, developed by Nancy Fraser, who argued that minority groups that have been traditionally disadvantaged must be recognized. (Recognition justice is discussed more comprehensively below.) Thus far the theory has been applied to identity-based groups, but it would be more applicable to energy if it addressed affected groups. Examples of energy-abused minority groups that should be recognized include the energy impoverished, Native Americans and other indigenous groups, and local people in the Sahara who were not recognized based on the colonial imaginaries of the Sahara as an empty landscape. Additionally, the Women's Energy Justice Network coined the phrase "the energy oppressed poor" to describe those without sufficient access to electricity and clean cooking fuels. They are the most prominent of the disadvantaged minority groups who should be recognized in the energy justice domain. In the United States, Native American groups use the term energy justice to protest the exploitation of energy on tribal lands and to promote the use of renewable energy. Honor the Earth, an organization formed by Native American activist and scholar Winona LaDuke and the Indigo Girls band, includes an initiative on energy justice to increase the use of renewable energy and promote tribal energy sovereignty. The Indigenous Environmental Network has a similar initiative. Energy refugees, or the energy displaced, are, often forcibly, removed from their land, and are another category of people who could be recognized but have not been categorized thus far.

Scholars and development practitioners typically equate energy justice with ending energy poverty, or a lack of access to electricity and clean cooking fuels (Guruswamy, 2010). Some development experts see energy as a "precondition" or “prerequisite” to satisfying many other needs, such as pumping clean water, powering hospitals, and refrigerating vaccines, as well as meeting the Millennium Development Goals. They believe an energy poverty line should be developed as a proxy for measuring well-being (Giannini Pereira, Vasconcelos Freitas, & da Silva, 2011). Other organizations, like the Solar Electric Light Fund, go a step further, calling energy a human right. The *Poor People’s Energy Outlook* states that “total energy access” is “the point of use in terms of the energy services people need, want, *and have a right to*—lighting, cooking and water heating, space heating, cooling, and information and communications technologies” (emphasis added) (Practical Action, 2012, p. xi).

Energy poverty is often viewed as a problem affecting only developing countries where many citizens have no electricity access, but recent studies illustrate that gradations of energy poverty exist across the globe. Although it is often overlooked, this illustrates that energy poverty is not just a matter of having energy or not but of whether one has a sufficient amount of energy. Buzar (2007) refers to energy poverty in the industrialized world as “the hidden geography of energy.” Even though Eastern and Central Europe are fully electrified, many households lack affordable heat, but such problems have been largely overlooked (ibid). In fact, many fully electrified countries have glaring inequalities in energy access. While 38% of Norwegians use half of the electricity generated in Norway, only 25% of Americans use half of the total U.S. energy generation (Jacobson, Milman, & Kammen, 2005). The U.S. Center for Energy and Environmental Policy defines energy justice not merely on the basis of access to electricity but also on “the achievement of a proportionate distribution of energy burdens among low- and moderate-income groups, disadvantaged populations, and minorities when compared to the energy burden falling on the rest of society" (Center for Energy and Environmental Policy University of Delaware, 2012).

While these conceptions of energy justice focus on increasing energy consumption, other scholars think energy justice has more to do with ending energy gluttony and redistributing these finite resources elsewhere. Illich wrote in the 1970s that viewing high energy consumption as a moral imperative enslaves the poor to a maximum economic growth model, social control, and other problems like pollution. He stated:

> This allows our lifestyle to become energy intensive, the right to work and need for gas connected, jobs and watts could be recognized as basic rights because they could be interpreted as basic needs, the modern state an employment agency with a gun to protect the fuel pump, politicians could win by the mere promise of more watts and jobs. The need for energy became morally obvious (Illich, 1983, published in Ghosn, 2009).

He argued that there is an amount of electricity per capita beyond which energy is provisioned at such great scale that it is beyond the control of just governance processes (Illich, 1974). He advocated for an energy ceiling—a line above which energy ceases to be correlated with improved quality of life. More recently, Grimsby (2011) revisited Illich's argument, claiming that a focus on energy poverty rather than energy equity ignores the gap in energy consumption per capita between developing and developed words. He thinks that increasing the consumption of the poor without decreasing the consumption of the wealthy would put too much strain on the world's resources, reflecting the *Limits to Growth* approach from Desertec Design I. He argued that an energy ceiling might be more pro-poor than an energy floor. (This is a fairly common discussion among environmental NGOs concerned about climate change and finite resources.)

One take-away point is that energy access, and its worth to people, should not be measured in electrification rates alone. Goldemberg, Johansson, Reddy, & Williams (1988) advocate for treating sustainable energy as a means of achieving human development goals, rather than as a good in-and-of-itself. The current energy development growth paradigm measures development based on energy supply and electrification rates. Instead, energy's worth should be valued according to the services it provides, such as lighting a house or powering a factory. Later I will explore how this more nuanced take on the "energy as a precursor" discourse relates well to capabilities justice theory.

A very different conception of energy justice focuses on how centralized energy systems impose particular political configurations on society. Here, energy justice is conceived as stemming from radically reconfiguring centralized energy systems into distributed systems in which citizens produce their own energy through small-scale technologies in their backyards (one of the system reconfiguration scenarios discussed in Chapter 1). While distributed systems are not explicitly correlated with energy justice, they underpin a popular vision of a just energy system. E.F. Schumacher developed this view in the 1970s, calling for appropriate, small-scale technologies, such as solar photovoltaics. This philosophy emphasizes that a democratic and open society can only be built on decentralized infrastructures and that centralized technologies like nuclear power subject society to an insular, military form of management (Sclove, 1995; Winner, 1977).

This dissertation shows that evaluating energy systems from a system-level perspective is essential, but the distributed energy critique often offers an idyllic vision of a just energy society, which may have limited utility in redressing energy injustices. Sen (2009) described the perils of comparative justice based upon utopian visions stating that a "theory of justice that can serve as the basis of practical reasoning must include ways of judging how to reduce injustice and advance justice, rather than aiming only at the characterization of perfectly just societies" (p. ix). He thinks injustice should be compared on a relative basis, not on the basis of a vision for a perfectly just society. For example, comparing Dali to Picasso is helpful to art critics. However, it is not necessary to compare Dali and Picasso to the most perfect picture in the world, or a "third irrelevant alternative" (ibid, p. 101). In its extreme form, the distributed path's techno-utopian view offers this third alternative, which could serve to mask new injustices stemming from a distributed system. While it makes the essential point that technological systems affect social arrangements and the reverse, it also overestimates the power of particular technologies to legislate social change and leaves energy justice for the unlikely day when societies' path dependent energy infrastructures are ripped out and replaced with radically different systems.

I do not mean to suggest that distributed technologies do not have advantages but that the distributed pathway is not a perfect solution for sociotechnical reordering that is free from trade-offs. The distributed energy vision often succumbs to the local trap, in which local-scale technologies are automatically assumed to be more just and democratic

(Purcell & Brown, 2005). Moreover, some criticize development banks for using solar PV to give the rural poor a small amount of electricity instead of linking them to premium-networked spaces, which could further the marginalization of the rural poor (Byrne & Toly, 2006). For example, PV in Morocco was framed as an appropriate technology for the poorest and most remote populations. Once a household gains access to a small solar panel—which is no doubt helpful in providing light—they are checked off as electrified and may not benefit from increased access any time in the near future, especially in a country that is struggling to meet growing electricity demand. In Chapter 4, I addressed how the Desertec dream stopped at the imagined boundary between North Africa and sub-Saharan Africa, even though people need energy more desperately in sub-Saharan Africa. Technologies such as solar lanterns are often viewed as more appropriate for these remote landscapes. I asked: Who should have the right to be linked to premium-networked spaces? What technologies are appropriate in the perceptions of local people? In Chapter 7, I compared the merits and drawbacks of national-scale electricity development versus local-scale electricity development in Morocco, finding that there were benefits and drawbacks to each, which were dependent not only on scale but also more importantly on procedure.

The answer to these questions is context dependent and requires comparative, system-level approaches. The issue of comparative energy justice is challenging at both the system and individual technology scales. Byrne & Toly (2006) argue that judging technologies as better (e.g., wind) rather than worse (e.g., coal) is an insufficient metric that lacks content. It provides little information about for whom it would be better, by what standard, and at what cost (including social and environmental costs not merely economic costs). Furthermore, these issues are multi-scalar, linking locales such as the village of Tasslemante in Morocco, to the streets of Berlin, perhaps even to rural areas in Benin. A richer comparison based upon the framework below and a public engagement process for discussing and selecting trade-offs and defining what appropriate technologies are would be needed, as outlined in the next section.

What Justice Theory Offers Energy

Below I overview the six categories of justice identified in the literature, which I then combine into the initial justice framework.

Distributive justice. Most of the existing conceptualizations of energy justice focus on distributive justice issues, primarily disparities in energy access. John Rawls developed distributive justice theory, which focuses on how benefits and harms are distributed within society. Rawls imagined a primordial period, or the original position, in which individuals convene to structure the societal institutions of justice. These individuals should be from the same geographic territory; have similar mental and physical capabilities; and be free, roughly equal, and independent. They negotiate the principles of justice for society from behind a "Veil of Ignorance," in which individuals do not know what their personal status in society will be. They work to gain "mutual benefit" by rationally and objectively negotiating the distribution of primary goods (ibid, p. 64).

On the demand side, energy's distributive outcomes are well defined by the concepts of energy poverty—who has access and who does not— and energy affordability—who pays and how much do they pay. The supply-side distributive injustices—who shoulders the risks of energy siting and production— are less acknowledged in the energy justice literature, although well acknowledged in the environmental justice literature. Distributive justice relates to often considered questions about whether there is equality and affordability of energy access. One significant distributive justice issue addressed throughout the dissertation is whether people have access to premium-networked spaces and whether the right to be networked is acknowledged. Design I in Chapter 5 pointed out that a lack of access to infrastructure in rural areas led to trends such as urban crowding. Design I's proponents argued that Europe had an obligation to ensure that its neighbors also enjoyed high levels of energy access so that they were not left in misery. Distributive justice relates to who wins and loses on the supply and demand sides of energy generation. For example, this dissertation asked: as siting conflicts become increasing polarized in the West, will electricity generation be pushed even further away from load centers into the developing world, resulting in an uneven share of the burdens of supply and the benefits of access? Who would benefit and who would lose if the entire Mediterranean were powered with Saharan desert power? In Chapter 5, the distributive justice concern was addressed that if a failure occurred in a regional power system, richer countries that are willing and able to pay more for electricity will likely maintain reliability, while poorer countries suffer from blackouts. Therefore, poorer countries bear a disproportionate risk related to a potential failure in the system. Distributive justice is the lens through which energy justice is typically perceived, but energy justice should be expanded to address other categories.

Procedural justice. A fair process for distributing these outcomes is also required for energy justice. A variety of scholars, most prominently Nussbaum and Sen, find Rawls' "original position" problematic in terms of procedural justice. In reality, not everyone is allowed to participate in the process of the distribution of goods and drawbacks (Barry, 1996). Nor are all of the participants truly on an equal playing field and able to work to their mutual advantage (ibid). This is relevant to energy justice because certain groups are disadvantaged. For example, women are disproportionately affected by dirty cookstoves, senior citizens typically have a higher energy burden, and the differently abled depend on electricity for medical care and devices. It is possible that these groups need more energy in order to have equal human capabilities.

Myriad institutions, not individuals, govern energy systems including national political and regulatory institutions, international organizations like the International Energy Agency, multinational corporations, and possibly even regional transmission system operators.[193] The process of governing energy is sociopolitically complex due to the number of institutions involved and their history. The decisions made by these institutions will affect citizens and the environment for decades. However, they do not typically frame problems in ways that account for energy systems' injustices and recognize disadvantaged groups, nor do they often provide representation for vulnerable and disadvantaged groups. For example, this dissertation illustrated that citizens did not participate in developing the social pact for electricity in Morocco, which defines the

[193] See Chapter 5.

benefits that should come from an electricity system. Furthermore, locals in Morocco lacked legitimate representation to stand up for their interests in energy development processes. This dissertation also illustrated how Dii played a role as a convener of stakeholders in the MENA region. This was a contested role in terms of procedural justice because Dii also acted as a gatekeeper in these conversations, and the conversations unsurprisingly did not provide an outlet for dissenting views. Achieving just processes for energy systems is therefore institutionally complex. Designing procedures through which citizens can participate in the design of energy projects and systems is vital both for procedural and distributive justice.

To achieve procedural justice, it is important to ask the following questions. Who frames the principles of justice? For whom are they framed? How are they framed? (Nussbaum, 2007). Disadvantaged groups— including the differently abled, women, children, senior citizens, and even nature— should have a voice or legitimate representation in the process. Without just processes, the needs of these citizens are unlikely to be addressed. Efforts to address energy poverty—like gel cookstoves—have sometimes failed due to the lack of an inclusive, culturally appropriate process for designing the technology. Cookstoves provide multiple socio-cultural functions (e.g., taste of food, bug control from smoke, cost of fuel) that will not necessarily be accounted for in the clean cookstove's design without a participatory process.

Social justice: capabilities. Nussbaum and Sen argue that justice is not only connected to the institutions of society but also to the capabilities that individuals have to secure rights and live fulfilling and enriching lives (Sen, 2009). Aggregate measures of human development, like GDP, are insufficient for measuring this as they do not measure capabilities or consider the distribution of benefits (ibid). Similarly, national electrification rates and energy consumption per capita do not measure the worth of energy access to people. Energy's worth should instead be valued according to the services it provides, such as lighting a house or powering a factory, and how these services empower people. The capabilities approach also illustrates that a theory of energy justice that is based only on technological choice is insufficient to guarantee enhanced human thriving and just outcomes. For example, renewable energy should not be considered a good in-and-of-itself but a tool for achieving human development goals (Goldemberg et al., 1988).

Since energy relates to capabilities, is it a human right as some NGOs argue? Nussbaum (2007) views capabilities as foundational for providing people with the capacity to secure their rights. For example, better education can help a person to secure his or her right to free speech (ibid). From a capabilities perspective, energy itself is not a right but is part of the capabilities that people need to be able to secure rights. On the other hand, conceiving of energy as a human right could be politically and strategically useful if it invokes a duty to achieve energy equity. Rights invoke duties e.g., the right not to be murdered leads to a duty not to murder (Mandle, 2006). If energy were a right, then there would be a duty to provide it. Pragmatically, it would be best to focus on the framing that will aid most in improving energy justice.

Capabilities justice also offers a critique of Illich's energy use ceiling. Nussbaum is undecided about what counts as sufficient capabilities. For example, in terms of adequate shelter, a mansion is excessive, while a tent is deficient (Nussbaum, 2007). Likewise, what counts as sufficient access to electricity is unclear. However, conceptualizing energy as providing capabilities rather than meeting demand, would, in theory, address Illich's concern that over a certain threshold energy becomes harmful to quality of life (Illich, 1974). This does not mean that developing countries should be denied access to industrialized countries' energy usage rates but that the improvement of human capabilities across the globe should be the primary goal and should not be obscured by a simplistic discussion of targets and ceilings that does not examine the capabilities of humans to thrive in society.

In the network society described by Castells (1996), technology is material culture. Conceiving of innovation as a technology whose time has come—rather than a novel technology—[194] is problematic in this regard because the technology may not be designed to meet the needs of current and future generations, especially in a way that improves their human capabilities. For example, the development of CSP in the Mediterranean was seen by some international organizations as a matter of human development, while others saw it as a matter of technology development. A combined focus on the two is needed so that the technologies are designed to be appropriate and to enhance capabilities for the affected communities. The Green Revolution, for example, illustrated that technologies are designed for specific social and cultural contexts and cannot be transferred in a linear and simplistic fashion. It also demonstrated that improved access to a commodity, while a worthy end-goal, can do damage in the process of implementation. During the Green Revolution, the local knowledge and innovativeness of the poor were misinterpreted and underestimated. The same could occur for transferring electrical power systems and clean cookstoves. The other extreme should

[194] See Chapter 5.

also be avoided— assuming that grid access is infeasible for those communities that want it. (Or, it is possible that countries without well-established grids could leapfrog to a different type of system that still provides benefits including the large-scale provision of power and reliability.) Culturally specific technological design is important for the achievement of capabilities justice.

Social justice: recognition justice. Another type of social justice theory is that of recognition justice, developed by Nancy Fraser. Fraser argues that minority groups that have been traditionally disadvantaged must be recognized for justice to be achieved. Examples of these groups, such as the energy oppressed poor, were provided above. For recognition justice to occur, residents near power plant sites should have a voice in the process. Developers should ask whether any particular racial, gender, or ethic group is asked to shoulder a disproportionate share of the energy burden. This study also illustrated that desert communities are often written out of geographical representations of the landscape and, therefore, their capabilities neither are improved from energy development nor from the distribution of benefits. The Desertec vision initially framed deserts as empty, but following controversy about whether the regional vision would meet local demand, Dii emphasized the importance of building projects near demand centers in North Africa to provide for skyrocketing energy needs for a growing population.

One potential pitfall of recognition justice is that groups, such as the energy oppressed poor, could be framed in a way that victimizes instead of empowers them. Development agencies and governments should be cautious about how they frame populations without access to energy and their energy needs to avoid characterizing them as unworthy of grid electricity. Small-scale technologies only provide certain end-uses (for example, they cannot power a factory). Distributed systems may indeed be the best choice in many contexts, but these decisions should not be made on assumptions that people in the Global South only need/deserve minimal amounts of electricity. This dissertation illustrated this pitfall with discussions of uneven development stemming from colonial electrification in Morocco[195] and incomplete engineering dreams for the Sahara that ignored local populations.[196]

Ecological justice. Transformations in electrical power systems are clearly important in relation to ecological justice due to their effects on climate change, environmental pollution, and other harms. The discipline of environmental ethics emerged in the 1960s with a critique that Kantian ethics, which confers moral status and dignity on beings based upon their ability to reason, was insufficient for ensuring the protection of nature (Callicott, 2009; "Environmental Ethics," 2008). Anthropocentric thought attributes only instrumental value to nature, and the ethical treatment of nature is based upon its affect on human beings (Stenmark, 2009). Environmental ethicists developed a non-anthropocentric, or non-human centered, ethic for valuing nature that would confer moral standing and significance to all organisms. In a compelling illustration of the shortfalls of anthropocentric and utilitarian ethics, Routley (1973) developed a hypothetical scenario in which the last man on earth faced no moral constraints on destroying the remaining organisms.

---

[195] See Chapter 6
[196] See Chapter 3

Holmes Rolston III and other non-anthropocentrists argue that each organism has a "good-of-its-kind," or an intrinsic value, separate from its human-attributed instrumental value (Rolston III, 1998, p. 131). Something that has intrinsic worth cannot be an end in itself (Callicott 2009).[197] Non-anthropocentrism is divided into two strands: ecocentrism and biocentrism. Biocentrists focus on living beings at the individual level (Stenmark 2009). Laura Westra, a strong proponent of this approach, views humans as disturbing the ecosystem. The most ethical decision is to avoid this disturbance. She argues for a "strong non-anthropocentric holism" to protect natural systems (Westra, 2009).

In contrast, environmental pragmatists argue that non-anthropocentric arguments are too simplistic and unrealistic for furthering environmental ethics in the policy realm, where such arguments have gained little traction (Stone, 2003). Pragmatists are working to develop politically feasible management theories to advance environmental policy goals. For example, Minteer and Collins (2008) are developing an ecological ethics for the environmental management field analogous to bioethics in the medical field. Norton (1991), a pragmatist, developed the convergence hypothesis, which speculates that non-anthropocentric and long-sighted anthropocentric viewpoints converge on the same policy goals because human and non-human interests typically align over a broad timescale. He proposed contextual management, in which decisions are made at the local level that aim to achieve the health of broader ecosystems. He thought the convergence hypothesis would generally hold when management decisions are based upon the safe

[197] To illustrate, Rolston (1999) recounted a switch in the signs at his favorite campground from an anthropocentric to a more non-anthropocentric rationale. The first sign instructed humans to leave the flowers for others to enjoy; the second sign stated "let the flowers live!".

minimum standard: “all species should be protected as long as the socioeconomic costs for doing so are bearable” (p. 136).

Minteer & Manning (2009) conducted an empirical study of environmental values on forest management in Vermont, finding a “strong moral pluralism,” that people value the environment for a multitude of reasons through a human-centric lens, supporting Norton’s views. The stakeholders in this study did not express non-anthropocentric environmental values. In this dissertation, Morocco’s perspective on climate change and environmental outcomes was nearly entirely instrumental—green electrons were not valued as goods in-and-of-themselves to protect the climate but as means of generating socioeconomic benefits. Morocco does not value the environment in non-anthropocentric ways, but it is working to support low carbon energy projects due to socioeconomic values. This generally supports the environmental pragmatist view on energy policy.

The other way in which this study supports a pragmatic view on energy justice, is through the discussion on natural capital in Chapter 4. When exporting electricity, or other goods, countries often implicitly export non-renewable imbedded natural capital, such as water and land use-related goods, which Dasgupta (2010) referred to as an “implicit subsidy.” Countries will need to decide whether these are acceptable costs to the environment and whether they wish to prioritize a development model that uses their resources to gain income from exports or whether they will prioritize domestic resource use.

This study sees the pragmatic view as a more operationalizable method of incorporating ecological justice into the conceptualization of energy justice. Electricity policy could, of course, relate to the protection of intrinsic environmental values, as even low carbon electricity technologies harm the local environment. Therefore, I have included ecological justice in the framework, with the caveat that this ecological justice is inevitably interpreted through anthropocentric lenses.

Intergenerational equity. Closely related to environmental justice is the concept of intergenerational equity. The Bruntland Commission report's well-know definition of sustainable development is meeting the needs of the present without compromising the ability of future generations to meet their needs. This is foundational to the concept of intergenerational equity. The econometric practice of using a discount rate prioritizes present over future generations (Matson & Carasso, 1999). It is clear that the full environmental cost of energy technologies to both present and future generations typically is not accounted (ibid). This study illustrated the temporal complexity of managing electricity systems, as described above, ranging from the long timescales involved in electricity planning, to the concept of the lifecycle of technologies, to the issue that our current energy institutions are ill-equipped to management complex temporal governance issues. Therefore, justice for future generations is relevant to electricity policy and should not be overlooked. This is also a matter of recognition justice—ensuring future generations are recognized—and procedural justice—ensuring future generations are spoken for during planning processes.

A New Framework for Energy Justice

The energy justice framework in **Table 6** is based upon the literature with empirical examples relating to energy. It was revised based upon findings from this study, as illustrated in Table 7.

Table 6.

Energy Justice Framework

Justice dimension	Description/ Key scholars	Empirical questions	Examples from energy cases
Procedural	-- Existence of a just process for distributing the primary goods/ burdens & benefits of the system -- Relates to freedom from coercion (discussed below) *(See Gould, Norton)*	-- Are the energy governance institutions just? -- Who participates in energy systems planning and who does not (which nation-states, which publics, which institutions)? What are the power disparities? -- Are some of the parties coerced into any actions, like selling resources? -- Who manages the public trust? -- Are trade-offs agreed upon in a transparent manner through public engagement processes?	-- Process for choosing energy sites in the U.S. and internationally haven't facilitated substantive public participation. -- Corruption is widespread in energy development procedures -- North-South energy projects may include neocolonial power disparities. -- Are productive and fair opportunities for collaboration pursued?
Social Justice: Recognition	-- Traditionally disadvantaged groups should be recognized. -- Typically identity-based but could be modified to recognize affected publics. *(See Fraser, Young)*	-- Are residents near power plant sites recognized? Do they have a voice in the process? -- Is a particular racial, gender, or ethnic group ignored? -- Are disadvantaged groups recognized in a way that empowers or subjugates them (e.g., "the energy oppressed poor)?	-- Inga Dam site in the DRC framed as uninhabited and the energy refugees weren't compensated (Lustgarten, 2009). --Women disproportionately affected by dirty cookstoves -- Native Americans disproportionately affected by energy extraction.

Social Justice: Capabilities	-- Just institutions are insufficient; must also examine individuals' capacity to live out a good life. -- Energy could be viewed as a precursor to basic human rights, or as a human right -- Human security relates to energy security *(See Sen, Nussbaum, Holland, Reddy)*	-- Who frames the principles of justice? -- Instead of considering electrification rates, what services does the energy system provide (e.g. powering resorts in Majorca, pumping water in Egypt)? -- Does the affected public have any power/ capability to imagine the future of energy systems? -- Are adaptive preferences influencing individuals to downplay their needs?	-- Development projects use solar PV to improve capabilities, e.g., pumping water to improve health -- Energy developed based on projected demand increases, not on needed services.
Distributive	-- How are the primary goods and burdens/ benefits distributed? How are trade-offs chosen and distributed? *(See Rawlsian theorists &* Cozzens, (2007)*)*	-- Do win-win discourses mask the distribution of burdens/ benefits? -- Is energy access affordable? What percentage of household income does it consume (i.e., energy burden)? -- Who has access to energy worldwide (energy poverty)? Should energy usage limits be set in the developed world? -- Who bears the risks of energy supply (e.g., pollution, land use, financing risks, mechanical failure)?	-- 1.3 billion people lack electricity, many of whom accept a disproportionate share of energy's supply burdens.
Inter-generational equity	-- Current generation reaps benefits; future generations shoulder burdens. *(See Thompson, Norton, Gardiner)*	-- Are future generations considered in the energy planning process? -- Will renewable energy systems actually replace fossil fuel power plants? -- Who bears the burden of climate mitigation?	-- Current generation benefits from fossil fuel use while the future generation bears greater climate change impacts.
Ecological justice	-- All organisms should get a fair share of resources, i.e., distributive justice should be extended to non-humans *(See Baxter)* -- Environmental pragmatists argue for good procedure to base environmental management on a plurality of values (Norton, 2005)	-- What are the environmental impacts of energy systems on the local and global environment, from a lifecycle perspective?	-- Even solar PV has negative environmental effects through mining and disposal.

Applying and Testing the Energy Justice Framework

Below I refine the energy justice framework based upon this empirical study. Two student research assistants and I coded the energy justice issues identified in this dissertation. The framework was useful and very few justice-related issues fell outside of the framework categories. Issues were identified in each category of justice, with the exception of purely non-anthropocentric ecological justice issues. Unsurprisingly, the most common category of injustice was distributive, but the framework helped to identify critical issues in other categories, as well as issues discussed below that were not neatly addressed by the categories.

Applying the framework illustrated many cases in which the justice categories were linked. For example, a lack of recognition meant capabilities were not met for the unrecognized population since the design of the infrastructure did not account for their needs. They were also bypassed or disadvantaged by the distributive outcomes of energy generation because they were not included in the procedure. Schlosberg (2007) also already noted that recognition is a precondition to achieving distributive justice. The framework now better illustrates the connections, synergies, and interdependencies among the categories of justice. In particular, better procedural justice was needed to avoid an inequitable distribution of outcomes. In several cases I argued that Desertec was not a fundamentally neocolonial or xenophobic vision; rather, these issues could be addressed through the implementation of a fair procedure and regional dialogue. Therefore, I moved procedural justice to the top of the framework as a precursor to achieving possible outcomes in other categories of justice.

Below, I will discuss five energy justice challenges identified in applying the energy justice framework— neocolonialism, capacity building and freedom from coercion, global energy security and justice, trade-offs and win-win discourses in energy system design, and the diagnosis of injustice at multiple scales—and then present the updated framework.

Neocolonialism. Colonialism and neocolonialism were empirical issues that arose from this study that were not neatly addressed by a single category of justice. Chapter 3 illustrated the colonial history, dating back to the 1850s, of today's discourses for Mediterranean energy system integration. Chapter 4 addressed the imagined geography of the Mediterranean and how the conquering and pioneering metaphors associated with deserts frame them as interstitial zones, devoid of people, to be bridged. These metaphors suggest that there is still an envisioned frontier to colonize.

The similarities to colonial era discourses suggest a lack of awareness and recognition of this complex history. The Desertec paradigm assumed that in a globalized world nation-state borders and sovereignty should no longer be important, but rather solving problems that transcend borders should be prioritized. However, as the colonial history and the negative outcomes for local people stemming from it still matters deeply to people living in the region, this could be perceived as callous. That said, neocolonialism was not always used substantively in the discourse but rather as cryptic stand-in for critiquing the justice dynamics of energy systems that cross nation-state borders between developed and developing worlds.[198] Just as colloquially calling something unsustainable or sustainable is often a mild way of calling it bad or good (Thompson, 2007), the neocolonial critique was often bandied about to express discomfort with a vision that connected dozens of countries across broad disparities. It was also used to appeal to guilt over past actions by European colonial powers. In Chapter 5, the Desertec Whitebook included an argument that Europeans had a moral obligation to help North African countries develop due to the inequities between the regions. Desertec Design I proponents then argued that energy autonomy was ethically questionable because Europe would proceed with energy development without acknowledging and improving the "future misery of its neighbors."

The energy justice framework helps to identify the issues latent in the neocolonial critique in more actionable forms. Neocolonial issues relate to distributive, procedural, and recognition justice. First, in energy visions for the Mediterranean, local people are often written out of the landscape, or desert landscapes are creatively redrawn to match the system's needs rather than local needs on the ground. As illustrated in Orientalist depictions of desert landscapes (such as in Design III in Chapter 5), these recognition justice pitfalls were often related to subvert racism. As illustrated in Chapter 6, colonial institutions focused on benefiting the empire, not on recognizing the needs of local people or ensuring they benefit. Second, neocolonial concerns related to fears that poorer countries would end up with worse distributive outcomes, accepting a disproportionate share of the burdens of energy generation versus energy provision. For example, the German Aerospace Center (DLR) was concerned that more powerful countries within the

[198] See Chapter 5 for a description of the neocolonial critique of Desertec.

Dii system (Design II) could afford to pay more to maintain the reliability of their power system while the lights went out in Morocco, if there were some failure.[199] Furthermore, the issue of guilt and obligation stemming from the past could be addressed more productively by examining the distributive energy justice issues at a regional scale using comparative techniques, so that the standard of living in Europe stemming from energy wealth is used as a benchmark for the standard of living in North Africa. Third, procedure matters for whether the outcomes of the system are neocolonial, as I have argued throughout the dissertation. Not all collaboration between the North and South of the Mediterranean is intrinsically neocolonial and assuming as much may impede opportunities for fruitful collaboration. Implementing a good procedure to avoid past negative distributive outcomes, as illustrated by the uneven development stemming from Morocco's colonial electricity system, is essential both at the national and transnational scales. This procedure should include voices from less powerful countries in the EU-MENA region.

Ironically, while some European reporters assumed that people in North Africa would view Desertec as neocolonial, decision-makers in Morocco supported exporting electricity to Europe and even saw Morocco as unfairly cut out of the European electricity market. In fact, Morocco was working to address the distributive justice issues stemming from the neocolonial critique through local content requirements and other policies to ensure benefits remained in the country. They were not intending to allow themselves to be exploited. Some Moroccans emphasized that the Desertec vision itself was ethical but that the procedure that had been available to participate was insufficiently

[199] See Chapter 5.

inclusive and therefore neocolonial. Moroccans should be given voice in deciding whether the process and outcomes are unjust.

From energy sovereignty to capacity building and freedom from coercion. In part, issues of neocolonialism relate to sovereignty, since colonies like Morocco lost their sovereignty for decades to European colonial powers. As I described in Chapter 5, after Independence the Moroccan government sought to reform the electrical power system into one that did work for Moroccans. Energy sovereignty refers to the right of communities and nation-states to have the ultimate authority over how their energy systems are designed and used. For example, Smith & Frehner (2010) believed that energy justice for Native Americans would include developing a "sustainable and self-sufficient community" that provides for self-determination and more equitable control of science, technology, and geopolitical space. Holleman (2012) argued that countries in the Global South should enjoy energy sovereignty rather than being supply depots for the North.

I argued throughout the dissertation that energy development at the local and national levels relates to issues of political development and sovereignty. Each nation-state has its own tacit social pact or social contract for electricity generation based on specific nation-state challenges. Energy development also relates to issues of national identity and pride. Processes for including the public in renewable energy siting were a test bed for greater decentralization of governance in Morocco, as Morocco considered a significant shift in its political development toward advanced regionalization.[200] To develop a single market for electricity in the Mediterranean, along with the necessary

---

[200] See Chapter 7.

political and regulatory institutions to management it (such as a Transmission System Operator), would require countries to cede sovereignty, and the specific goals of their national pacts/contracts, to regional, multi-lateral political processes. This presents drawbacks, as nations risk not securing the socioeconomic benefit they hope to gain from their electrical power systems, as well as risks from shouldering a possible system failure. It also has benefits, as nations could gain better economic and political collaboration—and even cultural understanding—as well as technological efficiency and saved costs through sociotechnical integration.

While sovereignty is an important concept it is also somewhat outdated, stemming from Realist international relations theory that views the international community as being in a state of anarchy in which states pursue their own narrow interests without moral principles (Waltz, 2004). More recent scholarship sees the sovereign nation-state as no longer dominant, with governance occurring instead through the actions of multinational corporations, NGOs, and international institutions steered by states (Stoker, 1998). These actions are indeed normative and sometimes morally principled (Nussbaum, 2007).

If a sovereign state were needed to apply the principles of justice and geographical proximity were required for negotiating the principles of justice (as Rawls argued) energy justice in a globalized world would simply be impossible because these complex systems cross borders and non-state actors have significant power in energy governance. System complexity makes energy independence and sovereignty infeasible in reality as energy must be sourced from supply chains and interdependencies are needed to maintain the reliability of the centralized system. Discourses of energy independence and sovereignty can serve to mask supply chain injustices that cross local, national, and regional scales in complex ways. If energy sovereignty were necessary for achieving energy justice, the trend toward the transnationalization or even globalization of electricity described in Chapter 1 would always result in injustices.

Freedom from coercion is a better principle for addressing issues of neocolonialism and energy independence/ interdependence. Sen emphasized the importance of freedom for the capabilities approach. Someone who chooses to stay at home for the day has more freedom than if a gang of thugs forced them to stay home, even though the end result is the same (Sen, 2009). Forcing nation-states to become energy-supply depots for richer countries violates the principle of freedom from coercion, without the implication that actors should only look out for their own interests, or the implication that actors must be sovereign and independent to achieve just outcomes. Freedom from coercion should be combined with ideas from recognition justice, so that greater care is given to the needs of minority groups, like Native Americans, who currently advocate for energy sovereignty. Achieving energy sovereignty is less important than ensuring a public and stakeholder engagement process free from coercion. It would be problematic for a private industry consortium like Dii to govern the visioning process for regional electricity systems because it is not elected by Mediterranean publics to represent them in the development of a just regional energy system. Freedom from coercion should be considered within the framework under procedural justice.

Just energy integration could be achieved between former colonies and colonial powers if the process is free from coercion. If Morocco were coerced into one day exporting green electricity to Europe, this would be unjust, but, in fact, Moroccans viewed their lack of access to European electricity markets as inequitable. Developing countries must decide for themselves whether they could yield more beneficial outcomes from using their energy resources domestically or exporting them, through a process free from coercion. When OECD countries switch to regional production networks, nearby non-OECD countries typically focus on exports that they hope will secure investments (Panebianco, 2003). Developing countries can benefit from know-how, technology, jobs, and capital, but in reality they often reap few benefits (ibid). Ensuring these benefits is an important part of distributive energy justice at the global scale. Additionally, addressing the "implicit subsidies" (Dasgupta, 2010) in these exported products relates to ecological justice, as the natural capital imbedded in these exports is rarely appropriately priced.

One complication with freedom from coercion is that capacity building of the kind described in Morocco in Chapters 6 and 7 is likely a precursor to avoiding coercion due to power disparities. The disparities and differences in quality of life between the North and South of the Mediterranean, described by the shatterbelt framing,[201] put weaker countries at risk of coercion. In Chapter 6, I illustrated that Morocco's electricity development is tugged in different directions because it is a poorer country. In contrast, neighboring Algeria has not had to seek FDI or liberalize its energy sector because it is wealthy from its natural gas resources. Through capacity building, Morocco seeks to become a better negotiator in international processes and a true collaborator in North-South energy projects. At the local level, people living in depressed Mediterranean zones are the ones who most need the benefits from electricity development but are the least equipped to benefit from it or to participate in the process to influence projects to secure

[201] see Chapter 4.

their benefit. Electricity has been framed by some NGOs as a precursor to securing human rights, but foundational development is needed in order for the community to have sufficient capacity to be prepared for the benefits from electrification and to avoid being coerced due to inequities and inequalities stemming from a lack of a level playing field. Addressing these inequities within and across the region through capacity building may be foundational to the eventual achievement of energy justice.

Energy security. Energy security is often seen as geopolitical and, again, a matter of nation-states protecting their interests. For example, in the United States, energy security is often conflated with energy independence. This study illustrated that multiple, and at times conflicting, framings of energy security exist. In Chapter 5, I discussed energy security framings in the three Desertec system designs ranging from diversification of the fuel portfolio, network stability, cost and affordability, to sufficiency of supply. For oil-rich countries in MENA, such as Saudi Arabia, maintaining high oil prices and sufficient demand is essential for energy security. For fuel-poor countries in MENA, securing a reliable and affordable source of fuels is framed as energy security.[202] In the European Union, energy integration—rather than energy independence—is often viewed as inevitable but the EU seeks to shift this integration toward 'good' countries, and away from Russia, and to avoid a situation in which a solar or oil cartel coerces them into certain political or monetary actions. In Morocco, energy integration was indeed framed as part of energy security and sustainable development, as developing national renewable energy resources simultaneously with regional connection to improve the intermittency problem for renewable energy would result in improved

[202] See Chapter 4.

energy security for Morocco. In fact, renewable energy is pushing countries outside of the United States to seriously consider energy integration as part of their energy security, due to the intermittency of renewable energy. This is a surprising finding, as renewable energy is often associated with energy independence and self-sufficiency.

In the midst of this plurality of framings of energy security, the Desertec Foundation added the concept of global energy security. The idea of global energy security counters the energy independence discourse and focuses on securitizing energy interdependence. As a concept that emphasizes how security and environmental problems cross nation-state boundaries, global energy security adapts a different worldview from the Realist perspective of the traditional sovereign nation-state acting in its own interest. Just as I argued it would be difficult to combine the social pacts/contracts for electricity generation across a region,[203] it may be difficult to fuse together the disparate framings of energy security described above into a global conception of energy security. However, as electricity systems become internationalized, or even globalized,[204] it is important to consider the prospects and tenets of global energy security for an interdependent world.

In Chapter 4, I argued that global energy security should not simply be based upon whether there is equality across global energy systems, in which everyone has access to the same premium-networked spaces with reliable, affordable energy. Instead, fairness should be considered. Global energy security for an interdependent world ought to move past equality and geopolitics and toward energy equity and justice, holding

[203] See Chapter 6.
[204] See the trends described in Chapter 1.

system builders and decision-makers to a higher standard. Below I propose several tenets of global energy security informed by this study.

Human security and improving human capabilities and energy inequities across the globe should be the first priority of global energy security. Human energy insecurity poses risks as, for example, marginalized populations turn to religious radicalism. The *bidonvilles*, or slums, of Casablanca, Morocco are one of the few areas that are not fully electrified in the country, where people often must rely on pirated electricity (Zaki, 2011). The 2003 Casablanca bombers came from this area, which many people attributed to the extreme poverty there (Howe, 2005).[205] Global energy security is not possible in a world in which massive energy poverty and injustice exists. This requires recognition justice for affected and disempowered communities so that they benefit from the capabilities provided by energy infrastructure when these systems are transformed.

To meet human security needs, global energy security should include a just process for recognizing and engaging citizens in the region in the development of an energy system. Above I discussed a fair process for multilateral cooperation that avoids coercion. Below the nation-state scale, citizens should be seen as true participants and collaborators in the energy system. Since direct participation at the region scale is obviously not always possible, representatives should adequately speak for the populations they represent.[206] Even though representation is necessary, the regional process should also seek to improve energy citizenship[207] to engage citizens in the region in imagining and constructing just energy futures that promote cross-cultural learning,

---

[205] See Chapter 6.
[206] In Chapter 7, I discussed how representatives did not necessarily reflect the interests of the population affected by power plant siting
[207] As discussed in Chapter 6.

tolerance, and immigration policy. In Chapter 5 I discussed the possibility that an integrated electricity system funded in part by citizens in Europe could lead either to cross-cultural awareness and green tourism or to marketing green electricity from North Africa using Orientalist imagery that frames the exports as exotic. The latter would be counter to the goal of fostering energy citizenship.

It is also important that global energy security avoids technological imperialism and that countries be given the opportunity to collaborate in R&D and to take a certain level of ownership over their electrical power systems, rather than only importing, for example, German technologies. Western countries using renewable energy technologies as “soft power” would not provide energy security for poorer countries and would violate the principle of freedom from coercion. It was clear that Morocco wanted energy dependency on its own terms. If Morocco were coerced into exporting electricity, or other unfavorable outcomes of energy integration, then energy integration would not meet their energy security goals. Achieving global energy security would therefore require a just procedure for envisioning and designing energy systems that is founded upon mutual trust, which has been a challenge historically at the multilateral level.

The *Limits to Growth* framing underpinned the Desertec Foundation’s perception of global energy security, in which energy sustainability and energy access for a growing population must be addressed at a regional, if not planetary, scale due to earth’s limited resources. Climate change mitigation and adaptation could also be a tenet of global energy security, although it should not be the sole factor. This is likely what the Desertec Foundation had in mind with the concept of global energy security, based upon the limits to growth framing. Decisions made by individual nation-states about the carbon intensity of their electricity generating systems will have global effects. Addressing climate change as part of global energy security is also important for intergenerational justice, as decisions made in the power sector today will affect several generations to come.

Trade-offs and win-win discourses. Even if system builders were equipped with guidance from the energy justice framework, they cannot equally prioritize everything in a finite world. All energy systems result in some social drawbacks for particular publics and environmental damage. Unfortunately, trade-offs will be made in energy systems design even if they are not made explicit through a transparent procedure.

Sen and Nussbaum differ on whether it is justifiable to make trade-offs within the capabilities framework. Nussbaum argues that trade-offs are forbidden because human goods are not fungible. One cannot make up for a lack of freedom of speech with more of something else (Nussbaum, 2007). In contrast, Sen sees trade-offs as a “somewhat crude vocabulary for multidimensional assessment” and views them as necessary in an imperfect world (Sen, 2009). Sen advocates for a pluralistic approach in which the public makes explicit reasoned trade-offs. Nussbaum’s view is principled, since such trade-offs could be perverse and morally repugnant as they limit people’s capabilities to secure their human rights. For example, quantifying the number of human lives that will be lost from particular air pollution standards, while honest, has led to public disgust. In some cases, such trade-offs may be “taboo trade-offs,” or those that “violate deeply-held normative institutions about the integrity, even sanctity, of certain forms of relationships and the moral-political values that derive from those relationships” (Fiske & Tetlock, 1997, p. 256). Some researchers have found that offering people monetary compensation for values they hold sacred—like siting energy facilities on sacred lands—backfires and further polarizes people (Atran & Axelrod, 2008). Systems builders should aim not to make trade-offs that impede or overlook human capabilities, such as building an energy system that reduces water security in neighboring villages or leaves people living adjacent to a major energy facility without electricity access.

In Chapter 1, I asked: what can be learned about energy justice by examining the Desertec vision at multiple scales? I found that if Germany's energy system were connected to Morocco's, energy justice trade-offs would be intertwined across nation-state borders and between wealthier and poorer countries. Yet the Desertec vision is framed as a win-win. Unless the system boundaries are drawn very narrowly, such win-win outcomes would be impossible to achieve. As this dissertation has illustrated, electricity issues are tied to complex integrated challenges, such as the energy-water nexus, in which water-impoverished villages could be negatively affected by CSP's use of water. Desertec's win-win framing generally referred to wins at a high level at the regional and abstract scale—security, regional stability, national energy policy—rather than examining the distributive outcomes of different social strata of the population.[208] This scalar disconnect is particularly salient as income inequality increases within nations and decreases among them (Firebaugh, 2009). Multi-scalar distributive outcomes could be masked by this win-win discourse. Morocco may benefit as a nation-state from reducing electricity imports by building solar power plants, but CSP siting negatively affected the village adjacent to the first power plant. Spain did not need electricity from North Africa and did not see itself as a winner in a future in which it became a transit country for other countries' green electrons. No system is a win-win; it is impossible to

[208] see Chapter 7.

achieve a win at all scales, as technological systems require trade-offs in a world with limited resources (see McShane et al., 2011).

A just regional collaborative process could in theory lead to a reasoned and just distribution of trade-offs. Public engagement methods for choosing trade-offs to make them explicit, while avoiding morally repugnant decisions that impede human capabilities, should be developed and tested for feasibility. Here, procedural justice is closely tied to capabilities and recognition justice—to ensure the most vulnerable populations are recognized and that their capabilities are improved—and to distributive justice as a just process is needed to avoid poorer countries accepting a disproportionate share of the trade-offs.

Multi-scalar, systems justice. In the beginning of the dissertation I asked what could be learned about energy justice by examining this vision at multiple scales. In order to design just energy systems in an energy interdependent world, justice concerns must be weighed across multiple jurisdictions and wide sociopolitical differences. System-level thinking and complexity (as defined above) are crucial for understanding energy transformations and energy justice, especially as they cross scales. A sociotechnical systems methodology provides a useful perspective on justice especially in a transnational world. Complex systems do not start from scratch but are layered on top of existing infrastructure, which complicates the ability to improve upon the energy justice outcomes of the old system throughout the energy transformation. Moreover, a technology's politics are very dependent upon the politics of the system. The justice outcomes of single technologies, like a solar PV panel, should therefore be considered in the context of how they link up to broader sociotechnical systems with complex politics.

For example, citizens in Arizona benefit from installing rooftop PV, while workers in rare earth metal mines in China that provide the materials for PV accept serious environmental and health burdens. In the Desertec system a water-poor, marginalized village in Morocco would be connected to the modern streets of Berlin. Moreover, the Desertec vision and other visions for the Sahara would have an impact so broad that they could be viewed as geoengineering projects. Looking across scales changes the calculus of energy justice outcomes and trade-offs.

Multi-scalar energy transformations seek to address integrated challenges from water quality and access to development to poverty. These new "reverse-salients" (Hughes, 1983)[209] illustrate the complexity of achieving positive energy system outcomes as trade-offs cross not only scales but also extend into domains outside of energy. Energy justice calls for complex solutions to complex problems, it is urgent, and it requires immediate attention to end human suffering. Comparative, or relative, justice in this globalized, high-tech world demands more than simply meeting basic needs. In the era of the Anthropocene, sufficient access to premium-networked spaces and fairness of outcomes is a must for achieving technological equity.

Nussbaum (2007) argued that there is no mutual advantage, as conceived by Rawls. Justice is justice, even if people in the developed world have to pay a lot for it. She argued that international institutions should be redesigned so that these injustices are avoided (ibid). Though she does not acknowledge it, this design process is fundamentally an issue about how transnational sociotechnical systems are constructed and redesigned. It is where technology policy and sociotechnical systems building intersect with the

---

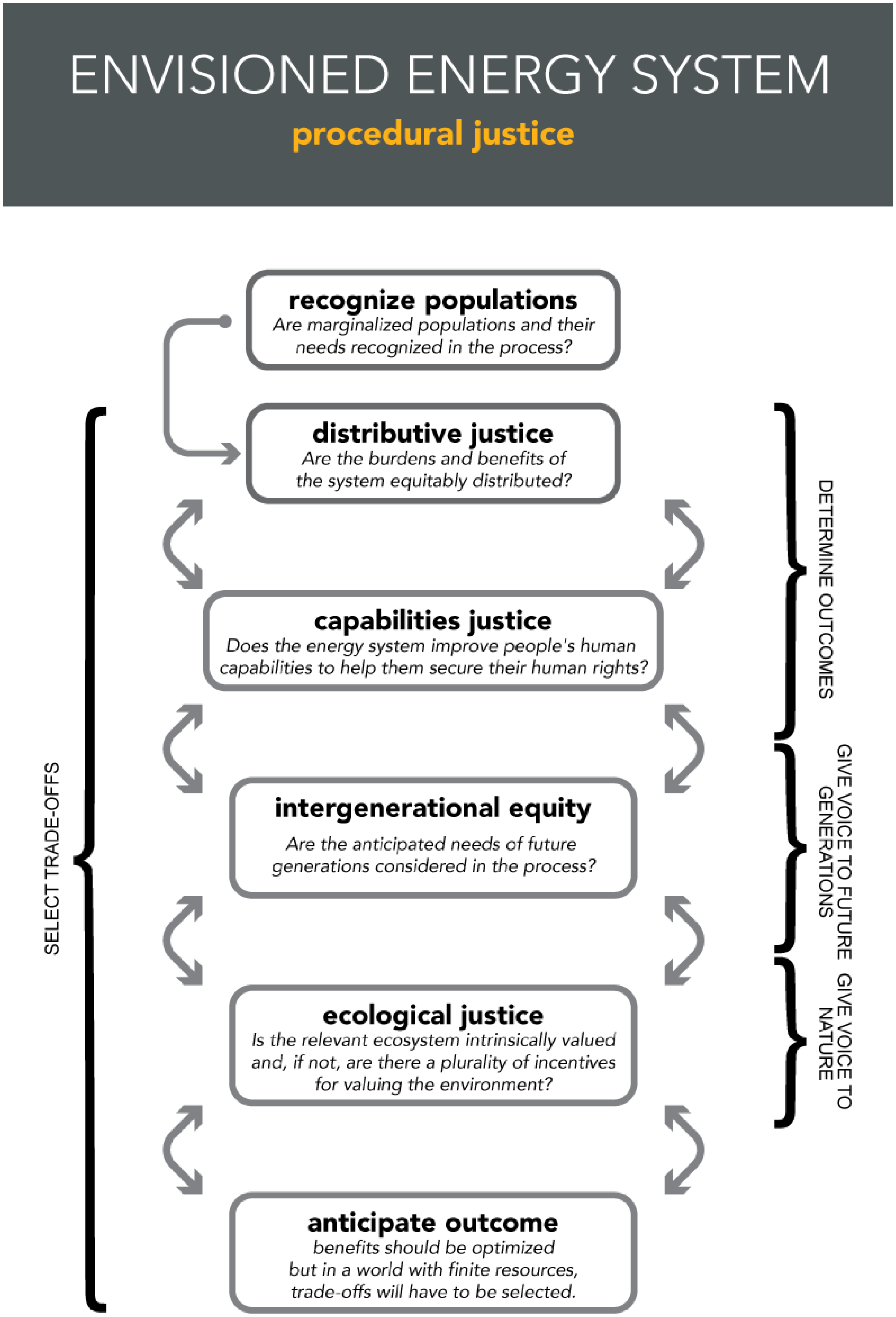
[209] see Chapter 1.

principles of justice. Energy is not the only area in which justice at one scale is connected to another and is a generalizable issue relating to justice and sociotechnical systems construction. Systems justice calls for us to collate the diverse ideas about energy justice, expand upon them based on reasoned principles, and re-evaluate them with a new framework. If we chose to move beyond a conceptualization of energy justice that merely pits the haves against the have-nots (i.e., energy poverty) and avoids a polarized centralized versus distributed energy debate, it will be necessary to address complex, multi-scalar systems.

Updated Framework. The revised framework aims to be useful both to the scholarly community and to energy systems builders in diagnosing injustices as energy system transformations evolve. Before using the framework, energy evaluators should explicitly define the energy system boundaries, substantiating these decisions based on mapping out the institutions and stakeholders that should be involved in the analysis. Outcomes will appear different when the boundary conditions are drawn at different scales (from local to global.) Both supply and demand sides should be considered. Evaluators should also consider what principles and values are public priorities in the design of the system, comprising the social contract for electricity. Often these principles include reliability, affordability, access, and sustainability. However, more nuanced and unique goals could be mapped out through a participatory stakeholder engagement process to gain citizen consent. Table 7 presents the updated version of the energy justice framework that accounts for the findings from this empirical study.

Table 7.

Updated Energy Justice Framework. Graphic by Ben Lewis


ENVISIONED ENERGY SYSTEM
procedural justice
recognize populations
Are marginalized populations and their needs recognized in the process?
distributive justice
Are the burdens and benefits of the system equitably distributed?
capabilities justice
Does the energy system improve people's human capabilities to help them secure their human rights?
intergenerational equity
Are the anticipated needs of future generations considered in the process?
ecological justice
Is the relevant ecosystem intrinsically valued and, if not, are there a plurality of incentives for valuing the environment?
anticipate outcome
benefits should be optimized but in a world with finite resources, trade-offs will have to be selected.
SELECT TRADE-OFFS
DETERMINE OUTCOMES
GIVE VOICE TO FUTURE GENERATIONS
GIVE VOICE TO NATURE

Conclusion: Visions for Just Energy Systems

As described in Chapter 1, this dissertation encompassed both analytical and normative goals, which were brought together in this chapter by a theoretical and empirical examination of energy justice. This dissertation asked: how are regional sociotechnical systems designed? What forces and processes shape aspects of the vision? And what are the consequences for a diverse Mediterranean region, with deep North-South inequities? To explore these questions, I used the Desertec vision as a key example of what is arguably the world's most ambitious renewable energy plan in order to better understand the political and societal aspects of a massive scale-up of renewable energy. This dissertation analyzed this proposed renewable energy transformation at multiple scales, from the global history of CSP technologies, to the vision's development at the regional level, to the vision's instantiation at the national level in Morocco, through to the construction of a CSP plant in Morocco.

While energy system transformations are often seen as technical, they are fundamentally sociotechnical, with high levels of temporal, geographical, sociopolitical, and environmental complexity. As energy transformations are underway across the globe, more focus on the visioning stage for sociotechnical systems is needed than has been provided by previous work on sociotechnical systems that relied upon historical methods. Sociotechnical systems have different justice outcomes and trade-offs at each stage, from imagined through to constructed and decommissioned, and from the local to the global scale. In order to propel the vision to the next step, some agreement is needed among stakeholders about the goals for the system. One challenge for the Desertec vision was that stakeholders could not agree on the principles behind the vision or even the appropriate method of proof-of-concept.

Through an exploration of three designs of the Desertec vision in Chapter 5, I illustrated how the visioning stage plays an important role in innovation and in shaping the future. That said, the consequences stemming from the visioning stage are less cemented than I originally assumed they would be, and a just procedure for apportioning trade-offs using the justice framework could guide this visioning stage. Once these systems develop momentum, their justice outcomes will be enduring, as evidenced from the long-standing infrastructural inequities between mountainous and coastal areas in the Mediterranean region.

One challenge with achieving energy justice is that these systems are highly complex, and the visioning process relates to uncertain futures. The sociopolitical complexity of the Mediterranean energy system would only deepen if multilateral processes were implemented for regional electricity systems. In Chapter 6, I argued that the Desertec vision would be complicated by the individual pacts or contracts for the benefits of electricity generation that each individual nation-state has. These social contracts reflect the goals and expectations for societal benefit stemming from electrical power systems (Victor & Heller, 2006). As electricity grids begin crossing nation-state lines around the globe, how will it affect the promises states make to their populations about the distribution of the social benefits and burdens of electricity development? This question should be one focus of the policy discussion as plans for regional energy integration are pursued. As the social pact is renegotiated in Morocco and other countries in the region—and countries consider negotiating the social pact at a bilateral or multilateral level through electricity integration—it is important to consider the principles of justice outlined in this chapter to ensure positive societal outcomes from electricity development.

Considering the importance of the visioning stage and other contemporary challenges of electrical power systems, I argued throughout the dissertation that some of the analytical components of Hughes' iconic work, *Networks of Power,* should be updated. Additionally, this final chapter shows that the complex normative components of sociotechnical systems need to be more rigorously incorporated into sociotechnical systems theory. In summary, I argued for four main analytical updates to *Networks of Power*, which I can now relate to themes of justice. First, I argued in Chapter 3 that a technology's emergence is situated. The politics of these technologies can change over time, but a just process that is founded on capacity building to address the uneven playing field related to inequity in the region is needed to avoid coercion. Otherwise the negative distributive, capabilities, recognition, and intergenerational justice issues, which are at the core of what actors in the Mediterranean refer to as neocolonialism, could result. Second, I argued that there are new, broader reverse salients at stake in electricity system transformations that connect electricity to integrated challenges. I argued above that this is a crucial aspect of complex systems justice in a multi-scalar world. Third, the conceptualization of innovation as a deferred dream successfully taking root—rather than a new invention—relates to new forms of systems management complexity. In order for negative capabilities outcomes to be addressed, technological innovation should be tailored to the needs of specific communities and locales. Fourth, energy development is important to political development. Contemporary energy transformations should not only be considered in a multi-country comparative study (e.g., England, Germany, United States) but should be analyzed in a transnational context. In this chapter, I argued that political development in a transnational world ought to move beyond the outmoded concept of energy sovereignty toward freedom from coercion and capacity building in order for energy justice to be achieved.

In Chapter 1, I described four scenarios for the future of energy transformations across the globe—a mixed distributed and centralized path, a distributed path, regionalization with significant energy integration, and business-as-usual based upon extracting extreme sources of fossil fuels. Business-as-usual is clearly no longer an option within the European sociopolitical context due to concern about climate change. The Desertec case study illuminated the sociopolitical significance and complexity of these possible energy transformations. A path toward renewable energy that is completely centralized in nature poses nearly insurmountable political collaboration challenges, as the goals and political processes of dozens of countries would need to be aligned. Yet, I have also illustrated some of the drawbacks and challenges related to the distributed path, which would require the most dramatic system transformation. It is unclear what path will be taken, but transformations are tangibly underway, and each path has different implications for justice.

Regardless of which pathway is pursued, better planning will be needed to avoid building technological juggernauts. This is a crucial opportunity to utilize the energy justice framework developed in this dissertation to guide energy transformations before injustices in new energy infrastructure are cemented. Chapter 5 illustrated that many in the electricity sector see innovation in electrical power systems as the realization of a deferred dream, rather than the implementation of radical new technologies. A modern electricity system is not innovative in the sense that it requires technologies that have not yet been developed but in the system-level reconfigurations needed to meet sustainability challenges in the power sector. The system plan should come before individual projects are built—rather than after the system is in crisis— yet sociopolitical complexity often prevents this from occurring.

It is often assumed that ridding energy systems of oil and coal will automatically alleviate injustices. However, this dissertation has illustrated that addressing energy justice is far more complex and multifaceted than this. Adam's assertion that institutions for temporal governance are lacking is important for theories of justice, as it strikes at the heart of procedural, distributive, and intergenerational justice issues (2003). I argued that just as landscapes are considered in the transformation of electrical power systems, so ought to be "timescapes." This temporal governance is crucial for anticipating problems with infrastructure that would be too big to fail, for apportioning the future trade-offs of energy systems, and for ensuring injustices are not cemented for decades to come. In his poem "What Happens to a Dream Deferred," Langston Hughes wondered whether a deferred dream will "stink like rotten meat and fester like a sore." To avoid a dystopic ending, better forms of temporal governance, as well as improved modes of evaluating and redressing energy injustice, will be needed to protect both current and future generations.

REFERENCES

500 millions USD pour refinancer Samir. (2014, May). *Economie Entreprises*, (170).

Adam, B. (1998). *Timescapes of Modernity: the environment and invisible hazards*. London: Routledge. Retrieved from http://site.ebrary.com.ezproxy1.lib.asu.edu/lib/asulib/docDetail.action?docID=10100119

Adam, B. (2003). Reflexive Modernization Temporalized. *Theory, Culture & Society, 20*(2), 59–78. http://doi.org/10.1177/0263276403020002004

Adam, B. (2004). Memory of Futures. *KronoScope*, *4*(2), 297–315. http://doi.org/10.1163/1568524042801392

Agueniou, S. (2014, June 30). La Compétitivité ne se résume pas au coût de l'énergie. *La Vie Éco*, (4755-57).

Alami, A. (2013, September 29). Gaps in Graduates' Skills Confound Morocco. *New York Times*. New York. Retrieved from http://www.nytimes.com/2013/09/30/world/africa/gaps-in-graduates-skills-confound-morocco.html?_r=2&

Allenby, B. R. (2012). *The theory and practice of sustainable engineering*. Upper Saddle River, NJ: Pearson Prentice Hall.

Alternative Energy Africa. (2014, April 27). Morocco's Energy Minister Asks for Japanese Investment. *Alternative Energy Africa*. Retrieved from http://www.ae-africa.com/read_article.php?NID=5550

Ambrozic, J. (2010). Beyond Public Reason on Energy Justice: Solidarity and Catholic Social Teaching. *Colorado Journal of International Environmental Law and Policy*, *21*, 381.

American Inventor Uses Egypt’s Sun for Power. (1916, July 2). *New York Times*. New York. Retrieved from http://www.debarel.com/BSB_Library/1916_shuman_ny_times.jpg

Amster, E. J. (2013). *Medicine and the Saints: Science, Islam, and the Colonial Encounter in Morocco, 1877-1956*. Austin: University of Texas Press.

Apelian, C. (2012). Modern mosque lamps: electricity in the historic monuments and tourist attractions of French colonial Fez, Morocco (1925–1950). *History and Technology*, *28*(2), 177–207. http://doi.org/10.1080/07341512.2012.694208

Arthur, W. B. (1994). *Increasing Returns and Path Dependence in the Economy*. University of Michigan Press.

Atran, S., & Axelrod, R. (2008). Reframing Sacred Values. *Negotiation Journal*, *24*(3), 221–246. http://doi.org/10.1111/j.1571-9979.2008.00182.x

Bank, W. (2009, November 30). Implementation, Completion and Results Report: (Loan-74480-MOR). The World Bank: Sustainable Development Department: Middle East and North Africa.

Barhdadi, A. (2013, September 13). Solar Energy Research in Morocco. Retrieved from http://users.ictp.it/~barhdadi/

Barjot, D. (2002a). Les entreprises françaises et l’électrification de l’Afrique du Nord : le cas de la Société générale d’entreprises. *Outre-Mers*, *89*(334), 279–304. http://doi.org/10.3406/outre.2002.3938

Barjot, D. (2002b). Rapport de synthèse. *Outre-Mers*, *89*(334), 47–53. http://doi.org/10.3406/outre.2002.3923

Barrera, F. R. (2010). *Solar Thermal Power: History of a Research Success (La electricidad termosolar: Historia de éxito de la investigación)*. Spain.

Barry, B. (1996). *Justice As Impartiality*. New York: Oxford University Press, USA.

Ben Ali, D. (1997). Economic Adjustment and Political Liberalization in Morocco. In H. A. Handoussa (Ed.), *Economic Transition in the Middle East: Global Challenges and Adjustment Strategies*. Cairo: American University in Cairo Press.

Berger, J. J. (1998). *Charging Ahead: The Business of Renewable Energy and what it Means for America*. Oakland: University of California Press.

Berlin Technology Museum. (2013, August). Wind Exhibit.

Berthonnet, A. (2008). La formation d'une culture économique et technique en Algérie (1830-1962): L'exemple des grandes infrastructures de génie civil. *French Colonial History*, *9*(1), 37–63. http://doi.org/10.1353/fch.0.0000

Bijker, W. (1995). *Of Bicycles, Bakelites, and Bulbs: Toward a Theory of Sociotechnical Change*. Cambridge: MIT Press.

Bijker, W. E. (2010). How is technology made?—That is the question! *Cambridge Journal of Economics, 34*(1), 63–76. http://doi.org/10.1093/cje/bep068

Birch, B. (1978, November 1). Energy Ethics Reaches the Church's Agenda. *Christian Century*, 1034–1038.

Bisson, J. (2003). *Mythes et réalités d'un désert convoité: le Sahara*. Paris: L'Harmattan.

Blumstein, C., Friedman, L. S., & Green, R. (2002). The History of Electricity Restructuring in California. *Journal of Industry, Competition and Trade*, *2*(1-2), 9–38. http://doi.org/10.1023/A:1020822720063

Boesman, W. (1994). *Big Science and Technology Projects: Analysis of 30 selected US government projects*. Washington, D.C: Congressional Research Service.

Bogaert, K. (2011). The Problem of Slums: Shifting Methods of Neoliberal Urban Government in Morocco. *Development and Change*, *42*(3), 709–731. http://doi.org/10.1111/j.1467-7660.2011.01706.x

Borup, M., Brown, N., Konrad, K., & Van Lente, H. (2006). The sociology of expectations in science and technology. *Technology Analysis & Strategic Management*, *18*(3-4), 285–298. http://doi.org/10.1080/09537320600777002

Boukhari, K. (2013, January 25). Royal Hand-Kissing Should Stop. *Al-Monitor*. Retrieved from http://www.al-monitor.com/pulse/politics/2013/01/morocco-royal-hand-kissing.html

Bouneau, C. (2002). Electrification des chemins de fer et Empires coloniaux : de l'Afrique du Nord française jusqu'au Second Conflit. *Outre-Mers*, *89*(334), 135–146. http://doi.org/10.3406/outre.2002.3929

Brown, M. (2009). *Science in Democracy: Expertise, Institutions, and Representation*. Cambridge: MIT Press.

Brown, N., Rappert, B., & Webster, A. (Eds.). (2000). *Contested Futures: A Sociology of Prospective Techno-Science*. Aldershot, England ; Burlington, VT: Ashgate.

Buzar, S. (2007). The hidden geographies of energy poverty in post-socialism: Between institutions and households. *Geoforum*, *38*(2), 224–240.

Byrne, J., & Mun, Y. M. (2003). Rethinking reform in the electricity sector: Power liberalisation or energy transformation? *Electricity Reform: Social and Environmental Challenges. United Nations Environmental Programme, Roskilde*, 48–76.

Byrne, J., Toly, N., & Glover, L. (2006). *Transforming power: energy, environment, and society in conflict*. Piscataway, New Jersey: Transaction Publishers.

Callicott, J. B. (2009). The Convergence Hypothesis Falsified: Implicit Intrinsic Value, Operational Rights, and de Facto Standing in the Endangered Species Act. In B.

A. Minteer (Ed.), *Nature in Common?: Environmental Ethics and the Contested Foundations of Environmental Policy*. Philadelphia: Temple University Press.

Castells, M. (1996). *The rise of the network society*. Hoboken: Blackwell Publishing Ltd.

Castells, M. (2000). Toward a Sociology of the Network Society. *Contemporary Sociology*, *29*(5), 693–699.

Catusse, M., Vairel, F., & Bono, I. (2010). *Le Maroc de Mohammed VI: mobilisations et action publique*. Paris: Karthala.

Center for Energy and Environmental Policy University of Delaware. (2012). *Policies for Achieving Energy Justice in Society: Best Practices for Applying Solar Energy Technologies to Low-Income Housing*. Delaware: Center for Energy and Environmental Policy University of Delaware.

Choi, Y. J., & Caporaso, J. A. (2002). Comparative regional integration. In W. Carlsnaes, T. Risse, & B. Simmons (Eds.), *Handbook of International Relations* (pp. 480–499). Thousand Oaks: Sage. Retrieved from http://books.google.com/books?hl=en&lr=&id=f90C7zgrcXYC&oi=fnd&pg=PA480&dq=Choi+and+Caporaso+2002&ots=dKY3LpLn2M&sig=XRMASP2LCx5sm9P06OFFLxBw998

Christopher Brown, J., & Purcell, M. (2005). There's nothing inherent about scale: political ecology, the local trap, and the politics of development in the Brazilian Amazon. *Geoforum*, *36*(5), 607–624. http://doi.org/10.1016/j.geoforum.2004.09.001

Ciupuliga, A. R., & Cuppen, E. (2013). The role of dialogue in fostering acceptance of transmission lines: the case of a France–Spain interconnection project. *Energy Policy*, *60*, 224–233. http://doi.org/10.1016/j.enpol.2013.05.028

Clercq, G. D. (2013, April 11). Saudi Arabia hopes to export solar electricity to Europe. *Reuters*. Paris. Retrieved from http://www.reuters.com/article/2013/04/11/saudi-solar-europe-idUSL5N0CY2SX20130411

Couvreux, J.-P., Moussa, P., Marseille, J., Beltran, A., & Cladé, J. (2002). Table ronde de conclusions. *Outre-Mers*, *89*(334), 601–619.

Cozzens, S. E. (2007). Distributive justice in science and technology policy. *Science & Public Policy (SPP)*, *34*(2), 85–94. http://doi.org/10.3152/030234207X193619

Credit Suisse Group. (n.d.). Atlantropa. *Cabinet*, *Spring 2003*(10). Retrieved from http://www.cabinetmagazine.org/issues/10/atlantropa.php

Cresswell, T. (2004). *Place: A Short Introduction* (1st ed.). Oxford, UK: Wiley-Blackwell.

Cronon, W. (1991). *Nature's Metropolis*. New York London: W.W. norton & Company.

Cumps, J. L., & Cumps, K. L. (1991). *Bargain for Profit. A Practical Guide to Bid for Power*. Belgium: Garant.

D'Almeida-Topor, H., & Frémeaux, J. (2002). Rapport de synthèse. *Outre-Mers*, *89*(334), 411–414. http://doi.org/10.3406/outre.2002.3947

Daly, J. (2013, August 25). Romania pulls plug on Nabucco pipeline. *OilPrice.com*. Retrieved from http://oilprice.com/Geopolitics/Europe/Romania-pulls-plug-on-Nabucco-pipeline.html

D'Angio, A. (2002). L'électrification du Maroc vue à travers l'action de la société Schneider et Cie (1907-1954). *Outre-Mers*, *89*(334-335), 317–329.

Dasgupta, P. (2010). Nature's role in sustaining economic development. *Philosophical Transactions of the Royal Society of London B: Biological Sciences*, *365*(1537), 5–11. http://doi.org/10.1098/rstb.2009.0231

Davies, S. R., & Selin, C. (2012). Energy Futures: Five Dilemmas of the Practice of Anticipatory Governance. *Environmental Communication: A Journal of Nature and Culture*, *6*(1), 119–136. http://doi.org/10.1080/17524032.2011.644632

Davis, D. (2007). *Resurrecting the Granary of Rome*. Athens: Ohio University Press.

Dawson, C. (2009). *EU Integration with North Africa: Trade Negotiations and Democracy Deficits in Morocco*. London: I.B.Tauris.

D, DIEKKRÜGER, B., Busche, H., Klose, A., Klose, S., Rademacher, C., & Schulz, O. (2010). Impact of Global Change on hydrology and soil degradation- Scenario analysis for the semi-arid Draa catchment (South Morocco). In *The Global Dimensions of change in River Basins: Threats, Linkages and Adaptation*. Bonn, Germany. Retrieved from http://s3.amazonaws.com/academia.edu.documents/30850226/GWSP-GCI_conference_2010_Proceedings.pdf?AWSAccessKeyId=AKIAJ56TQJRTWSMTNPEA&Expires=1423075018&Signature=VuhD1pR6VPh3pp%2BAt57hEUkfKKs%3D&response-content-disposition=inline#page=5

Debbarh, A. M. (2015). *L'ÉNERGIE : développement énergétique au Maroc depuis 1955, perspectives 2025*. Association Nationale des Collectivities Locales du Maroc. Retrieved from http://anclm.ma/IMG/pdf/Energie.pdf

Del Sarto, R., & Schumacher, T. (2005). From EMP to ENP: what's at stake with the European neighbourhood policy towards the southern Mediterranean?'. *European Foreign Affairs Review*, *10*(1), 17–38.

Des centrales photovoltaïque pour l'espace local un gain pour les citoyens et pour l'état. (2013). *Massolia*. Retrieved from http://www.massolia.com/rencontre/des-centrales-photovoltaique-pour-lespace-local-un-gain-pour-les-citoyens-et-pour-letat/

Desertec Industrial Initiative. (2012). *Desert Power Getting Started: The Manual for renewable electricity in MENA*. Munich Germany.

Deuxièmes Assises de l'Energie : Intégration industrielle Au Maroc, développement économique et perspectives de complémentarité Europe-Maghreb. (2011, June 2). Retrieved from http://www.massolia.com/energie-2/deuxiemes-assises-de-l%E2%80%99energie-integration-industrielle-au-maroc-developpement-economique-et-perspectives-de-complementarite-europe-maghreb/

Devine-Wright, P. (2011). *Renewable Energy and the Public: From NIMBY to Participation*. Oxford: EarthScan.

Devorkin, D. (1998). *Charles Greeley Abbot 1872-1973 A biographical Memoir*. Washington, D.C.: National Academies Press.

Document - Nigeria: Ten years on: injustice and violence haunt the oil Delta | Amnesty International. (n.d.). Retrieved December 20, 2012, from http://www.amnesty.org/en/library/asset/AFR44/022/2005/en/66c196ed-d49d-11dd-8a23-d58a49c0d652/afr440222005en.html

Doukkali, M. R. (2005). Water institutional reforms in Morocco. *Water Policy*, *7*(11), 71–88.

Dryef, M. (1997). Le développement du Maroc méditerranéen: le rôle de l'Etat. In B. Roux (Ed.), *LES ZONES DÉFAVORISÉES MÉDITERRANÉENNES*. Paris: Editions L'Harmattan.

Dubash, N. (2005). Regulation as an Arena For Social Policy: Examples from Electricity in Asia. Presented at the Arusha Conference, "New Frontiers of Social Policy."

Dubash, N. K. (2003). Revisiting electricity reform: The case for a sustainable development approach. *Utilities Policy*, *11*(3), 143–154. http://doi.org/10.1016/S0957-1787(03)00044-4

Dubash, N., & Singh, D. (2005). Alternating Currents Introduction to an International Review of Electricity Restructuring. *Economic and Political Weekly*.

Dubash, N., & Williams, J. (2006). The political economy of electricity liberalization. In J. Byrne, N. Toly, & L. Glover (Eds.), *Transforming power: energy, environment, and society in conflict*. Piscataway, New Jersey: Transaction Publishers.

Elsheshtawy, Y. (2008). *The Evolving Arab City: Tradition, Modernity and Urban Development*. London ; Portland, OR: Routledge.

Eneas, A. G. (1901, March 26). Solar generator.

Energy Sector Management Assistance Program (ESMAP). (2011, January 20). Power Sector Financial Vulnerability Assessment Impact of the Credit Crisis on Investments in the Power Sector: the Case of Morocco. World Bank. Retrieved from https://www.esmap.org/node/1128

Environmental Ethics. (2008). In *Stanford Encyclopedia of Philosophy*. Retrieved from http://plato.stanford.edu/entries/ethics-environmental/

Euro-Mediterranean Energy Market Integration Project. (2010). *MEDRING UPDATE: Volume-I Overview of the power systems of the Mediterranean Basin*.

European Commission. (2009). Energy: Energy Strategy for Europe. Retrieved May 1, 2011, from http://ec.europa.eu/energy/index_en.htm

European Commission. (2010, January 1). Coming Closer: EU assistance to its neighbours and beyond. European Commission. Retrieved from https://ec.europa.eu/europeaid/node/11132_en

European Commission. (2011). *Energy Security in Europe*. Brussels. Retrieved from http://ec.europa.eu/avservices/video/player.cfm?sitelang=en&ref=I071003&videolang=INT&starttime=0&endtime=0&autostart=true

Ezrahi, Y. (1990). *Descent of Icarus: Science and the Transformation of Contemporary Democracy*. Cambridge: Harvard University Press.

Fairley, P. (2008, November). Closing the Circuit. *IEEE Spectrum*. Retrieved from http://www.geni.org/globalenergy/library/technical-articles/transmission/ieee/spectrum/closing-the-circuit/index.shtml

Farrell, A. E., Zerriffi, H., & Dowlatabadi, H. (2004). Energy Infrastructure and Security. *Annual Review of Environment and Resources*, *29*(1), 421–469. http://doi.org/10.1146/annurev.energy.29.062403.102238

Feld, L. (2012, June 15). Interview: CSP Today Founder Belen Gallego on the Future of Concentrated Solar Power. *Renewable Energy World*. Retrieved from http://www.renewableenergyworld.com/rea/blog/post/2012/06/interview-csp-today-founder-belen-gallego-on-the-future-of-concentrated-solar-power?goback=%2Egde_2113510_member_125662841

Ferris, M. (n.d.). Transmission Line Switching. Retrieved March 19, 2015, from http://pages.cs.wisc.edu/~ferris/TransSwitch.html

Firebaugh, G. (2009). *The New Geography of Global Income Inequality*. Cambridge: Harvard University Press.

Fiske, A. P., & Tetlock, P. E. (1997). Taboo Trade-offs: Reactions to Transactions That Transgress the Spheres of Justice. *Political Psychology*, *18*(2), 255–297. http://doi.org/10.1111/0162-895X.00058

France to help Morocco's nuclear energy drive. (2010). *Expatica France*. Retrieved from http://www.expatica.com/fr/news/local_news/france-to-help-morocco-s-nuclear-energy-drive_80826.html

Frolova, M. (2013, June). *Energy and Landscape*. Granada, Spain.

Garcés-Mascareñas, B. (2012). *Labour Migration in Malaysia and Spain: Markets, Citizenship and Rights*. Amsterdam: Amsterdam University Press.

Geels, F. W. (2004). From sectoral systems of innovation to socio-technical systems: Insights about dynamics and change from sociology and institutional theory. *Research Policy*, *33*(6–7), 897–920. http://doi.org/10.1016/j.respol.2004.01.015

Geels, F. W., & Smit, W. A. (2000). Failed technology futures: pitfalls and lessons from a historical survey. *Futures*, *32*(9-10), 867–885.

Ghassemi, F., & White, I. (2007). *Inter-Basin Water Transfer: Case Studies from Australia, United States, Canada, China and India*. Cambridge: Cambridge University Press.

Ghosn, R. (2009). *New Geographies 2: landscapes of energy*. Printed in Hong Kong by Regal Printing; distributed by Harvard University Press: Harvard University Press.

Giannini Pereira, M., Vasconcelos Freitas, M. A., & da Silva, N. F. (2011). The challenge of energy poverty: Brazilian case study. *Energy Policy*, *39*(1), 167–175. http://doi.org/10.1016/j.enpol.2010.09.025

Glaser, L. (2009). *Electrifying the Rural American West: Stories of Power, People & Place*. Lincoln and London: University of Nebraska Press.

Gnad, O., & Vietor, M. (2011, July 1). Desert Powered Progress. *IP Journal*. Retrieved from https://ip-journal.dgap.org/en/ip-journal/topics/desert-powered-progress

Goldemberg, J., Johansson, T. B., Reddy, A. K. N., & Williams, R. (1988). *Energy for a Sustainable World*. New York City: John Wiley & Sons Inc.

Graham, S. (2000). Constructing Premium Network Spaces: Reflections on Infrastructure Networks and Contemporary Urban Development. *International Journal of Urban & Regional Research*, *24*(1), 183–200.

Granadino, R., & Mansouri, F. (2007, May 1). A Bridge Between Two Continents. *Transmission & Distribution World*. Retrieved from http://tdworld.com/underground-tampd/bridge-between-two-continents

Greacen, C., Engel, R., & Quetchenbach, T. (2013). *A Guidebook on Grid Interconnection and Islanded Operation of Mini--- Grid Power Systems Up to 200 kW*. Berkeley, CA: Lawrence Berkeley National Lab., CA (United States).

Green, S., Hough, D., & Miskimmon, A. (2011). *The Politics of the New Germany* (2nd ed.). London: Routledge.

Grimsby, L. K. (2011). Securing energy equity. *Energy Policy*, *39*(11), 6912–6913. http://doi.org/10.1016/j.enpol.2011.08.059

Group, O. B. (2012). *The Report: Morocco 2012*. Oxford Business Group.

Guruswamy, L. (2010). Energy Justice and Sustainable Development. *Colorado Journal of International Law and Policy*, *21*, 231–557.

Guruswamy, L. (2011). Energy Poverty. *Annual Review of Environment and Resources*, *36*(1), 139–161. http://doi.org/10.1146/annurev-environ-040610-090118

Guzzini, S. (2013). *Realism in International Relations and International Political Economy: The Continuing Story of a Death Foretold*. London: Routledge.

Hafner, M., Tagliapietra, S., Andaloussi, E., & Habib, E. (2012). *Outlook for Electricity and Renewable Energy in Southern and Eastern Mediterranean Countries* (SSRN Scholarly Paper No. ID 2156872). Rochester, NY: Social Science Research Network. Retrieved from http://papers.ssrn.com/abstract=2156872

Hammond, A. L., & Metz, W. D. (1977). Solar Energy Research: Making Solar After the Nuclear Model? *Science*, *197*(4300), 241–244. http://doi.org/10.1126/science.197.4300.241

Hashem, H. (2014, March 21). Masdar versus Spain: say adios to CSP investors? *CSP Today*. Retrieved from http://social.csptoday.com/markets/masdar-versus-spain-say-adios-csp-investors?utm_source=http%3A%2F%2Fuk.csptoday.com%2Ffc_csp_pvlz%2F&utm_medium=email&utm_campaign=CSP+Ebrief+24-03-2014en&utm_term=Masdar+versus+Spain%3A+say+adios+to+CSP+investors%3F&utm_content=67998

Haut-Commissariat au Plan. (n.d.-a). Emploi par branche d'activité de la population active occupée au milieu rural [government]. Retrieved March 19, 2015, from http://www.hcp.ma/Emploi-par-branche-d-activite-de-la-population-active-occupee-au-milieu-rural_a154.html

Haut-Commissariat au plan. (n.d.). Population du Maroc par année civile (en milliers et au milieu de l'année) par milieu de résidence : 1960 - 2050 [government]. Retrieved March 19, 2015, from http://www.hcp.ma/Population-du-Maroc-par-annee-civile-en-milliers-et-au-milieu-de-l-annee-par-milieu-de-residence-1960-2050_a677.html

Haut-Commissariat au Plan. (n.d.-b). Taux de chômage national selon le diplôme [government]. Retrieved March 19, 2015, from http://www.hcp.ma/Taux-de-chomage-national-selon-le-diplome_a267.html

Haut-Commissariat au Plan. (n.d.-c). Taux de Chômage selon le milieu [government]. Retrieved March 19, 2015, from http://www.hcp.ma/Taux-de-Chomage-selon-le-milieu_a255.html

Haut-Commissariat au Plan. (n.d.-d). Taux d'urbanisation (en %) par année : 1960 - 2050 [government]. Retrieved March 19, 2015, from http://www.hcp.ma/Taux-d-urbanisation-en-par-annee-1960-2050_a682.html

Haydar, Z. (2012, October 19). Syria Turns to Iran for Electricity, Leaves Regional Power Grid. *Al-Monitor*. Retrieved from http://www.al-monitor.com/pulse/business/2012/10/syria-signs-electricity-deal-with-iran-to-deal-with-power-shortage.html

Hecht, G. (2009). *The Radiance of France: Nuclear Power and National Identity after world war II* (new edition). Cambridge: MIT Press.

Heckel, M. (2011). *Desertec - Energy for Everybody* (1.0 ed.). Potsdam: Potsdam Press.

Heffernan, M. (2011). Shifting Sands: The Trans-Saharan Railway. In *Engineering Earth: The Impacts of Megaengineering projects*. Berlin: Springer.

Hess, D. J. (2005). Technology- and Product-Oriented Movements: Approximating Social Movement Studies and Science and Technology Studies. *Science, Technology & Human Values*, *30*(4), 515–535. http://doi.org/10.1177/0162243905276499

Hettne, B., & Söderbaum, F. (2000). Theorising the Rise of Regionness. *New Political Economy*, *5*(3), 457–472. http://doi.org/10.1080/713687778

Heurtebise, D. (2002). L’électrification outre-mer à travers les fonds du Centre des archives diplomatiques de Nantes. *Outre-Mers*, *89*(334), 37–46. http://doi.org/10.3406/outre.2002.3921

Hickman, L. (2011, December 11). Could the desert sun power the world? *The Guardian*. Retrieved from http://www.guardian.co.uk/environment/2011/dec/11/sahara-solar-panels-green-electricity

Hilgartner, S. (2000). *Science on Stage: Expert Advice as Public Drama* (1st ed.). Stanford University Press.

Hirsh, R. (1999). *Power Loss: The Origins of Deregulation and Restructuring in the American Electric Utility System*. Cambridge: MIT Press.

Hirsh, R. F., & Serchuk, A. H. (1996). Momentum Shifts in the American Electric Utility System: Catastrophic Change-Or No Change at All? *Technology and Culture*, *37*(2), 280. http://doi.org/10.2307/3106817

Hocke, Z. (2014, October 21). Morocco’s First Solar Power Plant to Start Operating in 2015. *Voice of America News*. Retrieved from http://www.voanews.com/content/morocco-first-solar-power-plant-to-start-operating-in-2015/2490557.html

Hodeir, C. (2002). La « Fée électricité » à l’Exposition coloniale de Paris (1931). *Outre-Mers*, *89*(334), 55–69. http://doi.org/10.3406/outre.2002.3924

Holleman, H. (2012). *Energy Justice and Foundations for a Sustainable Sociology of Energy*. University of Oregon. Retrieved from https://scholarsbank.uoregon.edu/xmlui/handle/1794/12419

Hommels, A. (2008). *Unbuilding Cities: Obduracy in Urban Sociotechnical Change*. Cambridge: The MIT Press.

Horden, P. (2012). Situations both alike? Connectivity, the Mediterranean, the Sahara. In J. McDougall & J. Scheele (Eds.), *Saharan Frontiers: Space and Mobility in Northwest Africa*. Bloomington: Indiana University Press.

Horden, P., & Purcell, N. (2000). *The Corrupting Sea: A Study of Mediterranean History*. Oxford, UK: Wiley-Blackwell.

Howe, M. (2005). *Morocco : The Islamist Awakening and Other Challenges: The Islamist Awakening and Other Challenges*. Oxford: Oxford University Press.

Hughes, T. (1983). *Networks of Power*. Baltimore: Johns Hopkins University Press.

Hughes, T. (1994). Technological Momentum. In M. Smith & L. Marx (Eds.), *Does Technology Drive History?*. Cambridge: MIT Press.

Hughes, T. P. (1986). The Seamless Web: Technology, Science, Etcetera, Etcetera. *Social Studies of Science*, *16*(2), 281–292. http://doi.org/10.1177/0306312786016002004

Huntington, S. P. (2011). *The Clash of Civilizations and the Remaking of World Order*. New York: Simon & Schuster.

Illich, I. (1974). *Energy and equity*. New York: Harper & Row.

Indicateurs Clés. (2014). Retrieved June 28, 2014, from http://www.mem.gov.ma/SitePages/IndicateursCles.aspx

Inland Almeria, villages in the province of Almeria Andalucía, Southern Spain. (n.d.). Retrieved April 5, 2014, from http://www.andalucia.com/province/almeria/indalo/home.htm

International Energy Agency. (2012). *World Energy Outlook 2012*. International Energy Agency/ OECD.

International Energy Agency/ OECD. (2010). *World Energy Outlook 2010* (No. ISBN: 978 92 64 08624 1) (p. 738).

Jacobson, A., Milman, A. D., & Kammen, D. M. (2005). Letting the (energy) Gini out of the bottle: Lorenz curves of cumulative electricity consumption and Gini coefficients as metrics of energy distribution and equity. *Energy Policy*, *33*(14), 1825–1832. http://doi.org/10.1016/j.enpol.2004.02.017

Joffé, G. (2009). Morocco's Reform Process: Wider Implications. *Mediterranean Politics*, *14*(2), 151–164. http://doi.org/10.1080/13629390902983716

Jones, G., & Bouamane, L. (2012). *"Power from Sunshine": A Business History of Solar Energy* (Working paper). Harvard University.

Kemp, R. P. M., Rip, A., & Schot, J. W. (2001). Constructing transition paths through the management of niches. Retrieved from http://doc.utwente.nl/42568/1/Kemp01constructing.PDF

Khawaja, M. (2012, October 11). Turkey cuts off power supply to Syria; denies political motives. *Arabian Gazette*. Retrieved from http://www.arabiangazette.com/turkey-syria-power-supply/

Kingdom of Morocco Ministry of Foreign Affairs and Cooperation. (n.d.). Advanced Regionalization [government]. Retrieved March 19, 2015, from https://www.diplomatie.ma/en/Regionalisationavancee.aspx

Kingsley, P. (2015, January 3). Arab spring prompts biggest migrant wave since second world war. *The Guardian*. London. Retrieved from http://www.theguardian.com/world/commentisfree/2015/jan/03/arab-spring-migrant-wave-instability-war

Kinsella, T. (2009, July 20). Politics abdicating responsibility to experts. *The Irish Times*. Ireland. Retrieved from http://www.lexisnexis.com.ezproxy1.lib.asu.edu/hottopics/lnacademic/?

Kloosterman, K. (2013, October 3). 13 Arab Nations Get Energy Future Mapped in Helpful New Report. *Green Prophet*. Retrieved from http://www.greenprophet.com/2013/10/13-arab-nations-get-energy-future-mapped-in-helpful-new-report/

Komendantova, N., Patt, A., Barras, L., & Battaglini, A. (2012). Perception of risks in renewable energy projects: The case of concentrated solar power in North Africa. *Energy Policy*, *40*, 103–109. http://doi.org/16/j.enpol.2009.12.008

Komendantova, N., Patt, A., & Williges, K. (2011). Solar power investment in North Africa: Reducing perceived risks. *Renewable and Sustainable Energy Reviews*, *15*(9), 4829–4835. http://doi.org/10.1016/j.rser.2011.07.068

Laird, F. N. (2013). Against Transitions? Uncovering Conflicts in Changing Energy Systems. *Science as Culture*, *22*(2), 149–156. http://doi.org/10.1080/09505431.2013.786992

Lamrini, R. (2006). *Y a-t-il un avenir au Maroc me demanda Yasmina: roman*. Paris: Marsam Editions.

Leach, M., Scoones, I., & Stirling, A. (2010). *Dynamic Sustainabilities: Technology, Environment, Social Justice*. London, UK: Earthscan.

Leiss, W. (1972). *The Domination of Nature*. Montreal: McGill Queens University Press.

Ley, W. (1954). *Engineers' Dreams*. New York: Viking Press.

Liebowitz, S. J., & Margolis, S. E. (1995). Path Dependence, Lock-In, and History. *Journal of Law, Economics and Organization*, *11*, 205.

Literacy rate, adult total (% of people ages 15 and above) | Data | Graph. (n.d.). Retrieved June 28, 2014, from http://data.worldbank.org/indicator/SE.ADT.LITR.ZS/countries/1W-XN-XQ-ZQ-MA?display=graph

Lotker, M. (1991). *Barriers to Commercialization of Large-Scale Solar ELectricity: Lessons Learned from the Luz Experience* (No. SAND91-7014). Albuquerque. Retrieved from http://www.nrel.gov/csp/troughnet/pdfs/sand91_7014.pdf

Lovins, A. B. (1977). *Soft energy paths: toward a durable peace*. San Francisco: Friends of the Earth International.

Lustgarten, A. (2009). *Conrad's Nightmare: The World's Biggest Dam and Development's Heart of Darkness*. Bankwatch.

Lynch, S. (2013, January 30). Egypt army chief: "Collapse" a threat; others doubtful. *USA Today*. Retrieved from http://www.usatoday.com/story/news/world/2013/01/29/egypt-army-chief-warns-of-collapse-of-state/1873459/

Maddy-Weitzman, B., & Zisenwine, D. (2012). *Contemporary Morocco: State, Politics and Society under Mohammed VI*. London: Routledge.

Maghraoui, D. (2009). The Strengths and Limits of Religious Reforms in Morocco. *Mediterranean Politics*, *14*(2), 195–211. http://doi.org/10.1080/13629390902985976

Maghraoui, D. (2013). *Revisiting the Colonial Past in Morocco*. London: Routledge.

Mandle, J. (2006). *Global Justice* (1st ed.). Stafford: Polity Press.

Manuel Rodriguez Garcia, J. (2010, February). *The Medring: Reality or fiction?*. Presented at the 1st Solar Thermal Electricity Industry Forum, Seville. Retrieved from http://www.estelasolar.eu/fileadmin/ESTELAdocs/documents/STEI_Forum/Presentations/Session_2.2.C_-_Juan_Manuel_Rodriguez_Garcia_-_The_Medring_Reality_or_Fiction.pdf

Maroc Export. (2013). 31 marchés ciblés pour l'année 2013.

Martínez, S. (2014, June). *Energy Efficiency and Renewable Energy in Spain*. Presented at the Arizona State University Meeting at IDAE, Madrid.

Matson, R. J., & Carasso, M. (1999). Sustainability, energy technologies, and ethics. *Renewable Energy*, *16*(1-4), 1200–1203. http://doi.org/10.1016/S0960-1481(98)00482-0

McCraw, T. (1971). *TVA and the Power Fight, 1933-1939*. Philadelphia: Lippincott.

McDougall, J., & Scheele, J. (2012). *Saharan Frontiers: Space and Mobility in Northwest Africa*. Bloomington: Indiana University Press.

McGrath, M. (2012, November 19). Desert solar power plan in doubt. *BBC*. Retrieved from http://www.bbc.co.uk/news/science-environment-20357167

McShane, T. O., Hirsch, P. D., Trung, T. C., Songorwa, A. N., Kinzig, A., Monteferri, B., … O'Connor, S. (2011). Hard choices: Making trade-offs between biodiversity conservation and human well-being. *Biological Conservation*, *144*(3), 966–972. http://doi.org/16/j.biocon.2010.04.038

Meadows, D., Randers, J., & Meadows, D. (1972). *Limits to Growth: The 30-Year Update*. Chelsea Green Publishing.

Meet BrightSource's Arnold Goldman. (2010, May 1). *Green Prophet*. Retrieved from http://www.greenprophet.com/2010/05/arnold-goldman-brightsource/

Merchant, C. (1989). *The death of nature: women, ecology, and the scientific revolution*. New York: Harper & Row.

Metz, W. D. (1977). Solar Thermal Electricity: Power Tower Dominates Research. *Science*, *197*(4301), 353–356. http://doi.org/10.1126/science.197.4301.353

Michael, M. (2000). Futures of the Present. In N. Brown, B. Rappert, & A. Webster (Eds.), *Contested Futures: A Sociology of Prospective Techno-Science*. Aldershot, England ; Burlington, VT: Ashgate.

Miller, C. A., Iles, A., & Jones, C. F. (2013). The Social Dimensions of Energy Transitions. *Science as Culture*, *22*(2), 135–148. http://doi.org/10.1080/09505431.2013.786989

Miller, C., & Moore, S. (2011). *Arizona's Energy Future* (No. 99th Town Hall). Phoenix: Arizona Town Hall. Retrieved from http://aztownhall.org/99

Miller, S. G. (2013). *A History of Modern Morocco*. Cambridge: Cambridge University Press.

Minerals Management Service. (2008). *Deepwater Gulf of Mexico 2008: America's Offshore Energy Future* (No. OCS Report MMS 2008-013). Washington, D.C: Minerals Management Service.

Minteer, B., & Manning, R. E. (2009). Convergence in environmental values- an empirical and conceptual defense. In B. Minteer (Ed.), *Nature in Common? Environmental Ethics and the Contested Foundations of Environmental Policy*. Philadelphia: Templeton University Press.

Mirsaeedi-Glossner, S. (2013). Iran's Flourishing Regional Influence. *Science & Diplomacy*. Retrieved from http://www.sciencediplomacy.org/article/2013/irans-flourishing-regional-influence

Misa, T. J., Brey, P., & Feenberg, A. (2004). *Modernity and Technology*. Cambridge: MIT Press.

Mitchell, T. (2011). *Carbon Democracy: Political Power in the Age of Oil*. London: Verso Books.

Morocco campaign #feb20 #morocco. (2011). Retrieved from http://www.youtube.com/watch?v=S0f6FSB7gxQ&feature=youtube_gdata_player

Morocco: HM King Mohammed Vi - Advanced Regionalization to Be Introduced in All Morocco's Regions. (2014, July 30). *Maghreb Arabe Presse (Rabat)*. Retrieved from http://allafrica.com/stories/201407311030.html

Morocco Named “2012 Offshoring Destination of the Year” by the European Outsourcing Association. (2012). Retrieved June 28, 2014, from http://www.medz-sourcing.com/en/presse/morocco-named-2012-offshoring-destination-of-the-year-by-the-european-outsourcing-association.html

Morocco’s unions protest austerity plans. (2014, April). *Al Jazeera English*. Retrieved from http://www.aljazeera.com/news/africa/2014/04/morocco-unions-protest-austerity-plans-201446131645914944.html

Müller-Jentsch, D. (2001). *The Development of Electricity Markets in the Euro-Mediterranean Area: Trends and Prospects for Liberalization and Regional Integration*. World Bank Publications.

Muller, K. (2005). Reconfigurer l’Eurafrique. *Matériaux Pour L’histoire de Notre Temps*, *77*(1), 52–60. http://doi.org/10.3406/mat.2005.1017

Munich RE. (2015). Blackout Risk Infographic | Blackout Technology [Infographic]. Retrieved March 19, 2015, from http://www.munichre.com/HSB/services/blackout-technology/blackout-risk/blackout-infographic/index.html

Norton, B. G., & Norton, B. G. (1991). *Toward unity among environmentalists*. Oxford University Press New York.

Nussbaum, M. C. (2007). *Frontiers of Justice: Disability, Nationality, Species Membership (Tanner Lectures of Human Values*. Cambridge, MA: Belknap Press of Harvard University Press.

Nussbaum, M. C. (2009). *The Clash Within: Democracy, Religious Violence, and India’s Future*. Cambridge: Belknap Press.

Nye, D. (1990). *Electrifying America : Social Meanings of a New Technology, 1880-1940*. Cambridge, MA: MIT Press.

Office National de l’électricité. (2013). Au service du développement.

Ortiz, F. (2014, February 4). Morocco says investors lining up for $9 bln solar project. *Reuters*. Retrieved from http://uk.reuters.com/article/2014/02/04/morocco-solar-idUKL5N0L92J220140204

Ozerkan, F. (2011). AFP: Turkey hits Syria with energy sanctions. *AFP*. Retrieved from http://www.google.com/hostednews/afp/article/ALeqM5jJRI1JuHWljLOzXL97ADprKCorAg?docId=CNG.e4e461402118db348f30ab6275a98e25.d91

Pace, M. (2006). *The politics of regional identity: meddling with the Mediterranean*. Hove UK: Psychology Press.

Panebianco, S. (2003). *A New Euro-Mediterranean Cultural Identity* (annotated edition). London ; Portland, OR: Routledge.

Perlin, J. (2013). *Let It Shine: The 6,000-Year Story of Solar Energy* (Revised Edition edition). San Francisco: New World Library.

Perrow, C. (1999). *Normal Accidents: Living with High-Risk Technologies*. Cambridge: MIT Press.

Petroski, H. (1997). Engineers’ dreams. *American Scientist*, *85*(4), 310.

Planck Foundation. (n.d.). *Deserts Become Economic Areas*. Retrieved from http://www.planck.org/downloads/Emerging-Nations-Desert-Development-PPP.pdf

Plan solaire marocain: Masen sous pression. (2013, June). *Economie Entreprises*. Retrieved from http://www.economie-entreprises.com/masen-sous-pression-2/

Pope, C. (1903). *Solar Heat Its Practical Applications*. Boston, MA: Colonial Press.

Porter, G. D. (2000). The city's many uses: cultural tourism, the sacred monarchy and the preservation of Fez's Medina. *The Journal of North African Studies*, *5*(2), 59–88. http://doi.org/10.1080/13629380008718398

Practical Action. (2012). *Poor People's Energy Outlook*. Warwickshire, UK: Practical Action. Retrieved from http://practicalaction.org

Purcell, M. (2006). Urban Democracy and the Local Trap. *Urban Studies*, *43*(11), 1921–1941. http://doi.org/10.1080/00420980600897826

Purcell, M., & Brown, J. C. (2005). Against the local trap: scale and the study of environment and development. *Progress in Development Studies*, *5*(4), 279–297. http://doi.org/10.1191/1464993405ps122oa

Rabinow, P. (2007). *Reflections on Fieldwork in Morocco*. Oakland: University of California Press.

Ragheb, M. (2011). *Solar Thermal Power and Energy Storage Historical Perspective*. Retrieved from http://mragheb.com/NPRE%20498ES%20Energy%20Storage%20Systems/Solar%20Thermal%20Power%20and%20Energy%20Storage%20Historical%20Perspective.pdf

Ramadan, T. (2008). *Face à nos peurs: Le choix de la confiance*. Tawhid.

Renewable Energy is a Win-win Situation for Everyone, Says CEO of the Desertec Industrial Initiative (DII). (2010, October 25). *The Tripoli Post*. Tripoli. Retrieved from http://www.tripolipost.com/articledetail.asp?c=2&i=5034

Rivlin, P. (2013). Morocco's Economy Under Mohammed VI. In *Contemporary Morocco: State, Politics and Society Under Mohammmed VI*. London: Routledge.

Roberson, J. (2014). The Changing Face of Morocco under King Hassan II. *Mediterranean Studies*, *22*(1), 57–83.

Rolston III, H. (1998). Challenges in Environmental Ethics. In M. J. Zimmerman, J. Callicott, G. Sessions, K. Warren, & J. Clark (Eds.), *Environmental Philosophy: From Animal Rights to radicial ecology* (2nd ed., pp. 124–144). Upper Saddle River, NJ: Prentice Hall.

Rose, M. (1995). *Cities of Light and Heat: Domesticating Gas and Electricity in Urban America*. University Park, PA: Pennsylvania State University Press.

Ross, M. (2001). Does Oil Hinder Democracy? *World Politics*, *53*(3), 325–361.

Rousseau, J.-J. (2002). *The Social Contract: And, The First and Second Discourses*. New Haven: Yale University Press.

Routley, R. (1973). Is there a need for a new, an environmental ethic? In *Proceedings of the XV World congress of philosophy*.

Roux, B. (1997). *Les Zones Défavorisées Méditerranéennes*. Paris: Editions L'Harmattan.

Royaume du Maroc Haut Commissariat au Plan. (2006). *Prospective Maroc 2030: Energie 2030 Quelles options pour le Maroc ?*. Retrieved from www.hcp.ma/file/111440/

Royaumont, L. de. (1882). *La conquête du soleil, applications scientifiques et industrielles de la chaleur solaire (héliodynamique)*. Paris: C. Marpon et E. Flammarion.

Ruiz Hernandez, V. (n.d.). *Solar Thermal Power. History of a research success (La Electricidad Termosolar. Historia de exito de la investigacion)*. Seville: Protermosolar.

Samborsky, B., Myrsalieva, N., & Mahmoud, M. (2013). *Arab Future Energy Index AFEX 2013*. Cairo, Egypt: RCREEE.

Sater, J. N. (2010). *Morocco: Challenges to Tradition and Modernity* (1st ed.). London: Routledge.

Scheele, J. (2012). *Smugglers and saints of the Sahara* (Vol. 120). Cambridge: Cambridge University Press.

Schinke, B. (2015, February 20). Civil society perspectives on renewable energy policy making in Morocco. Germanwatch, Heinrich Boll Stiftung Afrique du Nord Rabat. Retrieved from https://germanwatch.org/en/download/10931.pdf

Schlosberg, D. (2007). *Defining Environmental Justice: Theories, Movements, and Nature*. Oxford: Oxford University Press, USA.

Schumacher, E. F. (1973). *Small Is Beautiful: Economics as If People Mattered*. New York: HarperCollins.

Schwarz, S. (2014, October 11). Europeans do not understand Desertec. *Dii Website*. Retrieved from http://www.dii-eumena.com/press/news/single/article/994.html

Sclove, R. (1995). *Democracy and Technology*. New York, NY: Guilford Press.

Scott, J. W. (2008). *The politics of the veil*. Princeton: Princeton University Press.

Selin, C. (2008). The Sociology of the Future: Tracing Stories of Technology and Time. *Sociology Compass*, *2*(6), 1878–1895. http://doi.org/10.1111/j.1751-9020.2008.00147.x

Sen, A. (2009). *The idea of justice*. Cambridge: Harvard University Press.

Shapin, S., & Schaffer, S. (1985). Seeing and believing: the experimental production of pneumatic facts. In *Leviathan and the air-pump*.

Shatterbelt. (2010). In *Encyclopedia of geography terms, themes, and concepts*. Santa Barbara, CA. Retrieved from https://login.ezproxy1.lib.asu.edu/login?url=http://literati.credoreference.com.ezproxy1.lib.asu.edu/content/entry/abcgttc/shatterbelt/0

Silicon Valley Toxics Association. (2009). *Toward a Just and Sustainable Solar Energy Industry*. Silicon Valley Toxics Association.

Simeland, T., & Juma, M. (2011). Desertec: A Testimony for Deliberate Divide of the African Continent. In *Regional Integration in Africa: Bridging the North- Sub-Saharan Divide*. Pretoria, South Africa: Africa Institute of South Africa.

Slavin, D. H. (2001). *Colonial Cinema and Imperial France, 1919-1939: White Blind Spots, Male Fantasies, Settler Myths*. Baltimore: Johns Hopkins University Press.

Smale, A. (2015, January 5). Anti-Immigration Rallies in Germany Defy Calls to Desist. *The New York Times*. Retrieved from http://www.nytimes.com/2015/01/06/world/europe/pegida-rally-dresden-germany.html

Smith, S. L., & Frehner, B. (2010). *Indians & Energy: Exploitation and Opportunity in the American Southwest*. Santa Fe: SAR Press.

Société d'investissement énergétiques. (2010). *Etude conjoncturelle sur l'énergie au Maroc: Les Chiffres Clés*.

Société Marocaine d'Assurance à l'Exportation. (2013). Réalisations 2012.

Spencer, L. C. (1989). A comprehensive review of small solar-powered heat engines: Part II. Research since 1950—"conventional" engines up to 100 kW. *Solar Energy*, *43*(4), 197–210. http://doi.org/10.1016/0038-092X(89)90020-0

Spierenburg, D., & Poidevin, R. (1994). *The history of the high authority of the European Coal and Steel Community: supranationality in operation*. London: Weidenfeld and Nicolson. Retrieved from http://library.wur.nl/WebQuery/clc/910887

Starosielski, N. (2012). Warning: Do Not Dig': Negotiating the Visibility of Critical Infrastructures. *Journal of Visual Culture*, *11*(1), 38–57. http://doi.org/10.1177/1470412911430465

Stenmark. (2009). The Relevance of Environmental Ethical Theories for Policy Making. In B. Minteer (Ed.), *Nature in Common?: Environmental Ethics and the Contested Foundations of Environmental Policy*. Philadelphia: Temple University Press.

Stoker, G. (1998). Governance as theory: Five Propositions. *International Social Science Journal*, *50*(155), 17–28.

Stone, C. (2003). Do Morals Matter? The Influence of Ethics on Courts and Congress in Shaping U.S. Environmental Policies. *UC Davis Law Review*, *13*, 13–51.

Swearingen, W. D. (1988). *Moroccan Mirages: Agrarian Dreams and Deceptions, 1912-1986*. London: I.B.Tauris.

The Energiewende-- is there a Nordic way?. (2012, October). IASS Potsdam Germany.

The oil club's newest member. (2000, September 14). *The Economist*. Retrieved from http://www.economist.com/node/368035

The World Bank: Energy Sector Management Assistance program. (2009). *ESMAP 09 Annual Report* (p. 56).

Thompson, P. (2007). Agricultural Sustainability: What it is and what it is not. *International Journal of Agricultural Sustainability*, *5*(1), 5–16.

Tobey, R. C. (1996). *Technology as freedom*. Oakland: University of California Press.

Tozy, M. (2008). Islamists, Technocrats, and the Palace. *Journal of Democracy*, *19*(1), 34–41. http://doi.org/10.1353/jod.2008.0006

Trieb, F. (2006). *Trans-Mediterranean Interconnection for Concentrating Solar Power*. Stuttgart, Germany: German Aerospace Center Systems Analysis and Technology Assessment. Retrieved from http://www.dlr.de/tt/trans-csp

Trischler, H., & Weinberger, H. (2005). Engineering Europe: big technologies and military systems in the making of 20th century Europe. *History and Technology*, *21*(1), 49–83. http://doi.org/10.1080/07341510500037503

Van der Vleuten, E., & Raven, R. (2006). Lock-in and change: Distributed generation in Denmark in a long-term perspective. *Energy Policy*, *34*(18), 3739–3748. http://doi.org/10.1016/j.enpol.2005.08.016

Van Lente, H. (2000). Forceful futures: from promise to requirement. In N. Brown, B. Rappert, & A. Webster (Eds.), *Contested Futures: A Sociology of Prospective Techno-Science*. Aldershot, England ; Burlington, VT: Ashgate.

Van Lente, H., & Rip, A. (1998). Expectations in technological developments: an example of prospective structures to be filled by agency. In C. Disco & B. V. D. Meulen (Eds.), *Getting New Technologies Together: Studies in Making Sociotechnical Order*. Berlin: Walter de Gruyter.

Verbong, G., & Geels, F. (2007). The ongoing energy transition: Lessons from a socio-technical, multi-level analysis of the Dutch electricity system (1960–2004). *Energy Policy*, *35*(2), 1025–1037. http://doi.org/10.1016/j.enpol.2006.02.010

Victor, D., & Heller, T. (Eds.). (2006). *The Political Economy of Power Sector Reform: The Experiences of Five Major Developing Countries*. Cambridge: Cambridge University Press.

Vidican, G., Bohning, M., Burger, G., Regueira, E. de S., Muller, S., & Wendt, S. (2013). *Achieving Inclusive Competitiveness in the Emerging Solar Energy Sector in Morocco*. Bonn: The German Development Institute / Deutsches Institut für Entwicklungspolitik (DIE).

Waltz, K. (2004). Neorealism: Confusions and Criticisms. *Journal of Politics & Society*.

Warleigh-Lack, A., & Robinson, N. (2011). Learning or comparison in the study of regions? Fruitful dialogues and future research directions. In A. Warleigh-Lack, N. Robinson, & B. Rosamond (Eds.), *New Regionalism and the European Union: Dialogues, Comparisons and New Research Directions*. New York: Routledge.

Wender, B. A., Foley, R. W., Prado-Lopez, V., Ravikumar, D., Eisenberg, D. A., Hottle, T. A., … Guston, D. H. (2014). Illustrating Anticipatory Life Cycle Assessment for Emerging Photovoltaic Technologies. *Environmental Science & Technology*, *48*(18), 10531–10538. http://doi.org/10.1021/es5016923

Westra, L. (2009). Why Norton's approach is insufficient for environmental ethics. In B. Minteer (Ed.), *Nature in Common? Environmental Ethics and the Contested Foundations of Environmental Policy*. Philadelphia: Templeton University Press.

Williams, J. H., & Dubash, N. K. (2004). Asian Electricity Reform in Historical Perspective. *Pacific Affairs*, *77*(3), 411–436.

Winner, L. (1977). *Autonomous Technology: Technics-out-of-control as a Theme in Political Thought*. Cambridge, MA: The MIT Press.

Winner, L. (1980). Do Artifacts Have Politics? *Daedalus*, *109*(1).

Winner, L. (1986). *The Whale and the Reactor: A search for limits in an age of high technology*. Chicago and London: University of Chicago Press.

Wiser, R., Pickle, S., & Goldman, C. (1998). Renewable energy policy and electricity restructuring: a California case study. *Energy Policy*, *26*(6), 465–475. http://doi.org/10.1016/S0301-4215(98)00002-0

Wolff, G. (n.d.). *The Desertec Concept*. Retrieved from http://www.trec-uk.org.uk/resources/desertec_talk.pdf

World Bank. (2011). *Poor places, thriving people: how the Middle East and North Africa can rise above spatial disparities*. Washington, D.C: World Bank. Retrieved from http://elibrary.worldbank.org/doi/book/10.1596/978-0-8213-8321-6

World Bank. (2013). Morocco | Data. Retrieved March 19, 2015, from http://data.worldbank.org/country/morocco

World Bank. (2014). Doing Business in Morocco. Retrieved June 28, 2014, from http://www.doingbusiness.org/data/exploreeconomies/morocco

World Bank. (2015). Middle East and North Africa. Retrieved March 19, 2015, from http://www.worldbank.org/en/region/mena

World Bank Project Finance and Guarantees: resource mobilization and cofinancing vice presidency project finance and guarantees department: (1997). *Morocco's Jorf Lasfar Power station Project overview*. Retrieved from http://siteresources.worldbank.org/INTGUARANTEES/Resources/JorfLasfar_PFG_Note.pdf

Wuppertal Institute; Germanwatch. (forthcoming). *Social CSP*.

Yergin, D. (2006). Ensuring Energy Security. *Foreign Affairs*, *85*(2), 69–82. http://doi.org/10.2307/20031912

Yousef, T. M. (2004). Development, growth and policy reform in the Middle East and North Africa since 1950. *The Journal of Economic Perspectives*, *18*(3), 91–115.

Zaki, L. (2010). L'électrification temporaire des bidonvilles casablancais: aspects et limites d'une transformation "par le bas" de l'action publique. Les cas des carrières centrales. In *Le Maroc de Mohammed VI: mobilisations et action publique*. Paris: Karthala.

Zaki, L. (2011). L'électrification temporaire des bidonvilles casablancais. *Politique africaine*, *N° 120*(4), 45–66. http://doi.org/10.3917/polaf.120.0045

Zeigler, D. J. (1997). Morocco and California: Comparing Environment and Society. *Journal of Geography*, *96*(4), 191–195.

Zeller, T. (2009, June 22). Europe looks to Africa for solar power. *The International Herald Tribune*. Retrieved from http://www.lexisnexis.com.ezproxy1.lib.asu.edu/hottopics/lnacademic/?

Zickfeld, F., Wieland, A., Blohmke, J., Sohm, M., & Yousef, A. (2012). *Desert Power 2050: Perspectives on a Sustainable Power System for EUMENA*. Munich Germany: Dii GmbH.

Zisenwine, D. (2012). Mohammed VI and Moroccan foreign policy. In *Contemporary Morocco: State, Politics and Society Under Mohammmed VI*. London: Routledge.

APPENDIX A:

DESERTEC WINNERS/ LOSERS IDENTIFIED BY THE INTERVIEWEES FROM THIS STUDY

Winners/ Benefits	**Losers/ Drawbacks**
North Africans who get jobs	Oil companies and traditional utilities, if they do not adapt
Local content	Touregs/ Berbers/ local people in the desert
Access to electricity for people in North Africa	Environmental impacts inevitable from all energy development
Stable electricity system for North Africa to build other industries upon	Loss of sovereignty for countries
Stopping immigration	
Reducing the cost of electricity through integration. Reducing cost volatility.	
Giving people in villages reliable electricity 24 hours per day	
Already fostered increased awareness about renewable energy in Europe and worldwide	
Improved infrastructure for North Africa—better roads near power plant sites	
Involved industry players win	

APPENDIX B:

TRAINING PROGRAMS IN RENEWABLE ENERGY IN MOROCCO

(Note: not necessarily an exhaustive list)

Université Polytechnique Mohammed VI at the Université Khadjayat near Settat

Université Cadi Ayyad-Marrakech: Centre National D'Etudes et de Recherches sur l'Eau et l'Energie

Laboratoire des Energies Renouvelables et Efficacité Energétique—solar hot water, solar PV, solar desalination, solar distillation of medical plants, biomass
Studying: monitoring and modeling passive energy systems in buildings, k project with German company Simply Solar on parabolic troughs, solar desalination, desalination with reverse osmosis coupled with PV and wind energy, solar drying for medical plants, solar refrigeration

Université Ibn Zohr

6 relevant laboratories
2 masters degrees in Agadir (material, energy, and environmental engineering & science and technology for the environment: water, air, and sun)
Master in Energy and Renewable Energy in Guelmim
Professional license in Techniques of Exploiting Renewable Energy in Ouarzazate
A Diploma Engineer of State in engineering of processes of energy and environment
Studying: semiconductors, numeric modeling for PV, CSP

Université Mohammed V Agdal, Ecole Normale Supérieure Rabat
PV group working on semi-conducting materials
Professional license in Physical Techniques of Energies
Studying: imperfections in the structure of PV cells, the effects of light elements on the electronic properties, semiconducting materials, concentrating PV

Université Caid Ayyad Faculté des Sciences Semlalia Marrakech

Five relevant laboratories
Professional License in Energy Efficiency and Renewable Energies
Masters in Energy and Environment
Professional License and Specialized Masters in Buildings and Public Works
Studying: thin layers for PV conversion, simple and hybrid PV systems, energy systems based on thermal transfer, energy efficiency in buildings, thermal performance by solar radiation in greenhouses, physical instrumentation of renewable energy etc.

Université Hassan II Casablanca Faculté des Sciences Ain Chock

2 relevant laboratories
Masters in Energy Systems and Renewable Energy
License in Solar and Wind Energy

License in physics with an energy option
Continuing training for businesses in the field of renewable energy- masters and license
Studying: modeling hybrid energy systems, modeling different Rankine cycles with applications for CSP, wind energy conversion, modeling and simulation for energy performance with a Fresnel system, storage for solar thermal, energy efficiency in the electric hybrid grid, solar drying, PV and shading

Université Hassan II- Mohammedia – Casablanca Faculté des Sciences Ben M'sik, Casablanca

Three relevant laboratories
Masters in Renewable energy and material
Masters in valorization of natural resources and the protection of the environment
Studying: renewable energy optimization systems, optimizing electrodes for fuel cells, project InnoPV and InnoWind 2030—solar fridge and solar PV map

Université Moulay Ismail FST d'Errachidia

They offer training in renewable energy relating to: Solar PV, solar thermal, wind, engineering of energy process, material for the production of energy, energy systems, recuperation of energy, energy efficiency
Studying: material advances in the production of energy, material in phase changes, nanomaterial in the field of renewable energy, energy efficiency, recuperation of energy

Université Sidi Mohamed Ben Abdellah Faculté des Sciences Dhar El Mehrz

One relevant laboratory
Offer undergraduate student training in SMP material, a masters in the Physics of Materials and Nanostructures in cooperation with the University of Le Mans in France, more than 30 PhD students studying renewable energy.
Studying: PV properties relating to semiconductors, physics of conjugated polymers for applications in PV cells and organic light emitting diodes, magnetic properties of thin films and magnetic superlattices, nanocomposite polymer, photonic processes, electronic properties of impurities and excitonic complexes

Université Moulay Ismail FS de Meknès

Two relevant laboratories
Training relating to solar PV, solar thermal, wind, hydro, biomass, geothermal, systems of production in renewable energies, recuperation of energy, energy efficiency
Studying: concentrated PV, organic PV cells, new materials for solar, energy efficiency

Université Ibn Tofail Faculté des Sciences Kenitra

One relevant laboratory

Professional License in Renewable Energy
Specialized Masters in Renewable Energy
Studying: material for solar energy, semi-conductors and surface engineering, semi-conductor PV applications, luminescence of material etc.

Université Mohammed V- Agdal: faculté des sciences de Rabat

Two relevant laboratories
Fundamental license in Physical Material Sciences
Studying: PV conversation, electrochemical generators for the storage of energy, nanomaterial for batteries, semi-conductors for the environment, material for energy, solar radiation, solar drying, cooling and air conditioning, air conditioning for greenhouses, composite materials, etc.

APPENDIX C:

PICTURE PERMISSIONS

Permission for Image 54

Sharlissa,

Thanks for your email and apologies for the delayed reply.

Please find attached a jpg of the map for use in your dissertation.

Best regards

[see attached file: p19-at14a morocco+ power!-con copy.jpg]
Nick Carn

Publications and Marketing Director

Established in 1989, Cross-border Information (CbI) is a business intelligence and consultancy company with a research focus on Africa and the Middle East.

By constantly monitoring commercial and political activity across our core regions we help inform clients of the trends and developments that affect their businesses and interests.

Web: http://www.crossborderinformation.com

Permission for image 11

Dear Sharlissa,
Thank you very much for your email. You can use the photograph without any problems.
It would be nice, if you write underneath the photograph that it is made in the Chocolate Museum Cologne
I wish you all the best for your dissertation
Regards
Andrea Durry

Mit freundlichen Grüßen von der Schokoladenseite

Schokoladenmuseum Köln GmbH

Andrea Durry
Kuratorin

Permission for image 53

You have my permission to use the picture of the solar panel in front of the nomad tent.

I hope your thesis is going well.

Sincerely,

Lynnsee Starr

Permission for image 7/ 23

Hi Sharlissa, Thanks for your email. You have our permission to use the photo. Best of luck with your dissertation.

Kind regards,
JZ

-----Original Message-----
From: sharlissa.moore=asu.edu@newfangled.com
[mailto:sharlissa.moore=asu.edu@newfangled.com] On Behalf Of
sharlissa.moore@asu.edu
Sent: Saturday, March 21, 2015 1:41 PM
To: Jennifer Z. Rigney
Subject: Contact Us

Form ID: 7936

First Name: Sharlissa

Last Name: Moore

Email: sharlissa.moore@asu.edu

Phone:

Company: Arizona State University

Title: PhD candidate

Country: US

Comments: Hello,

I am wondering if I could have permission to use the picture of the Ivanpah plant "Ivanpah begins: steam blows" on your Ivanpah website (http://www.ivanpahsolar.com/photos-and-videos) for a chapter of my dissertation on the history of concentrating solar power. I will give credit for the image to BrightSource of course. Thank you for your consideration.

Permission for images 26 and 47

Dear Sharlissa,

The map image is available under Creative Commons Attribution-ShareAlike 3.0 Unported License. Therefore you can make use of the image as long as you correctly attribute the source of the image: **SolarGIS © 2015 GeoModel Solar**

Best regards,
Harsh

Permission for image 3.

Sharlissa,

You have my permission to use the electricity load diagram. I've included a high-resolution tiff version of the file with a copyright tag for your use. Simply note in the figure caption that the image is used with permission. If you need the image in a different file format, let me know and I will send you a different file.

Jimm

Dr. James D. Myers

Department of Geology and Geophysics

Dept 3006

University of Wyoming

Permission for images 30, 31, 32, 33, and 34

Dear Sharlissa,

I asked the CEO of Dii about your request and we do not mind that you use the pictures you showed in your email by referring to the source as Dii, I am the person who prepared the scenario maps, if the map resolution you have is not sufficient for you then I will send you the same maps with high resolution.

Also it will be great to get to know about your work, all the best in your PhD.

Ahmad

Image 38

Hi Sharlissa,

Please find enclosed the email exchange (in German) between me and Ms. Volmer. Ms. Volmer contacted Mr. Peter van Son, who is now responsible at RWE for the Desertec Project and he gave you the permission to use his Picture (as far as I understood the picture originally appeared on the Dii platform) . I hope that this is enough for the copyright requirements. If not please let me know or directly contact Mr. van Son.

Christine

-----Original Message-----
From: Volmer, Manuela [Manuela.Volmer@rwe.com]
Received: Dienstag, 31 Mär. 2015, 1:58PM
To: Sturm, Christine [Christine.Sturm@rwe.com]
Subject: WG: Picture permission question

Hallo Frau Sturm,

das Bild kann genutzt werden.

Viele Grüße

Manuela Volmer

RWE Group Business Service GmbH

Forschung & Entwicklung Konzern – R&D Support

Rellinghauser Str. 37, 45128 Essen

T intern: 70-15467

T extern: +49 201 12-15467

E manuela.volmer@rwe.com

Kennen Sie schon unsere Online-Broschüre, in der Sie mehr über unsere Forschungsprojekte erfahren?www.innovation.rwe.com

Von: van Son, Paul
Gesendet: Dienstag, 31. März 2015 13:54
An: Volmer, Manuela
Betreff: Re: Picture permission question

Vielen Dank. Selbstverständlich darf sie mein Bild nutzen.

Gruss, paul van Son

Von meinem iPhone gesendet

Am 31.03.2015 um 15:22 schrieb Volmer, Manuela <Manuela.Volmer@rwe.com>:

Hallo Herr van Son,

ich arbeite in der Abteilung von Herrn Drake und koordiniere hier die Beantwortung von Anfragen, die uns erreichen. Eine Studentin möchte gerne ein Bild nutzen (siehe unten). Ich glaube, das Bild war ursprünglich auf den Dii-Seiten zu sehen. Können Sie sagen, ob sie es nutzen kann?

Viele Grüße

Manuela Volmer

RWE Group Business Service GmbH

Forschung & Entwicklung Konzern – R&D Support

Rellinghauser Str. 37, 45128 Essen

T intern: 70-15467

T extern: +49 201 12-15467

E manuela.volmer@rwe.com

Kennen Sie schon unsere Online-Broschüre, in der Sie mehr über unsere Forschungsprojekte erfahren?www.innovation.rwe.com

Von: Sturm, Christine
Gesendet: Dienstag, 31. März 2015 10:01
An: Volmer, Manuela
Betreff: WG: picture permission question

Hallo Frau Volmer,

anbei wie besprochen das Bild, das meine Kommilitonin gerne in ihrer Arbeit nutzen möchte.

Mit freundlichen Grüßen / Kind regards

Christine Sturm

RWE Energiedienstleistungen GmbH
Leiterin Stoffstrommanagement
Head of Feedstock Management
Unterste-Wilms-Str. 52
44143 Dortmund

Tel +49 231 438 6182

Fax +49 231 438 2482

Mobil +49 172 571 9611

mailto:christine.sturm@rwe.com
www.rwe.com

Geschäftsführung: Jörn-Erik Mantz

Sitz der Gesellschaft: Dortmund
Eingetragen beim Amtsgericht Dortmund
Handelsregister-Nr. HRB 23078
USt.-IdNr. DE 265464927

□Go Green, keep it on the screen - think before you print.

Von: Christine Sturm [mailto:lala.sturm@googlemail.com]
Gesendet: Mittwoch, 25. März 2015 16:00
An: Sturm, Christine
Betreff: FW: picture permission question

From: Sharlissa Moore <sharlissa.moore@asu.edu>
Date: Sunday, March 22, 2015 at 9:18 PM
To: Christine Sturm <Christine.Sturm@asu.edu>
Subject: picture permission question

Hi Christine,

I hope you are doing well! How are things in Germany? I am finalizing my dissertation, and I am wondering if I could use the Desert Power picture from the RWE website (link below). I assume it is copyrighted. Do you know who I would contact at RWE for permission?

http://www.rwe.com/web/cms/en/364512/rwe/innovation/projects-technologies/renewables/desert-power/

Thanks,

Sharlissa

Desertec Foundation image 24, 29

Dear Sharlissa

Ignacio asked me to confirm the use of the pictures.

That’s no problem, you may use all three pics. Please mention DESERTEC foundation as the source.

Do you think it is possible to send us the dissertation as pdf and we upload it to our DESERTEC knowledge platform?

Best

Andreas

Mit freundlichen Grüßen

Andreas Huber

Mitglied des Vorstands

DESERTEC Foundation

Solar Plataforma: Image 6, 9, 15, 16, 17, 18, and 19

Buenos días Sharlissa,

Disculpa el retraso en la respuesta. Sí, no hay problema, las fotos que están disponibles en la WEB de la PSA puedas emplearlas.

Si fuera posible, nos interesaría que nos facilitase una copia de tu trabajo, en el momento en el que sea posible.

Un saludo,

Rosa García
PLATAFORMA SOLAR DE ALMERIA

Permission for Image 10

Dear Sharlissa,

Thank you for the form.
Here is the link to download the image:

https://wolke.deutsches-museum.de/public.php?service=files&t=9cbd291ff767b09cf8df3bdc36266496

Best,
Anna

Permission for Image 46

Ok Pas de problème si cette utilisation est positive, bonne chance et bon courage

2015-05-01 3:49 GMT+02:00 Sharlissa Moore <sharlissa.moore@asu.edu>:

Bonjour,

Je suis étudiante doctorant á Arizona State University aux États-Unis. Puis je-utiliser la photo dans votre journal de HM le roi: http://oujda-portail.net/ma/hm-the-king-inaugurates-integrated-solar-combined-cycle-power-plantin-eastern-morocco-19180.html#.VQ3u5mZTPn- dans ma thèse? Merci beaucoup pour votre considération.

Cordialement,

Sharlissa Moore

BIOGRAPHICAL SKETCH

Sharlissa Moore is a Ph.D. Candidate in the Human and Social Dimensions of Science and Technology program at Arizona State University. Her research seeks to understand the social and political aspects of renewable energy transitions. She also specializes in teaching students from various disciplines about the social dimensions of science and technology. She has instructed the undergraduate engineering course "Technological, Social, and Sustainable Systems." She has been the teaching assistant for two years for the ASU study abroad trip on sustainable development in Morocco and Spain and is helping to prepare a third trip. Sharlissa links research to application through her engagement in the professional science and technology policy domain. She has interned for the White House Office of Science and Technology Policy and the Science and Technology Policy Institute. She is the President of Student Pugwash USA, a nonprofit organization that engages students and young professionals in exploring the social and policy aspects of science and technology. Previously, she worked for ASU's Senior Vice President for Knowledge Enterprise Development and the Consortium for Science, Policy, and Outcomes. Sharlissa earned her B.A. in astronomy with a minor in physics from Smith College.