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Sustainable Infrastructure and South Mountain Village: Building Energy Use

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ASU-METIS-2018-005-CPR

May 2018

CEE 507 / PUP 553 / SOS 547: Urban Infrastructure Anatomy
Community Integrated Renewable Energy (CIRE) Project
South Mountain Village

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Project Deliverable 4
Final Report
April 30th 2018

Executive Summary

This report examines the energy infrastructure in the South Mountain Village of Phoenix AZ. The report is in support of the Rio Grande 2.0 project being implemented by the City of Phoenix in conjunction with Arizona State University. The report focuses on a small section of the village, for which we create energy demand profiles, solar generation profiles, and solar + storage generation profiles. We utilize these profiles to demonstrate the impact that neighborhood solar will have on the grid. We additionally research SRP's deployment of smart grid technologies and SRP's plans for the future of their power system. The report examines the benefits, and challenges of microgrid development in South Mountain Village.

We undertake this study to identify strategies that increase energy efficiency, that implement resilient and redundant systems in the existing energy grid, and that provide flexibility and adaptability to the community's energy systems. Deploying these strategies will ensure the sustained provision of energy to the community in the event of catastrophic events.

We demonstrate that the installation of rooftop solar photovoltaics on residential buildings in conjunction with battery storage systems proves more than sufficient to provide power to the residents of South Mountain Village. We explore the benefits and challenges for the development of smart grid infrastructure and microgrid networks in the village. We determine that the implementation of a smart grid and a parallel microgrid improves the resiliency of the Village's energy systems.

While SRP has managed to make progressive steps forward in implementing Smart Grid technologies, they can continue this progression by developing a unified communication system that is secure through cyber security measures to allow for reliable energy service to their customers. A hybrid development of smart grid and microgrid technologies in the village that employs rooftop solar photovoltaics and battery storage will provide community members with the resilient energy infrastructure they require in a future which entails multiplied risks of catastrophic events like increased heat waves and cyber attacks.

Introduction

We develop a conceptual plan for the integration of renewable energy infrastructure with existing energy infrastructure in the South Mountain Village of Phoenix, AZ. We comply with the strategies for resilience described by Ahern (2011): multifunctionality, redundancy and modularization, bio- and social diversity, multi-scalar and connected form, and adaptivity. We expect our concept to suffice for application throughout the future Phoenix metropolitan area energy system.

Motivation

South Mountain Village houses ~9,500 residents in ~3,500 households (US Census Bureau, 2015). Salt River Project (SRP) manages electrical utilities in the region. SRP provides some of the most reliable electrical energy in the world and customers report high satisfaction (T.L.C. Group, 2011). Despite SRP's excellence, we identify three motivations for further improvement of South Mountain Village's energy infrastructure.

The first motivation entails grid vulnerabilities that result from rising ambient air temperature. Projected increases in air temperature of 1 - 5°C by 2050 evince multiplied risks of equipment failures and power outages, particularly during hours of peak usage in summers when a power outage invites morbidity and mortality (Burillo et al. 2016). We thus consider strategies for reforming the grid that improve power management and energy efficiency and that lessen peak load.

The second motivation considers the risk of a cyberattack on electrical infrastructure. In 2015, a party infiltrated a Ukrainian regional electricity distribution company's computer and supervisory control and data acquisition (SCADA) systems. The group disconnected 30 substations for three hours and impacted service to approximately 225,000 customers (Lee et al. 2016). The risk of catastrophic power outages increases as cyber attacks increase in sophistication. We thus consider redundancy and autonomy in the design of a new power system for South Mountain Village.

The third motivation involves bounded rationality - the acknowledgement that we have limits to our understanding and cannot conceive of every occurrence which might merit consideration in the design of an infrastructure network. One example challenges the assumption that SRP remains a solvent enterprise in perpetuity. Recently, the Tennessee Valley Authority realized that its twenty-year plan will prove insufficient for an energy landscape in transition as renewable energy prices plummet, merely three years after the plan's formation (Roberts, 2018). Accounting for the unaccountable in designing an infrastructure network amid an energy landscape in flux requires flexibility and adaptability.

Design Strategies

Renewable energy sources include biomass, hydropower, geothermal, wind, and solar (US EIA, 2017). Multiple energy carriers and methods of harnessing energy comprise each type of renewable energy. We simplify our design by considering only the integration of residential rooftop solar photovoltaics with the existing grid. Solar photovoltaics improve energy efficiency in the South Mountain energy system by converting solar radiation into usable electricity. When coupled with battery storage, solar electricity may offset peak energy loads on the power grid.

We appeal to biomimicry in assessing means of integrating the energy harnessed from rooftop solar photovoltaics. Arboreal systems and rhizomatic systems demonstrate means of energy management which have sustained for millennia. The two represent distinct strategies: centralization and decentralization.

The paradigm of power management by utility companies comprises centralization. One enterprise coordinates nodes of energy supply and demand in a regional network and determines prices for the provision of power based on the costs of business. The singular enterprise determines strategies for managing emergencies and upgrades to the system. The aptly-named tree structure of network theory describes this relationship. The power grid that SRP has constructed is not presently designed to manage the supply of energy from nodes of consumption, such as residences where we recommend rooftop solar photovoltaics. A transition to a smart grid will increase resilience for the utility and their customers by improving management of the power system through embedded digital communication technologies.

Decentralization of the power grid entails the establishment of microgrids which function as autonomous units. Microgrids generate and distribute their own power on a neighborhood scale. Microgrids impart redundancy by permitting the provision of power in the event of a regional grid failure and adaptability by allowing for individual neighborhoods to tailor their grid configuration to their unique geographies.

Proposal

Our project consists of two components that together develop our community integrated renewable energy system for South Mountain Village. The first component analyzes building energy demand and solar energy software to model the energy consumption and solar energy production of a diverse housing stock neighborhood within the South Mountain Village so that a CIRE system can be implemented. Our team creates energy profiles to assess the overall solar production of the community and simulates the addition of battery storage systems. The second part consists of literature review and cost-benefit analysis on smart grid and microgrid systems to understand the feasibility of implementing a CIRE project in South Mountain Village. This section focuses on system components, integrating the system with the existing grid, challenges for implementation, and propose practical solutions that can be implemented for South Mountain

Village and other communities. Through literature review and case studies, the team implements a strategy to phase in grid improvements at a community scale.

Part I: Determining Electricity Consumption and Potential Solar Electricity Generation of a Community in South Mountain Village

Purpose

We seek to model energy demand profiles and solar energy generation capacities for South Mountain Village residential areas in Phoenix, Arizona. This permits us to determine the costs associated with energy consumption and the potential benefits to be realized by rooftop photovoltaic solar panels village-wide. This also permits us to identify discrepancies in peak generation and peak usage, which we hope to mitigate via the establishment of microgrids in communities throughout the village. The duration and intensity of consumption and generation discrepancies will determine the configuration of microgrid designs.

Hypothesis

We posit that residential energy demand profiles will be greatest in the mid-afternoon when residents return home and begin utilizing appliances en masse. Energy generation will be greatest at mid-day when the sun is most orthogonal to the panels.

Study Area

Figure 1: Study Area in South Mountain Village

Our study area is a randomly chosen neighborhood in South Mountain Village bounded by West Baseline Road to the south, South 44th Street to the west, South 48th Street to the east, and an easement to the north. We exclude the religious building in the northeast corner and the commercial buildings in the southeast corner to focus wholly on the residential areas. The easternmost parcels are zoned R1-6, while the central and westernmost parcels are zoned R-3A (City of Phoenix, n.d.). The easternmost parcels represent single family detached units. The westernmost parcels represent single-family attached units. The central parcels represent low-rise apartment buildings. The distinction between single-family attached and low-rise apartment buildings is arbitrary; we do so to increase the diversity of energy demand profiles in our model.

Figure 2-A: A typical single-family detached unit

Figure 2-B: Single-family attached units

Figure 2-C: Low-rise apartment buildings

Methods

Hourly Energy Consumption Profiles

We employ the hourly consumption profiles developed by the Office of Energy Efficiency & Renewable Energy (EERE) (Office of Energy Efficiency & Renewable Energy, 2013). EERE bases these profiles on sixteen commercial building types and three residential building archetypes in Typical Meteorological Year (TMY3) zones throughout the United States. Parameters for commercial buildings derive from the U.S. Department of Energy Commercial Reference Building Models of the National Building Stock. Parameters for residential buildings derive from statistical references of building types per climate zone from the Residential Energy Consumption Survey. We use the residential building profiles and the mid-rise apartment profile for the Phoenix Sky Harbor International Airport TMY3 zone.

We use the residential base consumption profile (Table E-1) to model single-family detached unit energy consumption. We also use the residential low consumption and high consumption profiles which respectively assume best-case and worst-case parameters for energy consumption.

We model the westernmost single family attached units by multiplying the residential base profiles by the number of units in one single-family attached unit and by multiplying the residential base profiles by the ratio of square footage of the base unit and actual unit footprints. EIA demonstrates that the former approach overestimates energy consumption in attached units and the latter approach underestimates energy consumption in attached units (Fig. 3), so we employ the average of the two.

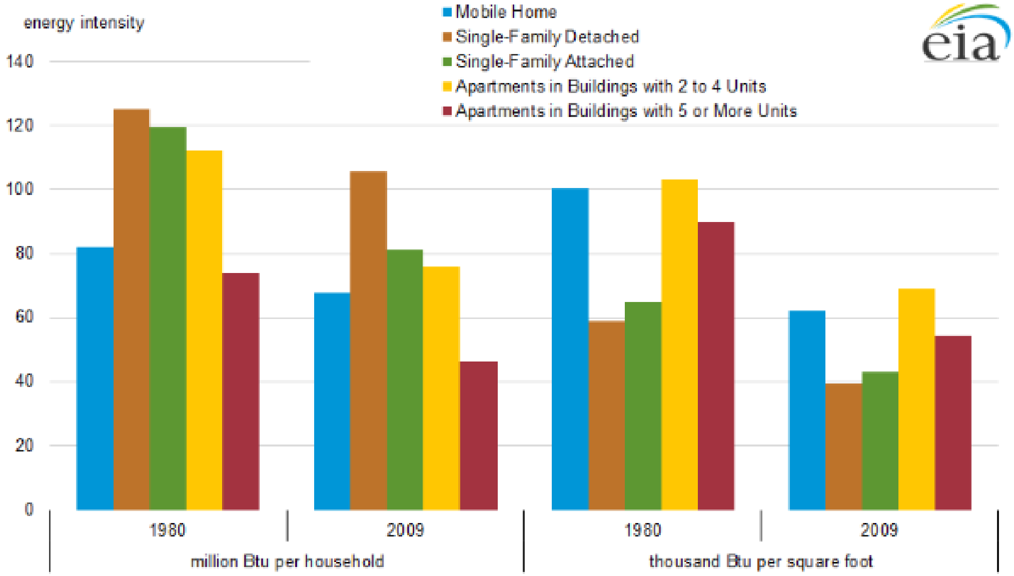


Figure 3: Energy Intensity in 1980 and 2009 by building type (US EIA 2015)

To model low-rise apartment electricity consumption, we assume that energy consumption scales linearly with the number of floors and with building footprint area. We multiply the mid-rise energy consumption profile by the ratio of floors in the low-rise to floors in the mid-rise (0.5) and multiply it again by the ratio of the low-rise footprint area to mid-rise footprint area (0.2026).

Hourly Energy Generation Profiles

We employ the Folsom Labs Helioscope solar design software for modeling hourly solar energy generation capacity. Helioscope models solar system performance by incorporating all factors which affect solar array performance into its analyses. HelioScope documentation lists the means by which the software processes inputs into generation profiles (Gibbs, 2012).

Demand vs Solar Comparison

We compare the energy demand and generation profiles against one another using the Energy Toolbase platform (Energy Toolbase, 2016). Energy Toolbase allows for the demand profiles to be modeled with the rate schedules of SRP to derive accurate costs comparisons between the pre- and post-solar energy bills. SRP suggests using the E-21 Residential Super Peak Time of Use rate schedule to model the pre-solar bills for the Single Family Detached and attached units. We employ the E-27 Customer Generation Price Plan for Residential rate schedule is used to model post-solar bills. The E-27 rate schedule allows for net metering and also applies a demand charge to the customer, both aspects of which are not included in the E-21 rate structure. We model low-rise apartment bills on the E-36 Standard General Service rate schedule for both pre- and post-solar profiles. This rate schedule has a demand charge and does not utilize net metering, buying back any excess energy at a fixed price around $0.02/kWh. These rate schedules are available in Appendix C. Energy Toolbase also permits the user to model the integration of a battery storage system and automatically develops the best charge and discharge times to maximize savings based on the rate schedule and demand of the profile being examined. For each system, Tesla Powerwalls were added to compare cost and net demand differences between solar and solar + storage systems.

Results

The annual solar generation reports for this project are shown in Appendix A. Accounting for the net metering policies of SRP, all three residential systems and, the low rise apartment are capable of offsetting 100% of their energy usage. The single-family attached were capable of offsetting 88% of the energy they used. The Energy Toolbase reports in Appendix B show the monthly offsets as well as the pre- and post-solar installation bills for the residents of the neighborhood. Figure 4 displays the total neighborhood generation and demand curves for June 21st based on the models discussed previously. June 21st was used in order to model the longest day of the year. In this figure, the net demand is the energy being provided or sent back to SRP.

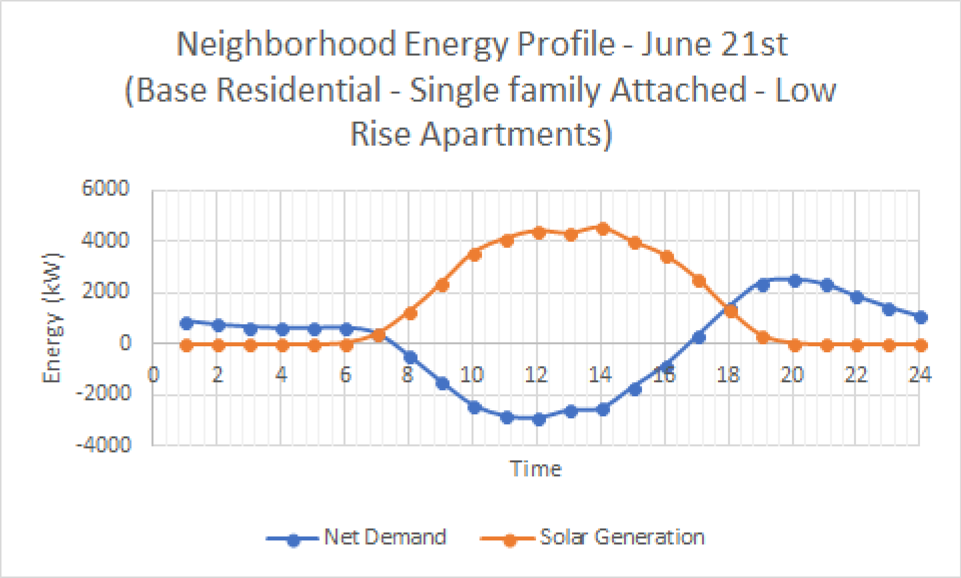


Figure 4: Neighborhood Energy Profile - Solar

Appendix E contains the breakdown of demand and solar generation for all three building styles. The residential housing units are modeled for the low, base, and high demand conditions. Appendix E also contains aggregated graphs which include the whole neighborhoods demand and solar generation broken down by building type and demand profile used. The graphs in Appendix F include the demand, not the net demand as shown in the figure above. Demand entails energy consumption per household, while net demand involves the difference between energy consumption and solar generation per household.

The final graphs in Appendix E display the solar generation offset capabilities with Tesla Powerwall systems. Fig. 5 displays the neighborhood energy profile with battery storage on June 21st.

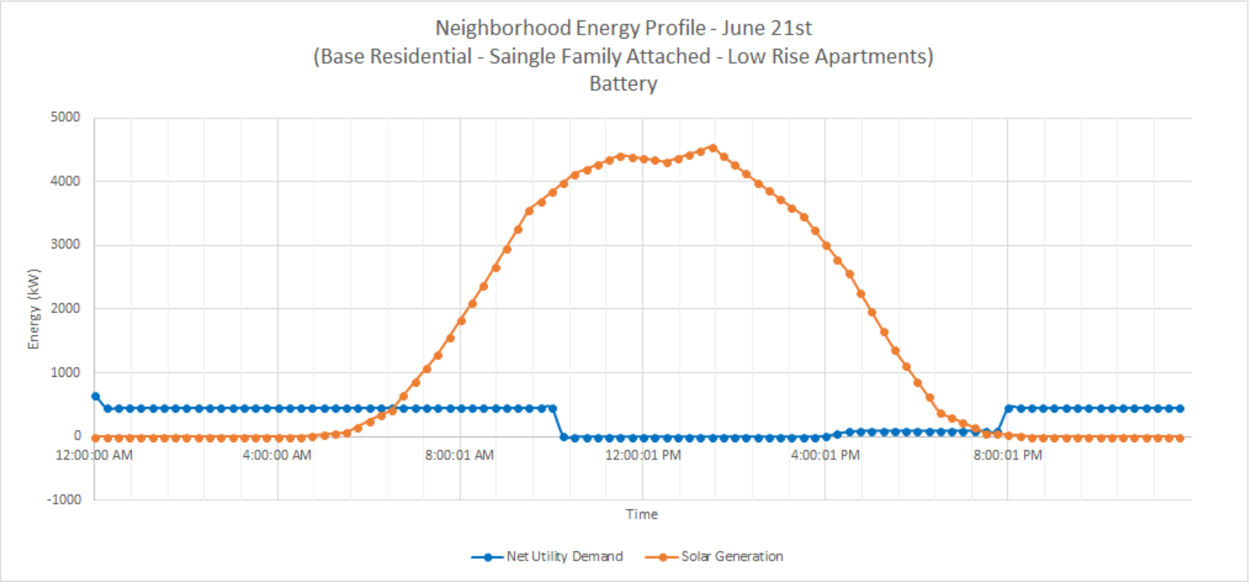
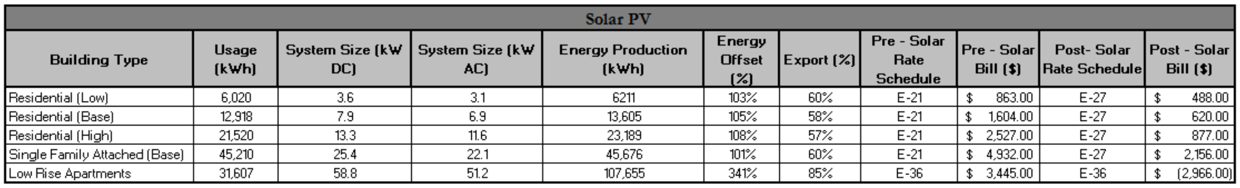


Figure 5: Neighborhood Energy Profile - Solar + Storage

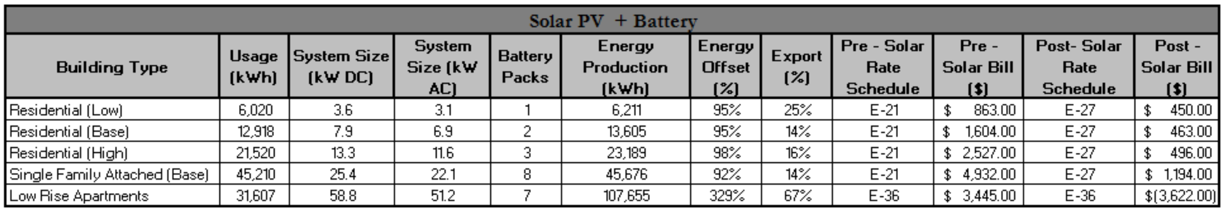
The two neighborhood energy profiles show the reduced strain on SRP when battery systems are incorporated. The net demand profile for the battery system only has a relatively flat curve with two small slopes, while the solar only system takes on a profile with large slopes to go along with a high peak and low valley. Table 1 below provides the final summary of the solar only system and Table 2 contains the summary for the solar + storage systems.

Table 1: Solar System Specs and Results



Solar PV										
Building Type	**Usage (kWh)**	**System Size (kW DC)**	**System Size (kW AC)**	**Energy Production (kWh)**	**Energy Offset (%)**	**Export (%)**	**Pre - Solar Rate Schedule**	**Pre - Solar Bill ($)**	**Post- Solar Rate Schedule**	**Post - Solar Bill ($)**
Residential (Low)	6,020	3.6	3.1	6211	103%	60%	E-21	$ 863.00	E-27	$ 488.00
Residential (Base)	12,918	7.9	6.9	13,605	105%	58%	E-21	$ 1,604.00	E-27	$ 620.00
Residential (High)	21,520	13.3	11.6	23,189	108%	57%	E-21	$ 2,527.00	E-27	$ 877.00
Single Family Attached (Base)	45,210	25.4	22.1	45,676	101%	60%	E-21	$ 4,932.00	E-27	$ 2,156.00
Low Rise Apartments	31,607	58.8	51.2	107,655	341%	85%	E-36	$ 3,445.00	E-36	$ (2,966.00)

Table 2: Solar + Storage System Specs and Results



Solar PV + Battery											
Building Type	**Usage (kWh)**	**System Size (kW DC)**	**System Size (kW AC)**	**Battery Packs**	**Energy Production (kWh)**	**Energy Offset (%)**	**Export (%)**	**Pre - Solar Rate Schedule**	**Pre - Solar Bill ($)**	**Post- Solar Rate Schedule**	**Post - Solar Bill ($)**
Residential (Low)	6,020	3.6	3.1	1	6,211	95%	25%	E-21	$ 863.00	E-27	$ 450.00
Residential (Base)	12,918	7.9	6.9	2	13,605	95%	14%	E-21	$ 1,604.00	E-27	$ 463.00
Residential (High)	21,520	13.3	11.6	3	23,189	98%	16%	E-21	$ 2,527.00	E-27	$ 496.00
Single Family Attached (Base)	45,210	25.4	22.1	8	45,676	92%	14%	E-21	$ 4,932.00	E-27	$ 1,194.00
Low Rise Apartments	31,607	58.8	51.2	7	107,655	329%	67%	E-36	$ 3,445.00	E-36	$(3,622.00)

Part II: Literature Review and Implementation Strategies

Smart Grid

Overview

Arizona is one of the sunniest states in America and can harness huge energy resources by taking advantage of the sun via rooftop solar photovoltaic installations. Arizona's path to solar has been rough due to utilities working against decentralized residential solar by implementing a net metering charge in 2014 and eliminating incentives. Even through it all, residents are still pursuing rooftop solar for their homes due to a price drop of solar technology and manufacturing of home batteries such as Tesla's Powerwall. These technologies will benefit not only residents but also the utilities in the face of more frequent and intense heat waves in Phoenix.

Upgrades to our grid system are needed to handle all the decentralized rooftop solar power being sent back onto the grid. In South Mountain Village, SRP manages the distribution of electricity. SRP is a public utility that is not governed by the Arizona Corporation Commission (ACC), which regulates the rates and services of Arizona's public utilities. This allows SRP to implement innovative technologies more quickly than utilities governed by the ACC. As a political subdivision of the State, SRP is not subject to ACC approval for its investments and need not submit regulatory filings nor demonstrate immediate benefits from smart grid infrastructure (Stern & Jones, 2012). SRP understands that residential solar is becoming more common despite initial roadblocks and is providing their customers the resources to install solar while upgrading their grid to manage the new energy inputs to their network.

SRP is an integrated utility with ownership interests in generation as well as being responsible for transmission and distribution services (SRP, 2006). SRP has 8,452 MW available to serve peak demand, and reported annual total sales of 34, 257 GWh in 2017 (SRP *Facts about SRP*, 2018). SRP has full or partial ownership interest in natural gas and coal-fired plants, one nuclear facility, and 838 MW of renewable power (SRP *Facts about SRP*, 2018). Hydro facilities compose 45% of SRP's renewable resources, or 382 MW (SRP *Facts about SRP*, 2018). SRP also owns over 1,500 miles of transmission lines and 1,400 miles of fiber optic lines (SmartGridNews, 2011). SRP recognizes that improving efficiencies in its systems through smart grid technologies can help lower costs and improve reliability while continuing to meet the modern energy challenges of a rapidly growing metropolitan area (Stern & Jones, 2012).

Smart grids grant utilities the control over their power infrastructure necessary to provide customers with reliable and affordable energy. Smart grid technologies empower communication between the utility and their customers and between customers and their energy-consuming appliances. Smart grid enabled utilities focus on the transmission and distribution of energy to the smart meter at the customer's residence, while customers manage their home's controls and appliances. The innovation behind smart grids is the digital technology that provides the two-way communications so that distributed solar can connect to the grid without disturbing it. Figure 6 below demonstrates the components and connections incorporated into a smart grid system.

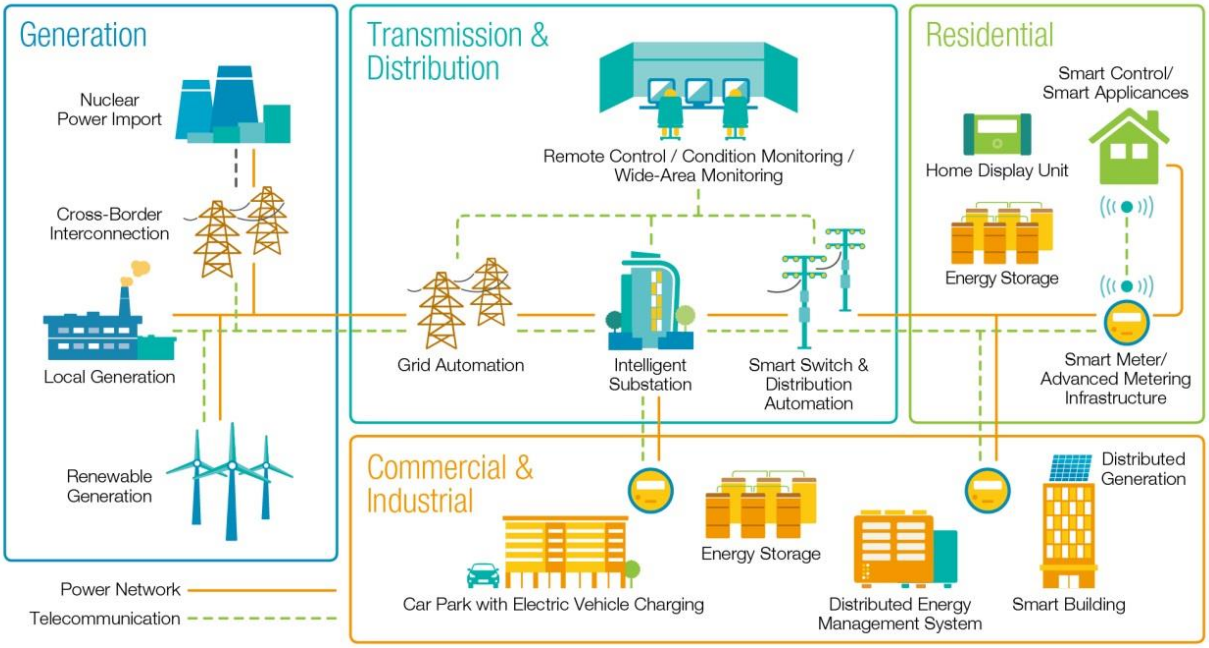


Figure 6: A smart grid network (CLP Group. 2016)

The US federal government has imparted additional momentum to this technological evolution by making a smart electric grid a central component of the US clean energy agenda and awarding $3.4 billion in smart grid investment grants to utilities and other entities via the American Recovery and Reinvestment Act (Stern & Jones, 2012). Salt River Project received a $56.9 million grant to invest in a smart meter network, which SRP has used to deploy a smart grid infrastructure backbone for their power system.

The Energy Independence and Security Act of 2007 established new standards under Section 111(d) of the Public Utilities Regulatory Policy Act (PURPA) (Stern & Jones, 2012). One of those new PURPA standards requires utilities to consider investments in smart grid systems based on cost-effectiveness, improved reliability, security, system performance, and societal benefits (16 U.S.C. § 2621(d) (2010)). In doing so, SRP is focused on building out the backbone of a smart grid system to support all components of the grid and ensure interoperability with future technologies (Stern & Jones, 2012).

SRP’s smart grid implementation goals have been focused on three key components. The first is to upgrade the communication system at the transmission level. The second goal is to implement information technology that connects to their operation technology to create unified communication infrastructure to govern all components of the grid. Lastly, a major goal moving into the 21st Century is to implement smart grid cyber security to minimize vulnerabilities of the data and communication technologies embedded into the grid.

Components

Sensors

Sensor devices monitor electrical frameworks and equipment states such as current, voltage, transformers and other grid components. Sensors that are connected through communication networks allow for the data on how the system is working to get to a central control facility.

Communications

Two way communication systems are vital components for Smart grids. This allows for information to get from the field devices to the a central control facility. Fiber optic networks and wireless transmitters are being integrated to allow for the two way communication to happen.

Analytical Software

Analytic software applications collect data from all the field devices and allows a utility operator to oversee all functions of the grid. New enterprise application integration has been a key investment for utilities to allow for better management of their system.

Implementation

In the early 1990's, SRP deployed the M-Power program - a pre-pay service where customers can access information from an in-home display unit, monitor spending, and pay for energy via smaller transactions. Customers enrolled in M-Power have more control of their electric consumption and have reduced their usage by an average of 12% (Stern & Jones, 2012). SRP customers have given the M-Power program an 89% approval rating and report wiser energy usage. SRP installed almost 100% of their substations with fiber optics to provide for low-latency monitoring and management of the units. The company also installed smart meters in 2013. SRP worked closely with the Electric Power Research Institute (EPRI) to create a Smart Grid Roadmap entailing seven key initiatives in 2008 that include the following (Nowaczyk *SRP Smart Grid Roadmap Validation Review*, 2009):

1. Improve existing Cyber Security strategies
2. Implement automated tools for WAN Monitoring
3. Create and deploy an Integrated Substation LAN strategy
4. Utilize a single Unified Communications infrastructure for field devices
5. Expand the deployment of Distribution Feeder Automation
6. Deploy an Electrical System Data Acquisition and Management for automation and analysis
7. Implement an integration bus for secure Enterprise Application Integration between applications and databases

EPRI, an independent non-profit organization, conducts research on the US power system and works closely with utilities to implement sustainable innovations in their systems. SRP is an original investor and participant of EPRI's Intelligrid program (Smart Grid Newsletter, 2006), a collaborating utility in the Smart Grid Demonstration Initiative (EPRI, 2010), and a participant in the Green Circuits Initiative (EPRI *Green Circuits Initiative*, 2010). SRP's "Smart Grid Vision" is to develop "a power delivery infrastructure that enables practical integration of advances in communications, computing, and electronics to optimize system reliability, contain costs, and accommodate the delivery of services to meet the future needs of [SRP] customers" (SRP Smart Grid Roadmap, 2009). SRP's "Mission Statement" is to "plan and deploy a well coordinated, interoperable, cost-effective corporate infrastructure that will enable the development, integration and application of new technologies throughout SRP that provide secure, high-quality, cost-effective, reliable services both internally and externally" (Nowaczyk *SRP Smart Grid Implementation*, 2009).

Cybersecurity

The goal of SRP's cyber security initiative is to develop secure infrastructure spanning from technology platforms to policies, procedures and employee culture to meet information requirements in a secure manner (Stern & Jones, 2012). SRP understands that a comprehensive enterprise-wide cybersecurity implementation will be difficult and take years to fully develop (Stern & Jones, 2016). The model covers risk management, standards compliance, incident management, and security operations (SRP *Smart Grid Roadmap*, 2009). In addition to compliance with NERC Critical Infrastructure Protection standards ("CIP"), SRP's enterprise cybersecurity plan is modeled after two National Institute of Standards and Technology (NIST) standards (Stern & Jones, 2012): NIST 800-37, Guide for applying the risk management framework to federal information systems assisted the development of preventative security protocols (Stern & Jones, 2012), and NIST 800-53, Recommended security controls for federal information systems and organizations guided SRP in developing its enterprise security control framework (SRP, National Science and Technology Council Subcommittee on Smart Grid, 2010).

Unified Communications

Unified communications across all levels of the grid and its various systems will allow the Smart Grid to coordinate operations more efficiently than at present. One potential goal is to connect advanced metering infrastructure (AMI) with distribution feeder automation (DFA) infrastructure (Stern & Jones, 2012). The integration of AMI and DFA would improve outage management by allowing individual customer data from smart meters to alert system operators to faults or voltage problems in the distribution system and would link automated system responses to pinpoint outage locations and reroute power for more efficient repair crew deployment and reduced restoration time (Stern & Jones, 2012). SCADA upgrades, intelligent distribution devices, and AMI/DFA architecture are needed to develop this unified system (SRP, *Smart Grid Roadmap*, 2009). An Enterprise Application Integration in which all data is connected to all SRP's office departments will allow for a better-managed system overall. Furthermore, a collaboration between departments will prove critical to the maximization of return on investments (SRP Smart Grid Roadmap, 2009).

Benefits

Implementing smart grid technologies into the existing grid provide benefits for the utility customers, utilities, and the environment. Customers will be able to improve their energy use by having more control over their home appliances and devices, while also being able to integrate rooftop solar. With Smart Grid upgrades, utilities will be able to improve their operations through their ability to oversee all components of the grid and react more quickly to disturbances. The number of outages and length of outages will be reduced through the ability to sense where the problems are occuring along the grid. This will provide an overall improved consumer experience. Lastly, smart grids will reduce carbon emissions by allowing the integration of distributed renewable energy generation and reducing the dependency from fossil fuel power plants.

Challenges

Electrical grids represent complex systems. Smart grid technology entails an increase in interaction between components of the grid and therefore increases complexity. SRP has encountered several challenges in reforming its infrastructure that it must overcome to enable full communication and control over the network.

SRP is having difficulty connecting communications with the “last mile” of its distribution system and linking the AMI system with the DFA system (Stern & Jones, 2012). The two systems use disparate communication technology with incompatible latencies and capacities. The establishment of connections between the two systems is not feasible with the infrastructure in place today (Stern & Jones, 2012). SRP predicts that initial linkages between AMI and DFA systems are a minimum of five years away, and will need to determine that carrying out the linkage of the AMI and DFA systems is in the best interest of SRP and its customers (Stern & Jones, 2012).

SRP ranks the Enterprise Application Integration initiative as the most difficult endeavor in its smart grid implementation plan (Stern & Jones, 2012). Despite the difficulty, SRP expects to realize vast improvements in operations efficiency by executing the initiative. This will be a massive IT project that entails linking the data regarding all grid levels and assets to all of SRP's office departments.

SRP struggles to identify a communications technology that will enable secure and reliable connections at an efficient cost (Stern & Jones, 2012). Cybersecurity will be very important moving forward to protect assets and consumer privacy. In today's world, it is getting harder to provide these services and this is where SRP is struggling to implement the right cybersecurity measures.

Final Smart Grid Thoughts

SRP has been successful in a wide range of smart grid deployment via advanced planning and policy support, a successful partnership with EPRI, and a holistic approach to smart grid technology integration (Stern & Jones, 2012). SRP's smart meters had no cost burden onto their customers; the benefits have exceeded the costs of smart meter procurement and installation. Due to the implementation of the smart meters, as of March 2011, SRP has remotely addressed over 1.2 million service orders, saved over 401,000 labor hours, avoided 2.0 million driving miles, and conserved 198,000 gallons of fuel (Stern & Jones, 2012). SRP understands that smart metering implementation is not the last step in transforming the existing grid to a Smart state. The companies Smart Grid Roadmap goes to show that they have a plan of moving forward integrating Smart Grid technologies into the future to allow for the grid to become more resilient, secure, and cost-effective. SRP's longtime experience and leadership on voluntary time of use rates, which it has further leveraged with smart meter technology, offers promise that voluntary, opt-in approaches to dynamic pricing can be successful with good program design and strong credibility with your customers (Stern & Jones, 2012). Customers approve of SRP's M-Power prepay program which demonstrates that giving customers both current feedback on their electrical usage and the ability to control that usage through appropriate technology can lead to significant reductions in electrical usage and highly satisfied customers (Stern & Jones, 2012).

Microgrid

Definition

A microgrid is a discrete energy system including distributed energy sources and loads which can operate in parallel with or independently from the main power grid. To some extent, microgrids mirror conventional power grids on a smaller scale. Like electrical grids, they consist of power generation, distribution, and controls. Microgrids differ from traditional grids by shortening distance between power generation and power consumption, which results in increased efficiencies and reducing transmission losses. Microgrids can connect and disconnect from existing grid through energy management systems and also buy and sell back to the grid as needed. Microgrids can also integrate renewable energy sources such as solar, wind power, and geothermal system with fewer disruptions to the overall system than can conventional power grids.

Components

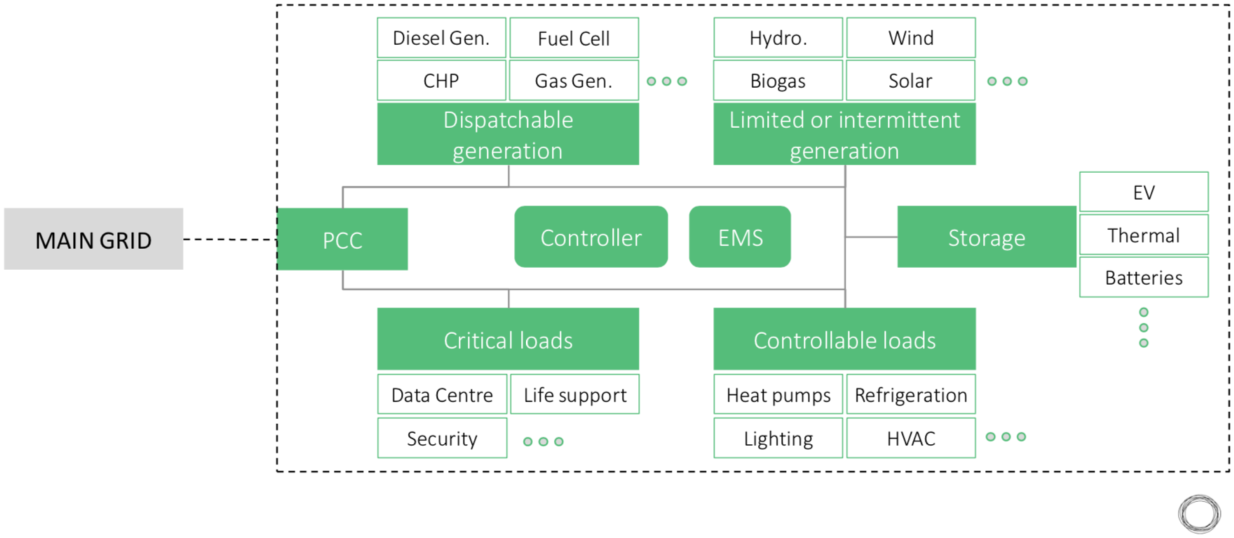


Figure 7: General representation of a on-grid (grid connected) microgrid (ENEA, 2017)

Generation

Microgrids require a main source of generation to supply energy to its connected loads without the help of the main grid. Auxiliary sources may serve as backup energy generation sources. Resilient generation configurations may entail a combination of diverse energy sources such as solar PV, wind and combustion turbines. Considerations in the selection of generation include the level of available time requirement, the desire for renewable forms of energy, availability of fuel, storage capabilities, and facility cost.

Storage

Along with generation systems, microgrids require energy storage. This component allows the microgrid to save energy that is produced when supply exceeds demand and to distribute that energy when demand exceeds supply. For example, batteries in a solar photovoltaic system store energy during off-peak daylight hours and release the energy back to the microgrid during peak usage in the evening hours. Energy storage can facilitate arbitrage opportunities where wholesale power markets exist or when time-based rate schedules such as real-time pricing and critical peak pricing are available.

Loads

Critical loads have to be served under all conditions, while deferrable loads can be adjusted for microgrid load balancing or for economic reasons.

Controller

In charge of the instantaneous operation of the system. It translates the energy demands of the microgrid and the EMS arbitrage into sequences of operation to the microgrid assets that allows the generation and storage resources to be optimized. For example, non-critical loads like lighting, or HVAC can be turned down to ensure energy flow to critical loads such as computer servers and life-support equipment, especially during times when variable renewable generators are not available. As with batteries, load control can also promote arbitrage opportunities in power markets and where time - of -use rates are available.

Energy Management System

The energy management system (EMS) maintains the real-time balance of generation and load. In a complex microgrid, the management system is made up of sophisticated software platforms, smart sensors, and metering designed for real-time optimization and control of the generators, energy storage, and loads.

Point of Common Coupling

The Point of Common Coupling (PCC) is the transformer that represents the physical separation between main grid and microgrid. During interconnected operation, the PCC must be designed for reliable parallel operation of the microgrid and the main grid. In an islanded mode, the interconnection must also allow for the smooth synchronization of the microgrid and the main grid.

Benefits

Microgrids can bring many benefits to end users such as:

Provide power quality, reliability, and security for end users and operators of the grid. The network reliability is evaluated on the probability of the islanding mode and the influences of the storage systems on the power availability (Borges, 2011). During natural disasters or risk multiplying disturbances outages may occur to the existing grid and could cause an increased risk of morbidity of the population affected. Microgrids can be an emergency back up system to keep electricity flowing to critical infrastructure like hospitals, grocery stores, gas stations, shelters, and hopefully resident’s homes to reduce the risk of morbidity.

Enhance the integration of renewable energy sources. This helps to reduce the life-cycle cost and minimize carbon footprint and greenhouse gas emissions of current fossil fuel generation. In regards to environmental stewardship, the branding value of private owners is eco-friendly orientation.

Minimize costs by prioritizing different energy sources based on various criteria. For example, the system might prioritize solar and wind supply during the day when the availability of those two resources and the overall energy demand from the grid are high. At night, it would then pull power from the grid, when demand is low and renewable generation is minimal. More savings can be gained in a battery-integrated microgrid in which the storage draws low-cost power from the grid at night to store and release during peak demand periods.

Challenges

Value of Resilience

Resilience means that the system needs to be designed to protect residents under low probability and high consequence events such as natural disasters and cyber/ physical attacks. However, South Mountain Village has a low Built Environment Vulnerability Index (Borden, Kevin A., et al. 2007) due to its low urban density which means a very low probability of high impact events. Since a microgrid system provides disaster resilience, and reliability for its community, the employment of microgrid for this community can be seen as a redundancy.

Resilience considers the likelihood of threats to a system. Cost-benefit analyses that utilize dollars as a numeraire must quantify the value of human health and system integrity and multiply these values by the probability that catastrophic events occur. Imparting monetary value to human life entails ethical concerns for which our society has yet to establish a suitable paradigm. Determinations of risk that are couched in historical occurrences no longer prove sufficient in the Anthropocene (Chester & Allenby, 2018). Quantification of the value of a microgrid which incorporates resilience thus proves untenable.

Regulation

Authorities need to upgrade their regulation to cover microgrid features such as a small-scale system, user rights, and rating system. The existing regulatory framework cannot be applied to the size of microgrids particularly; for example, the lack of franchise rights and administrative obligations (ENEA, 2017). Ensuring the rights of end users to choose suppliers or transparent tariffs is often stated as complex for small-scale networks and can, therefore, lead to disputes. Grid fees such as basic service charge components per day in APS and SRP rate schedules no longer represent the actual costs of the network which mainly covers users with high self-consumption levels.

Finance

Limited financial incentives and a lack of specific regulations have hampered the growth of microgrid in South Mountain Village.

Table 3: Renewable Energy Incentives in the US (Amjad, 2017)

State	FIT	Net Metering	Personal Tax	Corporate Tax	Sales Tax	Property Tax	Rebates	Grants	Loan	Bonds	Performance Base Incentives
Alabama	x	x	✓	x	x	x	✓	x	✓	x	✓
Alaska	x	✓	x	x	x	✓	x	✓	✓	x	✓
Arizona	x	✓	✓	✓	✓	✓	✓	x	✓	x	x
Arkansas	x	✓	x	x	x	x	✓	x	✓	x	x
California	✓	✓	x	x	✓	✓	✓	x	✓	x	✓
Colorado	x	✓	x	x	✓	✓	✓	✓	✓	x	✓
Connecticut	x	✓	x	x	✓	✓	✓	✓	✓	x	✓
Delaware	x	✓	x	x	x	x	✓	x	✓	x	✓
Florida	✓	✓	x	✓	✓	✓	✓	x	✓	x	✓
Georgia	x	✓	x	x	✓	x	✓	✓	✓	x	✓

An overview of renewable energy incentive in Arizona is shown in Table 3. Although one-time credits for new renewable energy installation have applied, performance-based incentives during its life cycle stimulating the growth of the size of the microgrid is not available in Arizona. SRP's E-27 Customer Generation Price Plan reduces the energy charge on this plan about half the rate of the their standard residential price plan. This plan also allows for the buyback of excess energy at the retail price during its generation. For SRP's E-36 Standard Price Plan for General Service payback for any excess solar generation is only 2 cents per kWh.

Technical

Islanding is a complex process that raises technical challenges. For example, protection of electrical assets might be an issue which should then be ensured by advanced equipment. Then to reduce controller prices, an engineer might limit case-by-case customization (ENEA, 2017). These controllers imply that an engineer will reduce the flexibility of the microgrid in order to reduce its complexity.

Final Recommendations

Within part I of this report we analyze the typical energy profiles for common buildings in the South Mountain Village region and determine the potential for solar photovoltaic generation on top of said structures. We identify the potential to reduce strain on the existing grid and to flatten peak demand by simulating the installation of rooftop solar and battery storage in residential zones. We also determine the potential for generating surplus energy which communities may sell to the existing grid.

Part II of this report our team researches how SRP will implement smart grid technologies into their existing grid network to allow for distributed solar to be feasible, improved management of the transmission and distribution system, and an overall better consumer experience for the South Mountain Village. SRP is at the forefront of Smart Grid implementations and has a Smart Grid Roadmap to guide them to a total Smart Grid system. Next, our focus was on if microgrid technology would be feasible for the South Mountain Village at this time. Due to regulatory, the value of resiliency, and upfront costs of implementing microgrids in Phoenix doesn't make this an effective resiliency strategy at this time, but maybe once microgrid technology matures at the national level through more Department of Energy (DOE) investment of demonstration projects.

The recommendation is to utilize the vast amounts of solar potential throughout South Mountain Village by allowing neighborhoods to produce their own power via rooftop solar photovoltaic installation, to sell surplus power back to the grid, and to develop a parallel autonomous microgrid that permits energy provision in the event of a system-wide failure. While solar only systems are beneficial, solar + storage systems should be recommended to residents to decrease grid export and increase savings. Smart grid technology is a crucial implementation of SRP's existing grid system and will improve management on the utility side of the smart meter while creating an overall better consumer experience.

Low - Residential (South) Eric - Urban Infrastructure, Tempe Az

Report

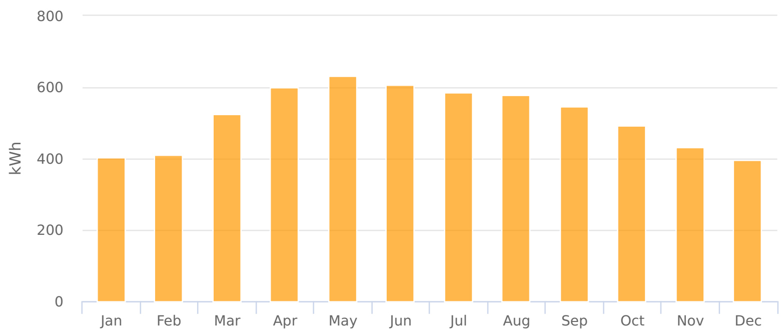
Project Name	Eric - Urban Infrastructure
Project Address	Tempe Az
Prepared By	

System Metrics

Design	Low - Residential (South)
Module DC Nameplate	3.60 kW
Inverter AC Nameplate	3.00 kW Load Ratio: 1.20
Annual Production	6.211 MWh
Performance Ratio	73.8%
kWh/kWp	1,725.2
Weather Dataset	TMY, PHOENIX SKY HARBOR INTL AP, NSRDB (tmy3, I)
Simulator Version	1d80ad2d41-f3b7fc5dab-e2be6f71b1-f933a7f880

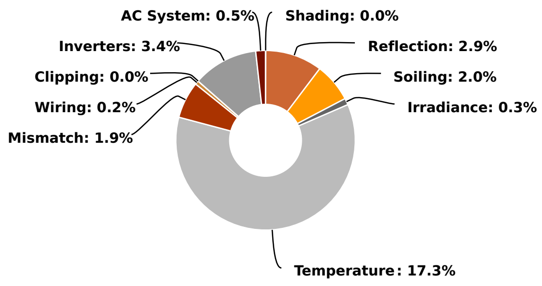
Project Location

Monthly Production



Month	GHI (kWh/m^2)	POA (kWh/m^2)	Shaded (kWh/m^2)	Nameplate (kWh)	Grid (kWh)
January	101.9	140.4	140.4	478.9	404.3
February	116.5	146.9	146.9	502.6	412.1
March	165.4	190.2	190.2	652.0	523.5
April	212.6	225.7	225.7	774.9	599.6
May	243.2	241.6	241.6	828.0	630.6
June	249.5	241.5	241.5	827.7	606.5
July	236.1	233.1	233.1	799.7	586.7
August	220.9	229.3	229.3	786.0	579.5
September	190.2	213.3	213.3	732.6	546.2
October	149.5	184.6	184.5	632.3	491.9
November	113.2	154.7	154.5	527.6	433.2
December	95.2	136.6	136.6	465.4	396.7

Sources of System Loss



Annual Production Report

Annual Production

	Description	Output	% Delta
Irradiance (kWh/m²)	Annual Global Horizontal Irradiance	2,094.2	
	POA Irradiance	2,337.8	11.6%
	Shaded Irradiance	2,337.5	0.0%
	Irradiance after Reflection	2,268.8	-2.9%
	Irradiance after Soiling	2,223.4	-2.0%
	Total Collector Irradiance	**2,223.4**	**0.0%**
Energy (kWh)	Nameplate	8,007.7	
	Output at Irradiance Levels	7,980.8	-0.3%
	Output at Cell Temperature Derate	6,597.5	-17.3%
	Output After Mismatch	6,472.3	-1.9%
	Optimal DC Output	6,459.5	-0.2%
	Constrained DC Output	6,459.4	0.0%
	Inverter Output	6,242.0	-3.4%
	Energy to Grid	**6,210.8**	**-0.5%**

Temperature Metrics

Avg. Operating Ambient Temp	27.0 °C
Avg. Operating Cell Temp	52.1 °C

Simulation Metrics

Operating Hours	4607
Solved Hours	4607

Condition Set

Description	Condition Set 1
Weather Dataset	TMY, PHOENIX SKY HARBOR INTL AP, NSRDB (tmy3, I)
Solar Angle Location	Meteo Lat/Lng
Transposition Model	Perez Model
Temperature Model	Sandia Model

Temperature Model Parameters

Rack Type	a	b	Temperature Delta
Fixed Tilt	-3.56	-0.075	3°C
Flush Mount	-2.81	-0.0455	0°C

Soiling (%)

J	F	M	A	M	J	J	A	S	O	N	D
2	2	2	2	2	2	2	2	2	2	2	2

Irradiation Variance	5%
Cell Temperature Spread	4° C
Module Binning Range	-2.5% to 2.5%
AC System Derate	0.50%

Module Characterizations

Module	Characterization
HiS-S360RI (Hyundai)	CFV_HiS-S360RI_R2_V6.PAN, PAN

Component Characterizations

Device	Characterization
Sunny Boy SB 3000TLUS-12 (240V AC) (SMA)	Default Characterization

Components

Component	Name	Count
Inverters	Sunny Boy SB 3000TLUS-12 (240V AC) (SMA)	1 (3.00 kW)
Strings	10 AWG (Copper)	1 (38.0 ft)
Module	Hyundai, HiS-S360RI (360W)	10 (3.60 kW)

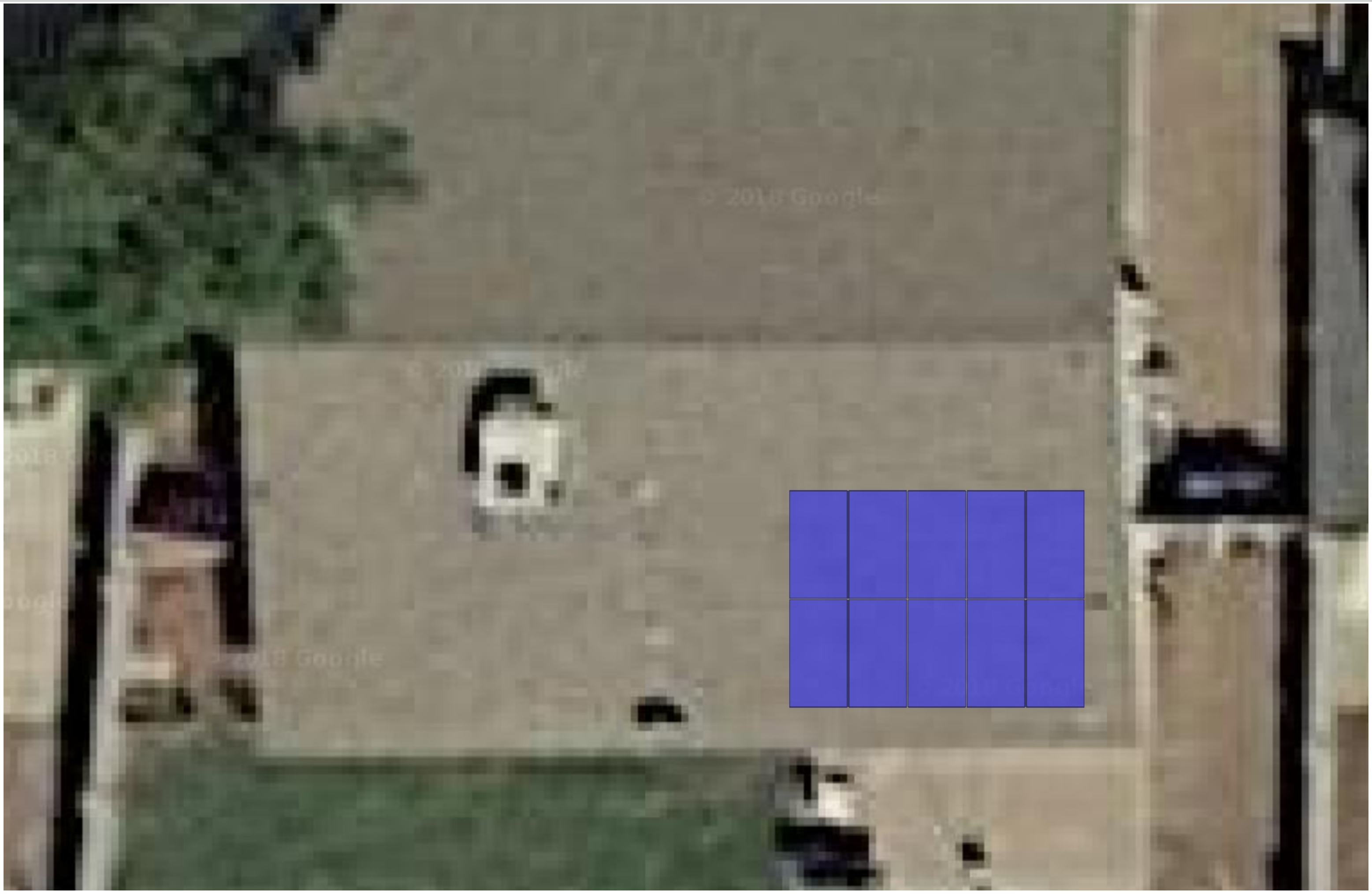
Wiring Zones

Description	Combiner Poles	String Size	Stringing Strategy
Wiring Zone	12	5-11	Along Racking

Field Segments

Description	Racking	Orientation	Tilt	Azimuth	Intrarow Spacing	Frame Size	Frames	Modules	Power
Field Segment 1	Flush Mount	Portrait (Vertical)	18.4°	180°	0.1 ft	2x1	5	10	3.60 kW

Detailed Layout



Annual Production Report

Base- Residential (South) Eric - Urban Infrastructure, Tempe Az

Report

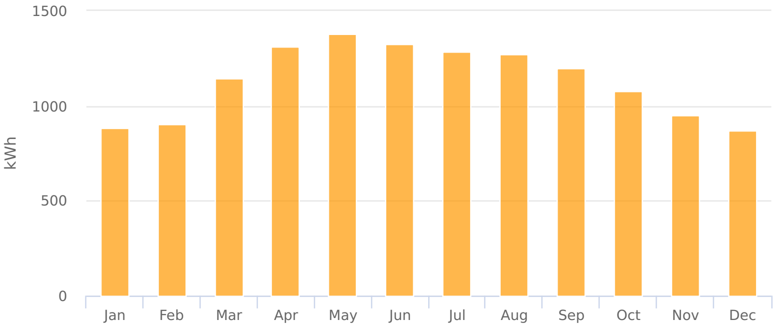
Project Name	Eric - Urban Infrastructure
Project Address	Tempe Az
Prepared By	

System Metrics

Design	Base- Residential (South)
Module DC Nameplate	7.92 kW
Inverter AC Nameplate	7.00 kW Load Ratio: 1.13
Annual Production	13.60 MWh
Performance Ratio	73.5%
kWh/kWp	1,717.7
Weather Dataset	TMY, PHOENIX SKY HARBOR INTL AP, NSRDB (tmy3, I)
Simulator Version	1d80ad2d41-f3b7fc5dab-e2be6f71b1-f933a7f880

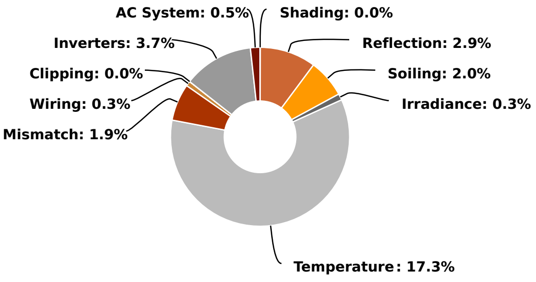
Project Location

Monthly Production



Month	GHI (kWh/m^2)	POA (kWh/m^2)	Shaded (kWh/m^2)	Nameplate (kWh)	Grid (kWh)
January	101.9	140.4	140.4	1,053.4	886.6
February	116.5	146.9	146.9	1,105.6	903.4
March	165.4	190.2	190.2	1,434.0	1,146.4
April	212.6	225.7	225.7	1,704.4	1,311.9
May	243.2	241.6	241.6	1,821.2	1,380.5
June	249.5	241.5	241.5	1,820.6	1,328.6
July	236.1	233.1	233.1	1,759.0	1,284.3
August	220.9	229.3	229.3	1,729.0	1,269.7
September	190.2	213.3	213.3	1,611.4	1,196.5
October	149.5	184.6	184.5	1,390.9	1,077.6
November	113.2	154.7	154.5	1,160.6	949.5
December	95.2	136.6	136.6	1,023.6	869.0

Sources of System Loss



A4

Annual Production

	Description	Output	% Delta
Irradiance (kWh/m^2)	Annual Global Horizontal Irradiance	2,094.2	
	POA Irradiance	2,337.8	11.6%
	Shaded Irradiance	2,337.5	0.0%
	Irradiance after Reflection	2,268.8	-2.9%
	Irradiance after Soiling	2,223.4	-2.0%
	Total Collector Irradiance	**2,223.4**	**0.0%**
Energy (kWh)	Nameplate	17,613.9	
	Output at Irradiance Levels	17,555.1	-0.3%
	Output at Cell Temperature Derate	14,513.1	-17.3%
	Output After Mismatch	14,231.0	-1.9%
	Optimal DC Output	14,194.2	-0.3%
	Constrained DC Output	14,194.2	0.0%
	Inverter Output	13,672.5	-3.7%
	Energy to Grid	**13,604.1**	**-0.5%**
Temperature Metrics			
	Avg. Operating Ambient Temp	27.0 °C	
	Avg. Operating Cell Temp	52.1 °C	
Simulation Metrics			
	Operating Hours	4607	
	Solved Hours	4607	

Condition Set

Description	Condition Set 1
Weather Dataset	TMY, PHOENIX SKY HARBOR INTL AP, NSRDB (tmy3, I)
Solar Angle Location	Meteo Lat/Lng
Transposition Model	Perez Model
Temperature Model	Sandia Model

Temperature Model Parameters

Rack Type	a	b	Temperature Delta
Fixed Tilt	-3.56	-0.075	3°C
Flush Mount	-2.81	-0.0455	0°C

Soiling (%)

J	F	M	A	M	J	J	A	S	O	N	D
2	2	2	2	2	2	2	2	2	2	2	2

Irradiation Variance	5%
Cell Temperature Spread	4° C
Module Binning Range	-2.5% to 2.5%
AC System Derate	0.50%

Module Characterizations

Module	Characterization
HiS-S360RI (Hyundai)	CFV_HiS-S360RI_R2_V6.PAN, PAN

Component Characterizations

Device	Characterization
Sunny Boy SB 7000-US-12 (240V AC) (SMA)	Default Characterization

Components

Component	Name	Count
Inverters	Sunny Boy SB 7000-US-12 (240V AC) (SMA)	1 (7.00 kW)
Strings	10 AWG (Copper)	2 (92.9 ft)
Module	Hyundai, HiS-S360RI (360W)	22 (7.92 kW)

Wiring Zones

Description	Combiner Poles	String Size	Stringing Strategy
Wiring Zone	12	7-11	Along Racking

Field Segments

Description	Racking	Orientation	Tilt	Azimuth	Intrarow Spacing	Frame Size	Frames	Modules	Power
Field Segment 1	Flush Mount	Portrait (Vertical)	18.4°	180°	0.1 ft	2x1	12	22	7.92 kW

Detailed Layout

High - Residential (South) Eric - Urban Infrastructure, Tempe Az

Report

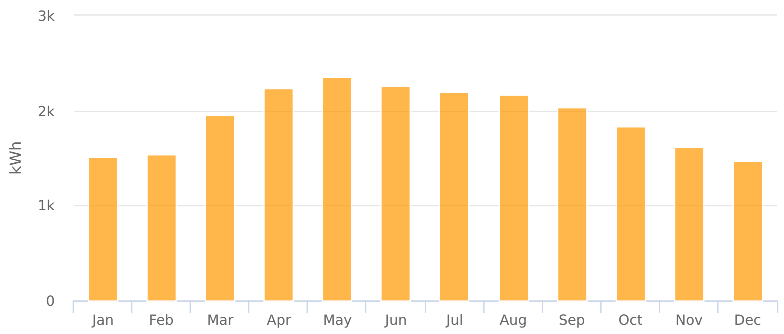
Project Name	Eric - Urban Infrastructure
Project Address	Tempe Az
Prepared By	

System Metrics

Design	High - Residential (South)
Module DC Nameplate	13.3 kW
Inverter AC Nameplate	12.0 kW Load Ratio: 1.11
Annual Production	23.19 MWh
Performance Ratio	74.5%
kWh/kWp	1,740.9
Weather Dataset	TMY, PHOENIX SKY HARBOR INTL AP, NSRDB (tmy3, I)
Simulator Version	1d80ad2d41-f3b7fc5dab-e2be6f71b1-f933a7f880

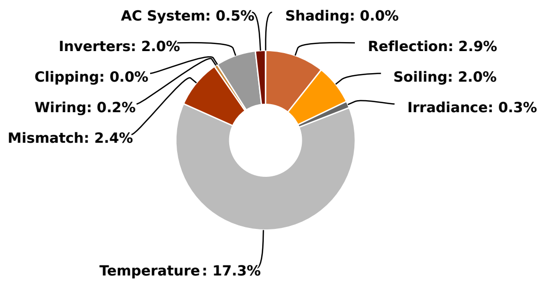
Project Location

Monthly Production



Month	GHI (kWh/m^2)	POA (kWh/m^2)	Shaded (kWh/m^2)	Nameplate (kWh)	Grid (kWh)
January	101.9	140.4	140.4	1,771.6	1,508.1
February	116.5	146.9	146.9	1,859.4	1,537.6
March	165.4	190.2	190.2	2,411.8	1,953.6
April	212.6	225.7	225.7	2,866.5	2,239.7
May	243.2	241.6	241.6	3,063.0	2,355.5
June	249.5	241.5	241.5	3,061.9	2,267.6
July	236.1	233.1	233.1	2,958.3	2,192.2
August	220.9	229.3	229.3	2,907.8	2,164.4
September	190.2	213.3	213.3	2,710.1	2,040.3
October	149.5	184.6	184.5	2,339.2	1,836.2
November	113.2	154.7	154.5	1,951.9	1,615.7
December	95.2	136.6	136.6	1,721.5	1,477.9

Sources of System Loss



Annual Production Report

Annual Production

	Description	Output	% Delta
Irradiance (kWh/m^2)	Annual Global Horizontal Irradiance	2,094.2	
	POA Irradiance	2,337.8	11.6%
	Shaded Irradiance	2,337.5	0.0%
	Irradiance after Reflection	2,268.8	-2.9%
	Irradiance after Soiling	2,223.4	-2.0%
	Total Collector Irradiance	**2,223.4**	**0.0%**
Energy (kWh)	Nameplate	29,623.2	
	Output at Irradiance Levels	29,524.3	-0.3%
	Output at Cell Temperature Derate	24,408.1	-17.3%
	Output After Mismatch	23,820.4	-2.4%
	Optimal DC Output	23,779.6	-0.2%
	Constrained DC Output	23,779.6	0.0%
	Inverter Output	23,305.2	-2.0%
	Energy to Grid	**23,188.7**	**-0.5%**
Temperature Metrics			
	Avg. Operating Ambient Temp		27.0 °C
	Avg. Operating Cell Temp		52.1 °C
Simulation Metrics			
	Operating Hours		4607
	Solved Hours		4607

Condition Set

Description	Condition Set 1
Weather Dataset	TMY, PHOENIX SKY HARBOR INTL AP, NSRDB (tmy3, I)
Solar Angle Location	Meteo Lat/Lng
Transposition Model	Perez Model
Temperature Model	Sandia Model

Temperature Model Parameters

Rack Type	a	b	Temperature Delta
Fixed Tilt	-3.56	-0.075	3°C
Flush Mount	-2.81	-0.0455	0°C

Soiling (%)

J	F	M	A	M	J	J	A	S	O	N	D
2	2	2	2	2	2	2	2	2	2	2	2

Irradiation Variance	5%
Cell Temperature Spread	4° C
Module Binning Range	-2.5% to 2.5%
AC System Derate	0.50%

Module Characterizations

Module	Characterization
HiS-S360RI (Hyundai)	CFV_HiS-S360RI_R2_V6.PAN, PAN

Component Characterizations

Device	Characterization
STP 12000TL-10 (SMA)	Default Characterization

Components

Component	Name	Count
Inverters	STP 12000TL-10 (SMA)	1 (12.0 kW)
Strings	10 AWG (Copper)	2 (59.0 ft)
Module	Hyundai, HiS-S360RI (360W)	37 (13.3 kW)

Wiring Zones

Description	Combiner Poles	String Size	Stringing Strategy
Wiring Zone	12	11-19	Along Racking

Field Segments

Description	Racking	Orientation	Tilt	Azimuth	Intrarow Spacing	Frame Size	Frames	Modules	Power
Field Segment 1	Flush Mount	Portrait (Vertical)	18.4°	180°	0.1 ft	1x1	51	37	13.3 kW

Detailed Layout

Single Family Attached (South) Eric - Urban Infrastructure, Tempe Az

Report

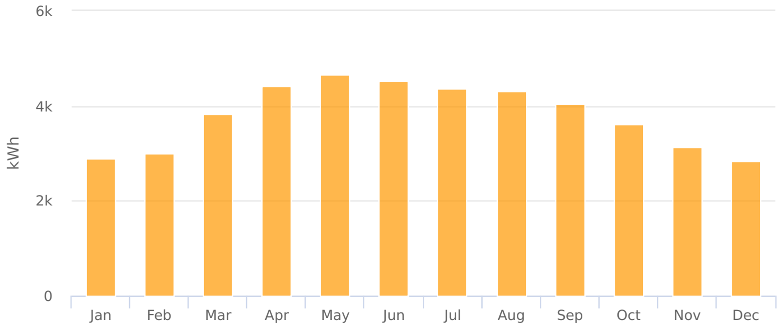
Project Name	Eric - Urban Infrastructure
Project Address	Tempe Az
Prepared By	

System Metrics

Design	Single Family Attached (South)
Module DC Nameplate	25.4 kW
Inverter AC Nameplate	24.1 kW Load Ratio: 1.05
Annual Production	45.68 MWh
Performance Ratio	77.0%
kWh/kWp	1,799.7
Weather Dataset	TMY, PHOENIX SKY HARBOR INTL AP, NSRDB (tmy3, I)
Simulator Version	1d80ad2d41-f3b7fc5dab-e2be6f71b1-f933a7f880

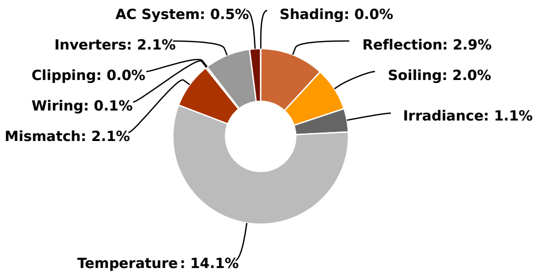
Project Location

Monthly Production



Month	GHI (kWh/m^2)	POA (kWh/m^2)	Shaded (kWh/m^2)	Nameplate (kWh)	Grid (kWh)
January	101.9	140.2	140.2	3,366.7	2,906.1
February	116.5	146.9	146.9	3,541.0	2,990.5
March	165.4	190.1	190.1	4,589.8	3,819.5
April	212.6	225.8	225.8	5,463.1	4,429.1
May	243.2	241.6	241.6	5,833.0	4,667.5
June	249.5	241.5	241.5	5,830.7	4,527.0
July	236.1	233.1	233.1	5,631.3	4,374.3
August	220.9	229.2	229.2	5,535.1	4,315.8
September	190.2	213.3	213.3	5,158.8	4,057.7
October	149.5	184.7	184.6	4,454.9	3,613.0
November	113.2	154.6	154.5	3,715.9	3,136.1
December	95.2	136.4	136.4	3,272.5	2,840.3

Sources of System Loss



Annual Production Report

Annual Production

	Description	Output	% Delta
Irradiance (kWh/m²)	Annual Global Horizontal Irradiance	2,094.2	
	POA Irradiance	2,337.4	11.6%
	Shaded Irradiance	2,337.1	0.0%
	Irradiance after Reflection	2,268.5	-2.9%
	Irradiance after Soiling	2,223.1	-2.0%
	Total Collector Irradiance	**2,223.1**	**0.0%**
Energy (kWh)	Nameplate	56,392.8	
	Output at Irradiance Levels	55,787.2	-1.1%
	Output at Cell Temperature Derate	47,930.9	-14.1%
	Output After Mismatch	46,924.7	-2.1%
	Optimal DC Output	46,889.1	-0.1%
	Constrained DC Output	46,889.1	0.0%
	Inverter Output	45,906.4	-2.1%
	Energy to Grid	**45,676.8**	**-0.5%**
Temperature Metrics			
	Avg. Operating Ambient Temp	27.0 °C	
	Avg. Operating Cell Temp	52.1 °C	
Simulation Metrics			
	Operating Hours		4607
	Solved Hours		4607

Condition Set

Description	Condition Set 1
Weather Dataset	TMY, PHOENIX SKY HARBOR INTL AP, NSRDB (tmy3, I)
Solar Angle Location	Meteo Lat/Lng
Transposition Model	Perez Model
Temperature Model	Sandia Model

Temperature Model Parameters

Rack Type	a	b	Temperature Delta
Fixed Tilt	-3.56	-0.075	3°C
Flush Mount	-2.81	-0.0455	0°C

Soiling (%)

J	F	M	A	M	J	J	A	S	O	N	D
2	2	2	2	2	2	2	2	2	2	2	2

Irradiation Variance	5%
Cell Temperature Spread	4° C
Module Binning Range	-2.5% to 2.5%
AC System Derate	0.50%

Module Characterizations

Module	Characterization
SPR-X22-470_COM (SunPower)	Sunpower_SPR_X22_470_COM.PAN, PAN

Component Characterizations

Device	Characterization
Sunny Tripower 24000TL-US (SMA)	Modified CEC

Components

Component	Name	Count
Inverters	Sunny Tripower 24000TL-US (SMA)	1 (24.1 kW)
Strings	10 AWG (Copper)	6 (286.1 ft)
Module	SunPower, SPR-X22-470_COM (470W)	54 (25.4 kW)

Wiring Zones

Description	Combiner Poles	String Size	Stringing Strategy
Wiring Zone	12	3-10	Along Racking

Field Segments

Description	Racking	Orientation	Tilt	Azimuth	Intrarow Spacing	Frame Size	Frames	Modules	Power
Field Segment 1	Flush Mount	Portrait (Vertical)	18.4°	176.367°	0.0 ft	1x1	54	54	25.4 kW

Detailed Layout

Low Rise - Apartments (South) Eric - Urban Infrastructure, Tempe Az

Report

Project Name	Eric - Urban Infrastructure
Project Address	Tempe Az
Prepared By	

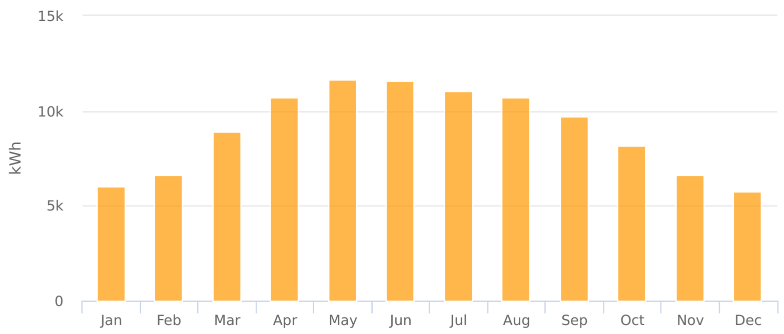
System Metrics

Design	Low Rise - Apartments (South)
Module DC Nameplate	58.8 kW
Inverter AC Nameplate	50.0 kW Load Ratio: 1.18
Annual Production	107.7 MWh
Performance Ratio	81.5%
kWh/kWp	1,832.4
Weather Dataset	TMY, PHOENIX SKY HARBOR INTL AP, NSRDB (tmy3, I)
Simulator Version	1d80ad2d41-f3b7fc5dab-e2be6f71b1-f933a7f880

Project Location

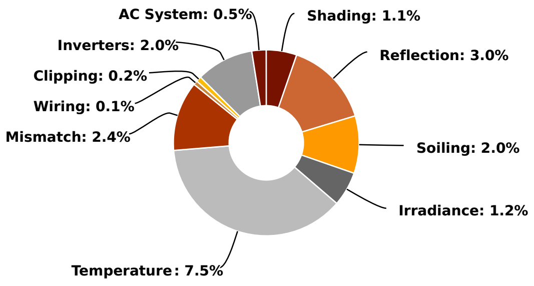
DigitalGlobe, U.S. Geological Survey, USDA Farm Service Agency

Monthly Production



Month	GHI (kWh/m^2)	POA (kWh/m^2)	Shaded (kWh/m^2)	Nameplate (kWh)	Grid (kWh)
January	101.9	124.1	120.5	6,657.4	6,059.7
February	116.5	134.3	132.8	7,382.7	6,636.9
March	165.4	180.7	179.5	10,007.8	8,935.7
April	212.6	222.0	220.7	12,354.5	10,721.4
May	243.2	244.8	243.3	13,627.8	11,685.2
June	249.5	247.6	246.1	13,802.1	11,586.4
July	236.1	236.9	235.2	13,193.1	11,058.8
August	220.9	227.9	226.4	12,669.5	10,689.7
September	190.2	204.8	203.5	11,384.4	9,692.0
October	149.5	170.2	168.7	9,394.4	8,176.0
November	113.2	137.0	133.9	7,414.1	6,636.8
December	95.2	118.9	114.6	6,317.9	5,775.9

Sources of System Loss



Annual Production Report

Annual Production

	Description	Output	% Delta
Irradiance (kWh/m^2)	Annual Global Horizontal Irradiance	2,094.2	
	POA Irradiance	2,249.2	7.4%
	Shaded Irradiance	2,225.2	-1.1%
	Irradiance after Reflection	2,158.4	-3.0%
	Irradiance after Soiling	2,115.2	-2.0%
	Total Collector Irradiance	**2,115.2**	**0.0%**
Energy (kWh)	Nameplate	124,205.6	
	Output at Irradiance Levels	122,716.7	-1.2%
	Output at Cell Temperature Derate	113,532.0	-7.5%
	Output After Mismatch	110,776.4	-2.4%
	Optimal DC Output	110,612.6	-0.1%
	Constrained DC Output	110,407.7	-0.2%
	Inverter Output	108,195.0	-2.0%
	Energy to Grid	**107,654.0**	**-0.5%**
Temperature Metrics			
	Avg. Operating Ambient Temp	27.0 °C	
	Avg. Operating Cell Temp	38.7 °C	
Simulation Metrics			
	Operating Hours		4607
	Solved Hours		4607

Condition Set

<table>
<tr><td>Description</td><td colspan="12">Condition Set 1</td></tr>
<tr><td>Weather Dataset</td><td colspan="12">TMY, PHOENIX SKY HARBOR INTL AP, NSRDB (tmy3, I)</td></tr>
<tr><td>Solar Angle Location</td><td colspan="12">Meteo Lat/Lng</td></tr>
<tr><td>Transposition Model</td><td colspan="12">Perez Model</td></tr>
<tr><td>Temperature Model</td><td colspan="12">Sandia Model</td></tr>
<tr><td rowspan="3">Temperature Model Parameters</td><td colspan="3">Rack Type</td><td colspan="3">a</td><td colspan="3">b</td><td colspan="3">Temperature Delta</td></tr>
<tr><td colspan="3">Fixed Tilt</td><td colspan="3">-3.56</td><td colspan="3">-0.075</td><td colspan="3">3°C</td></tr>
<tr><td colspan="3">Flush Mount</td><td colspan="3">-2.81</td><td colspan="3">-0.0455</td><td colspan="3">0°C</td></tr>
<tr><td rowspan="2">Soiling (%)</td><td>J</td><td>F</td><td>M</td><td>A</td><td>M</td><td>J</td><td>J</td><td>A</td><td>S</td><td>O</td><td>N</td><td>D</td></tr>
<tr><td>2</td><td>2</td><td>2</td><td>2</td><td>2</td><td>2</td><td>2</td><td>2</td><td>2</td><td>2</td><td>2</td><td>2</td></tr>
<tr><td>Irradiation Variance</td><td colspan="12">5%</td></tr>
<tr><td>Cell Temperature Spread</td><td colspan="12">4° C</td></tr>
<tr><td>Module Binning Range</td><td colspan="12">-2.5% to 2.5%</td></tr>
<tr><td>AC System Derate</td><td colspan="12">0.50%</td></tr>
<tr><td rowspan="2">Module Characterizations</td><td colspan="6">Module</td><td colspan="6">Characterization</td></tr>
<tr><td colspan="6">SPR-X22-470_COM (SunPower)</td><td colspan="6">Sunpower_SPR_X22_470_COM.PAN, PAN</td></tr>
<tr><td rowspan="2">Component Characterizations</td><td colspan="6">Device</td><td colspan="6">Characterization</td></tr>
<tr><td colspan="6">SOLID-Q 50 (SMA)</td><td colspan="6">Spec Sheet</td></tr>
</table>

Components

Component	Name	Count
Inverters	SOLID-Q 50 (SMA)	1 (50.0 kW)
Strings	10 AWG (Copper)	13 (1,272.8 ft)
Module	SunPower, SPR-X22-470_COM (470W)	125 (58.8 kW)

Wiring Zones

Description	Combiner Poles	String Size	Stringing Strategy
Wiring Zone	12	8-10	Along Racking

Field Segments

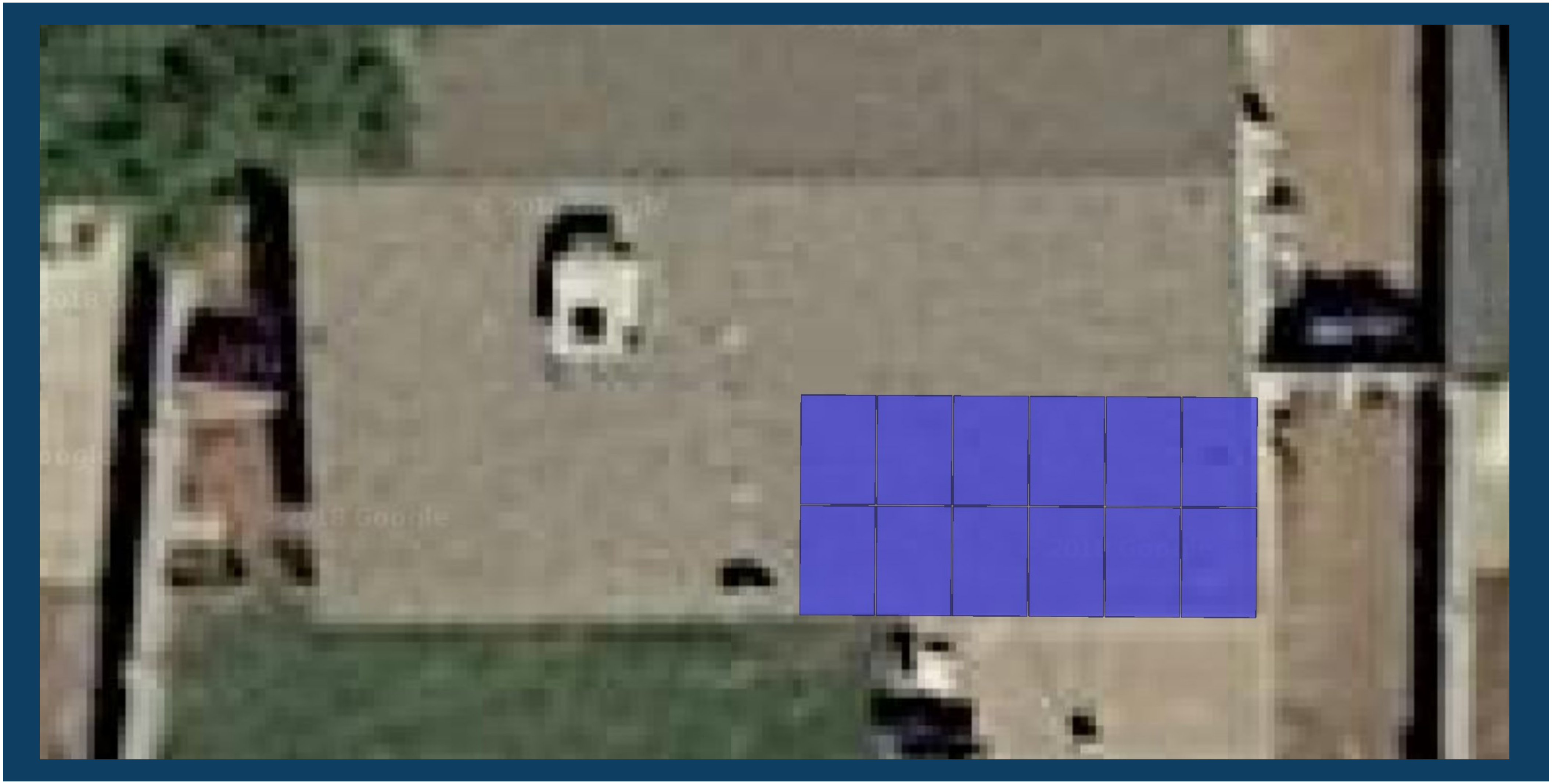
Description	Racking	Orientation	Tilt	Azimuth	Intrarow Spacing	Frame Size	Frames	Modules	Power
Field Segment 1	Fixed Tilt	Landscape (Horizontal)	10°	180°	1.0 ft	1x1	125	125	58.8 kW

Detailed Layout

?nnclbgv @+ClcpewRmmj`_qc Pcnmprq

Low - Residential

4424 E Baseline Rd , Phoenix, AZ 85



PV System Size

Power Rating (kW-DC):	3.6 kW-DC
Power Rating (kW-AC):	3.0 kW-AC

Energy kWh Offset (%):

103.1728%

PV System Production

DC/AC Ratio:	1.2
Production Ratio:	1,725 kWh/kW-DC

Eric Johnson - 4/13/2018

Low - Residential

4424 E Baseline Rd Phoenix, AZ 85042

PV System Characteristics

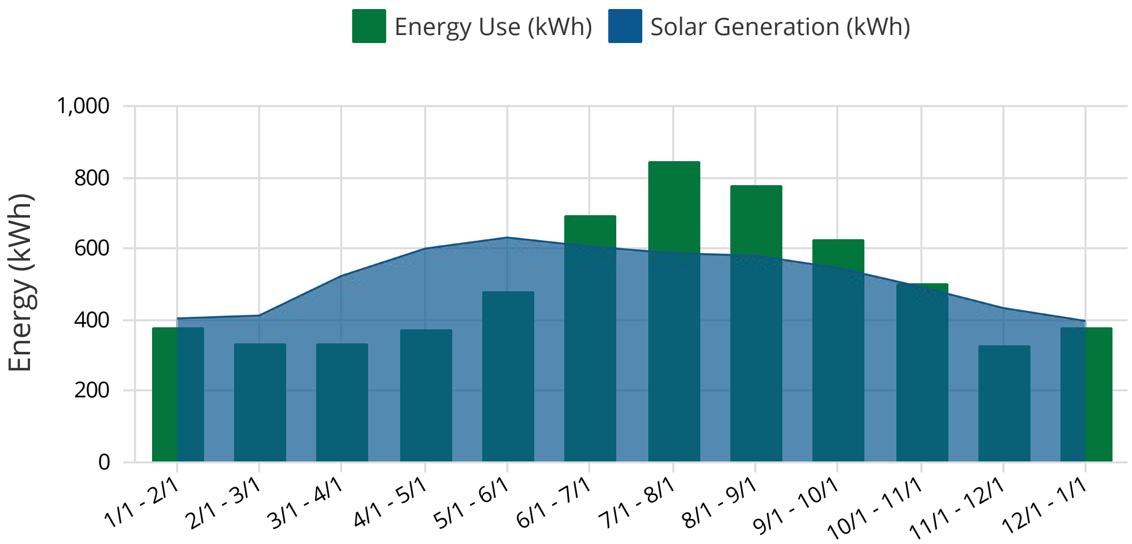
Power Rating (kW-DC):	3.6 kW-DC
Power Rating (kW-AC):	3.0 kW-AC
Energy kWh Offset (%):	103.1728
Solar PV Export (%):	60.1%

Total Annual Generation: 6,211 kWh

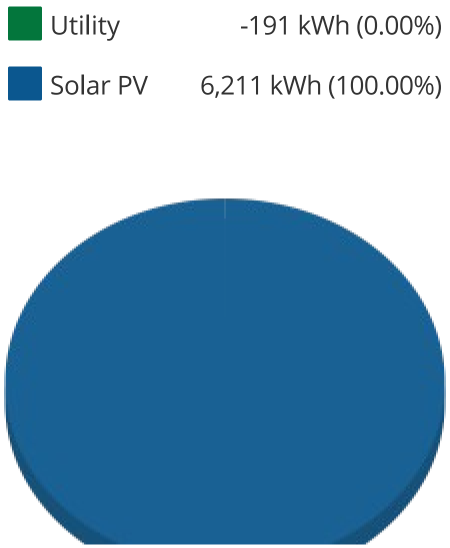
PV System Specifications

Solar Panels:	(10) Hyundai HiS-S360RI
Inverters:	(1) SMA Sunny Boy SB 3000TLUS-12 (240V AC)
Application Type:	Low - Residential

Monthly Energy Use Mix



Annual Energy Use Mix



Utility Rate Analysis

Avoided Cost Summary

Avoided Cost (Energy):	0.1019
Avoided Cost (Demand):	-0.0174
Avoided Cost (Blended):	0.0845

Avoided Cost: 0.0845

Utility Summary

Utility Company:	Salt River Project
Current Rate Schedule:	E-21
Proposed Rate Schedule:	E-27
Account Number:	
Meter Number:	

Utility Usage & Charges Before

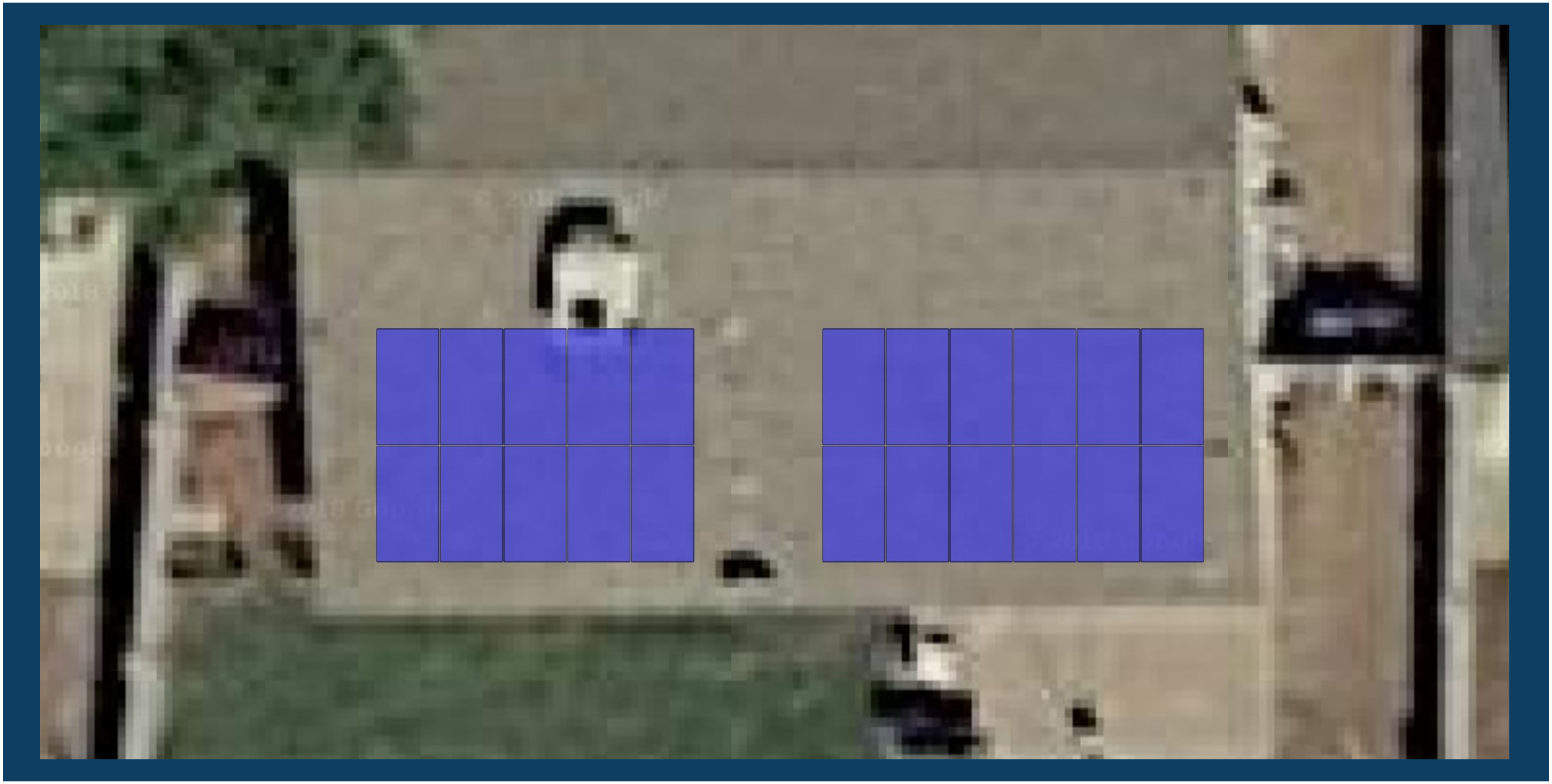
Time Periods	Energy Use (kWh)	Charges	Charges
Bill Ranges & Seasons	Total	Total	
1/1/2017 - 2/1/2017 W	375	$50	
2/1/2017 - 3/1/2017 W	331	$46	
3/1/2017 - 4/1/2017 W	334	$46	
4/1/2017 - 5/1/2017 W	369	$50	
5/1/2017 - 6/1/2017 S1	479	$75	
6/1/2017 - 7/1/2017 S1	693	$100	
7/1/2017 - 8/1/2017 SP1	842	$121	
8/1/2017 - 9/1/2017 SP1	773	$115	
9/1/2017 - 10/1/2017 S2	622	$90	
10/1/2017 - 11/1/2017 S2	500	$76	
11/1/2017 - 12/1/2017 W	325	$46	
12/1/2017 - 1/1/2018 W	377	$50	
Totals:	6,020	$863	

Utility Usage & Charges After

Time Periods	Energy Use (kWh)	Max Demand (kW)	Charges
Bill Ranges & Seasons	Total	NC / Max	Total
1/1/2017 - 2/1/2017 W	-29	1	$35
2/1/2017 - 3/1/2017 W	-80	1	$33
3/1/2017 - 4/1/2017 W	-189	1	$29
4/1/2017 - 5/1/2017 W	-230	1	$27
5/1/2017 - 6/1/2017 S1	-151	1	$34
6/1/2017 - 7/1/2017 S1	86	2	$52
7/1/2017 - 8/1/2017 SP1	256	2	$64
8/1/2017 - 9/1/2017 SP1	193	2	$61
9/1/2017 - 10/1/2017 S2	76	2	$52
10/1/2017 - 11/1/2017 S2	8	1	$41
11/1/2017 - 12/1/2017 W	-108	1	$32
12/1/2017 - 1/1/2018 W	-20	1	$36
Totals:	-188	-	$488

Base - Residential

4424 E Baseline Rd , Phoenix, AZ 85042



PV System Size

Power Rating (kW-DC):	7.9 kW-DC
Power Rating (kW-AC):	7.0 kW-AC

Energy kWh Offset (%):

105.3182%

PV System Production

DC/AC Ratio:	1.1314
Production Ratio:	1,718 kWh/kW-DC

Eric Johnson - 4/13/2018

Base - Residential

4424 E Baseline Rd Phoenix, AZ 85042

PV System Characteristics

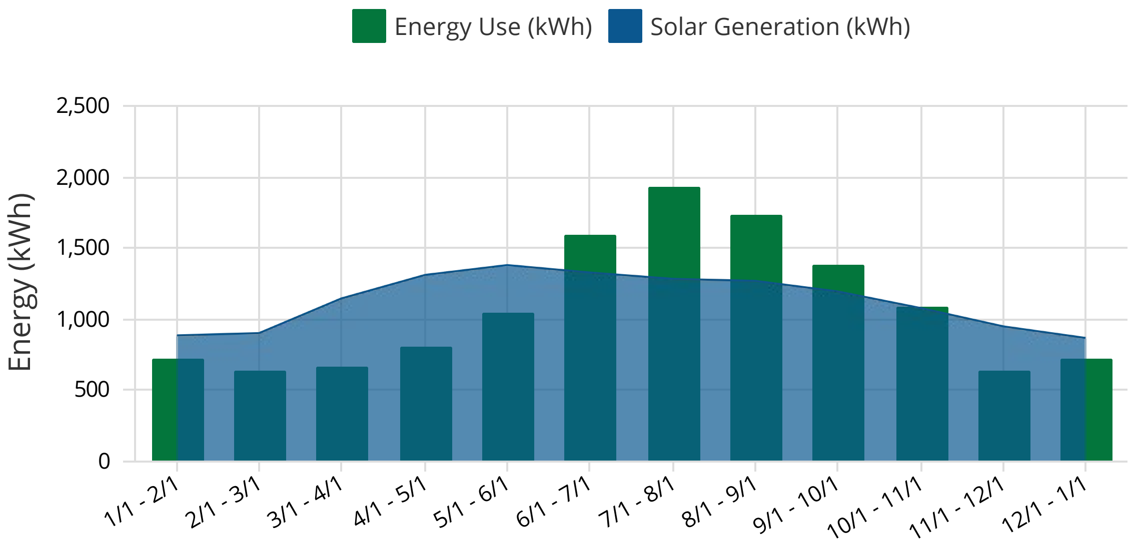
Power Rating (kW-DC):	7.9 kW-DC
Power Rating (kW-AC):	7.0 kW-AC
Energy kWh Offset (%):	105.3182
Solar PV Export (%):	57.6%

Total Annual Generation: 13,605 kWh

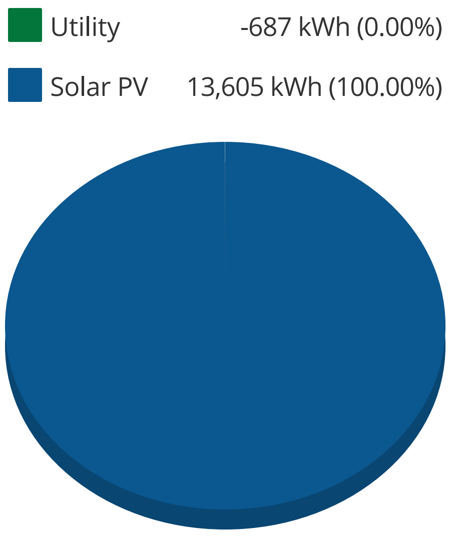
PV System Specifications

Solar Panels:	(22) Hyundai HiS-S360RI
Inverters:	(1) SMA Sunny Boy SB 7000-US-12 (240V AC)
Application Type:	Base - Residential (South)

Monthly Energy Use Mix



Annual Energy Use Mix



Utility Rate Analysis

Avoided Cost Summary

Avoided Cost (Energy):	0.1028
Avoided Cost (Demand):	-0.0195
Avoided Cost (Blended):	0.0833

Avoided Cost: 0.0833

Utility Summary

Utility Company:	Salt River Project
Current Rate Schedule:	E-21
Proposed Rate Schedule:	E-27
Account Number:	
Meter Number:	

Utility Usage & Charges Before

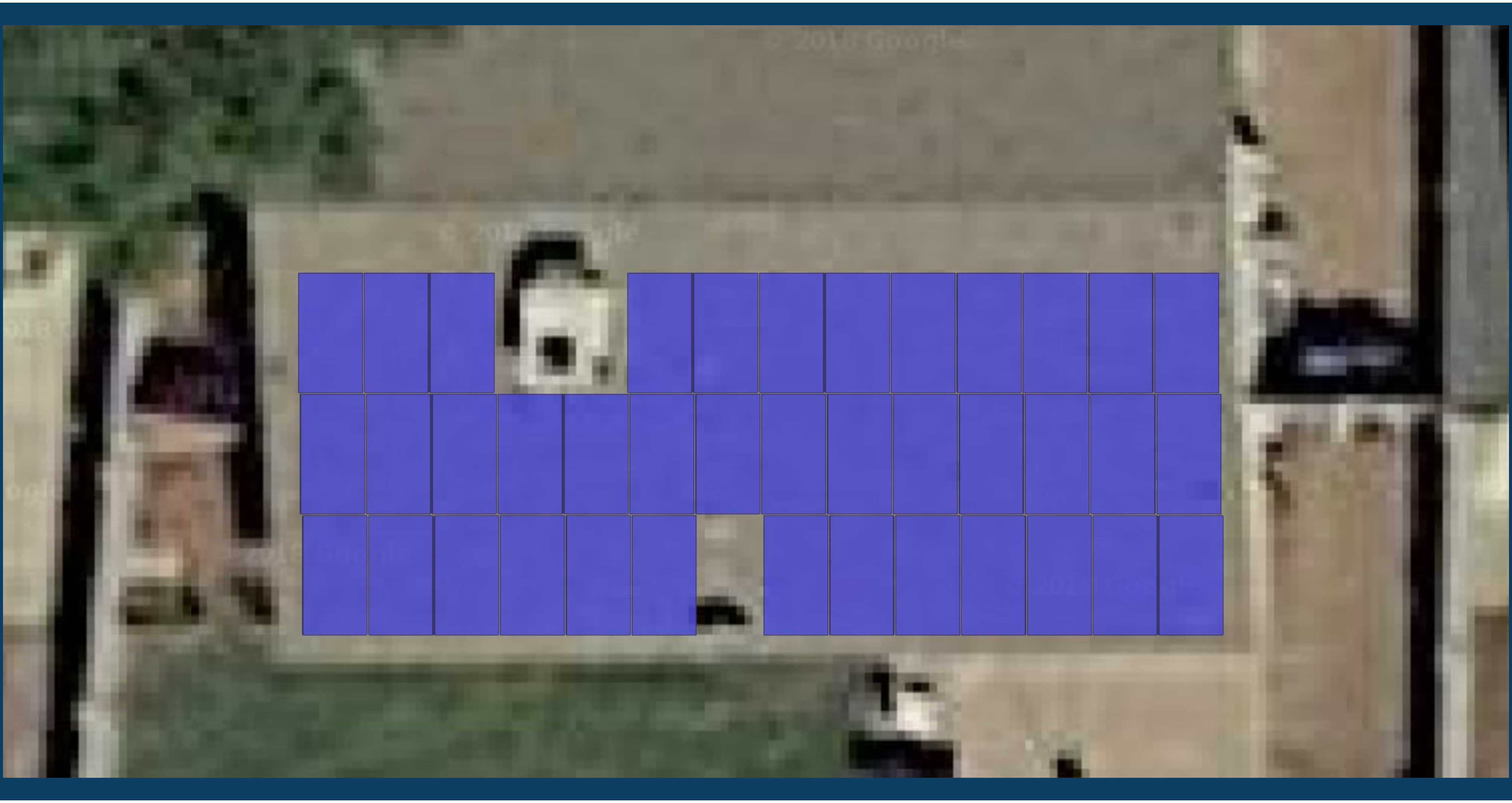
Time Periods	Energy Use (kWh)	Charges	Charges
Bill Ranges & Seasons	Total	Total	
1/1/2017 - 2/1/2017 W	723	$77	
2/1/2017 - 3/1/2017 W	631	$70	
3/1/2017 - 4/1/2017 W	666	$73	
4/1/2017 - 5/1/2017 W	794	$84	
5/1/2017 - 6/1/2017 S1	1,041	$141	
6/1/2017 - 7/1/2017 S1	1,590	$203	
7/1/2017 - 8/1/2017 SP1	1,926	$250	
8/1/2017 - 9/1/2017 SP1	1,730	$234	
9/1/2017 - 10/1/2017 S2	1,383	$178	
10/1/2017 - 11/1/2017 S2	1,083	$145	
11/1/2017 - 12/1/2017 W	635	$71	
12/1/2017 - 1/1/2018 W	716	$77	
Totals:	12,918	$1,604	

Utility Usage & Charges After

Time Periods	Energy Use (kWh)	Max Demand (kW)	Charges
Bill Ranges & Seasons	Total	NC / Max	Total
1/1/2017 - 2/1/2017 W	-164	2	$34
2/1/2017 - 3/1/2017 W	-273	2	$29
3/1/2017 - 4/1/2017 W	-481	2	$21
4/1/2017 - 5/1/2017 W	-518	3	$23
5/1/2017 - 6/1/2017 S1	-340	3	$43
6/1/2017 - 7/1/2017 S1	261	4	$82
7/1/2017 - 8/1/2017 SP1	641	4	$109
8/1/2017 - 9/1/2017 SP1	460	4	$101
9/1/2017 - 10/1/2017 S2	186	4	$79
10/1/2017 - 11/1/2017 S2	5	3	$57
11/1/2017 - 12/1/2017 W	-314	2	$28
12/1/2017 - 1/1/2018 W	-153	2	$34
Totals:	-690	-	$620

High - Residential

4424 E Baseline Rd , Phoenix, AZ 85042



PV System Size

Power Rating (kW-DC):	13.3 kW-DC
Power Rating (kW-AC):	12.0 kW-AC

Energy kWh Offset (%):

107.7556%

PV System Production

DC/AC Ratio:	1.11
Production Ratio:	1,741 kWh/kW-DC

Eric Johnson - 4/13/2018

High - Residential

4424 E Baseline Rd Phoenix, AZ 85042

PV System Characteristics

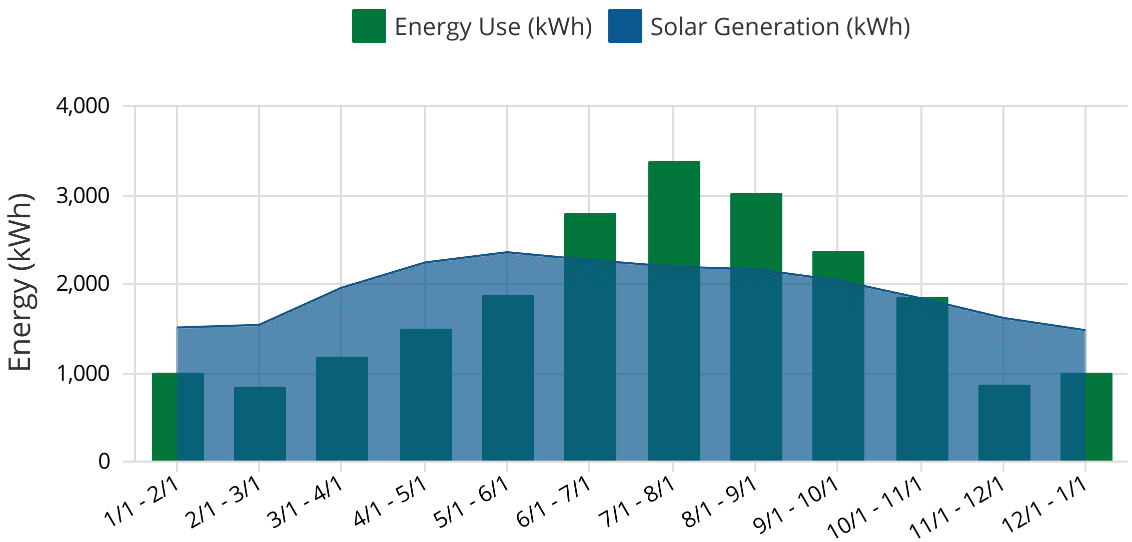
Power Rating (kW-DC):	13.3 kW-DC
Power Rating (kW-AC):	12.0 kW-AC
Energy kWh Offset (%):	107.7556
Solar PV Export (%):	56.9%

Total Annual Generation: 23,189 kWh

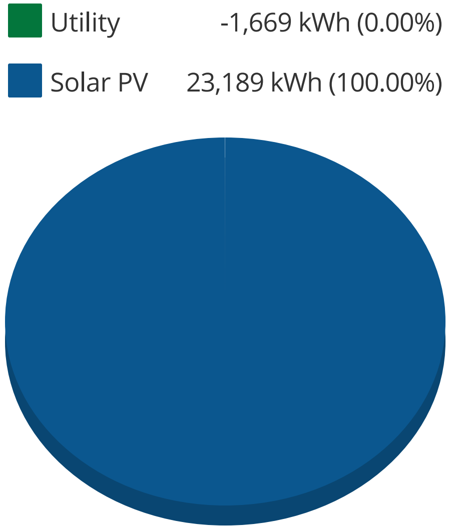
PV System Specifications

Solar Panels:	(37) Hyundai HiS-S360RI
Inverters:	(1) SMA STP 12000TL-10
Application Type:	High - Residential (South)

Monthly Energy Use Mix



Annual Energy Use Mix



Utility Rate Analysis

Avoided Cost Summary

Avoided Cost (Energy):	0.1022
Avoided Cost (Demand):	-0.0246
Avoided Cost (Blended):	0.0776

Avoided Cost: 0.0776

Utility Summary

Utility Company:	Salt River Project
Current Rate Schedule:	E-21
Proposed Rate Schedule:	E-27
Account Number:	
Meter Number:	

Utility Usage & Charges Before

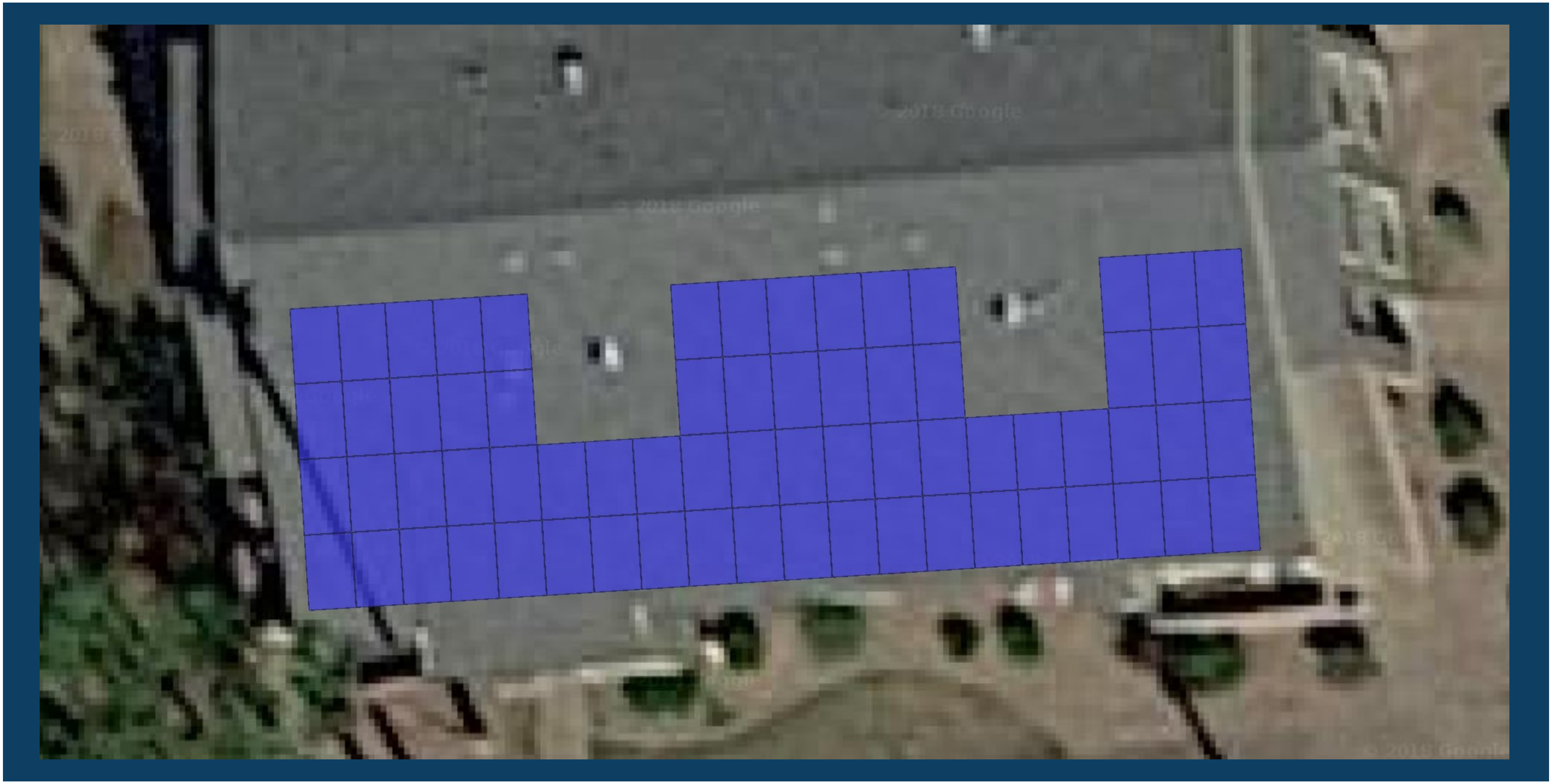
Time Periods	Energy Use (kWh)	Charges	Charges
Bill Ranges & Seasons	Total	Total	
1/1/2017 - 2/1/2017 W	979	$98	
2/1/2017 - 3/1/2017 W	840	$86	
3/1/2017 - 4/1/2017 W	1,166	$114	
4/1/2017 - 5/1/2017 W	1,480	$141	
5/1/2017 - 6/1/2017 S1	1,862	$238	
6/1/2017 - 7/1/2017 S1	2,776	$336	
7/1/2017 - 8/1/2017 SP1	3,362	$415	
8/1/2017 - 9/1/2017 SP1	3,015	$389	
9/1/2017 - 10/1/2017 S2	2,365	$290	
10/1/2017 - 11/1/2017 S2	1,849	$235	
11/1/2017 - 12/1/2017 W	847	$88	
12/1/2017 - 1/1/2018 W	979	$98	
Totals:	21,520	$2,527	

Utility Usage & Charges After

Time Periods	Energy Use (kWh)	Max Demand (kW)	Charges
Bill Ranges & Seasons	Total	NC / Max	Total
1/1/2017 - 2/1/2017 W	-529	2	$20
2/1/2017 - 3/1/2017 W	-697	2	$13
3/1/2017 - 4/1/2017 W	-787	4	$19
4/1/2017 - 5/1/2017 W	-759	5	$25
5/1/2017 - 6/1/2017 S1	-493	6	$81
6/1/2017 - 7/1/2017 S1	508	7	$136
7/1/2017 - 8/1/2017 SP1	1,170	7	$187
8/1/2017 - 9/1/2017 SP1	850	7	$173
9/1/2017 - 10/1/2017 S2	325	7	$129
10/1/2017 - 11/1/2017 S2	13	6	$102
11/1/2017 - 12/1/2017 W	-769	2	$10
12/1/2017 - 1/1/2018 W	-499	3	$25
Totals:	-1,667	-	$877

Single Family Attached

4424 E Baseline Rd , Phoenix, AZ 85042



PV System Size

Power Rating (kW-DC):	25.4 kW-DC
Power Rating (kW-AC):	24.1 kW-AC

Energy kWh Offset (%):

88.396%

PV System Production

DC/AC Ratio:	1.0549
Production Ratio:	1,800 kWh/kW-DC

Eric Johnson - 4/13/2018

Single Family Attached

4424 E Baseline Rd Phoenix, AZ 85042

PV System Characteristics

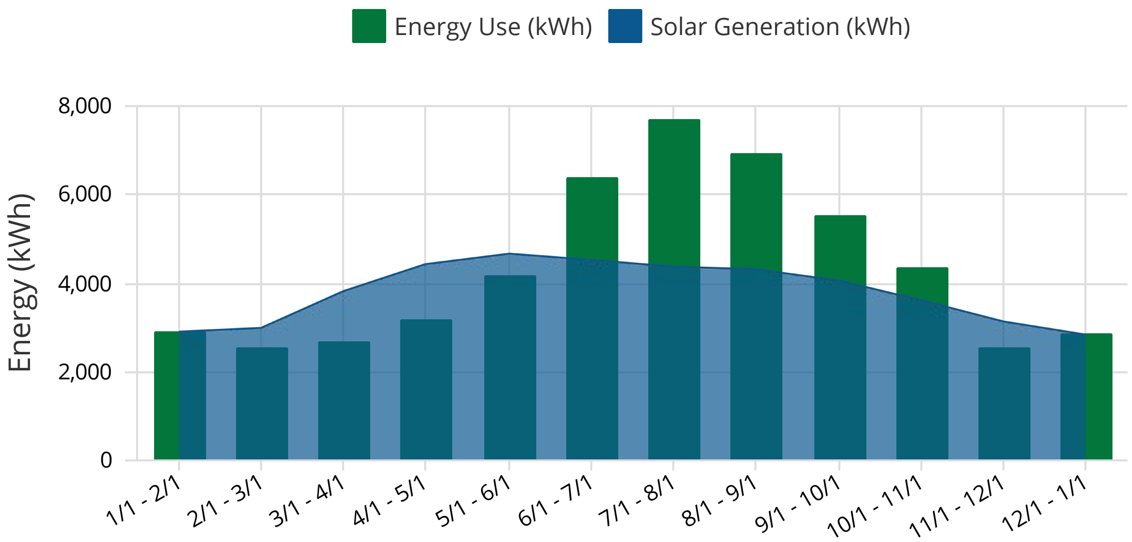
Power Rating (kW-DC):	25.4 kW-DC
Power Rating (kW-AC):	24.1 kW-AC
Energy kWh Offset (%):	88.396
Solar PV Export (%):	51.8%

Total Annual Generation: 45,676 kWh

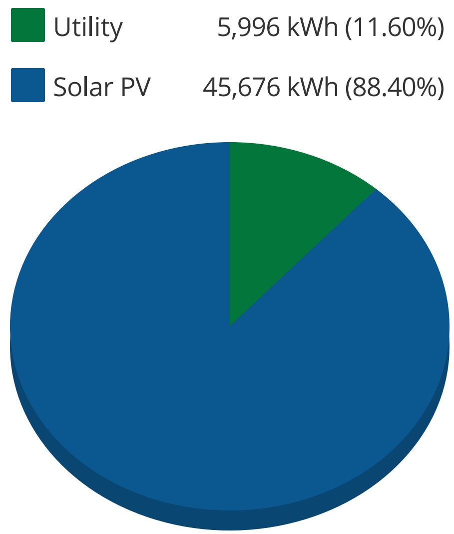
PV System Specifications

Solar Panels:	(54) SunPower SPR-X22-470_COM
Inverters:	(1) SMA Sunny Tripower 24000TL-US
Application Type:	Low Rise - Apartment

Monthly Energy Use Mix



Annual Energy Use Mix



Utility Rate Analysis

Avoided Cost Summary

Avoided Cost (Energy):	0.1126
Avoided Cost (Demand):	-0.0455
Avoided Cost (Blended):	0.0671

Avoided Cost: 0.0671

Utility Summary

Utility Company:	Salt River Project
Current Rate Schedule:	E-21
Proposed Rate Schedule:	E-27
Account Number:	
Meter Number:	

Utility Usage & Charges Before

Time Periods	Energy Use (kWh)	Charges	Charges
Bill Ranges & Seasons	Total	Total	
1/1/2017 - 2/1/2017 W	2,892	$250	
2/1/2017 - 3/1/2017 W	2,523	$220	
3/1/2017 - 4/1/2017 W	2,665	$232	
4/1/2017 - 5/1/2017 W	3,177	$277	
5/1/2017 - 6/1/2017 S1	4,163	$507	
6/1/2017 - 7/1/2017 S1	6,359	$753	
7/1/2017 - 8/1/2017 SP1	7,704	$938	
8/1/2017 - 9/1/2017 SP1	6,921	$877	
9/1/2017 - 10/1/2017 S2	5,531	$652	
10/1/2017 - 11/1/2017 S2	4,332	$519	
11/1/2017 - 12/1/2017 W	2,540	$223	
12/1/2017 - 1/1/2018 W	2,865	$248	
Totals:	51,672	$5,697	

Utility Usage & Charges After

Time Periods	Energy Use (kWh)	Max Demand (kW)	Charges
Bill Ranges & Seasons	Total	NC / Max	Total
1/1/2017 - 2/1/2017 W	-13	7	$68
2/1/2017 - 3/1/2017 W	-468	7	$50
3/1/2017 - 4/1/2017 W	-1,154	8	$28
4/1/2017 - 5/1/2017 W	-1,252	11	$46
5/1/2017 - 6/1/2017 S1	-504	14	$222
6/1/2017 - 7/1/2017 S1	1,832	17	$429
7/1/2017 - 8/1/2017 SP1	3,330	17	$584
8/1/2017 - 9/1/2017 SP1	2,605	18	$552
9/1/2017 - 10/1/2017 S2	1,472	16	$386
10/1/2017 - 11/1/2017 S2	719	14	$302
11/1/2017 - 12/1/2017 W	-597	7	$45
12/1/2017 - 1/1/2018 W	25	7	$70
Totals:	5,995	-	$2,783

Low Rise - Apartments (South)

4424 E Baseline Rd , Phoenix, AZ 85042

PV System Size

Power Rating (kW-DC):	58.8 kW-DC
Power Rating (kW-AC):	50.0 kW-AC

Energy kWh Offset (%):

340.6049%

PV System Production

DC/AC Ratio:	1.175
Production Ratio:	1,832 kWh/kW-DC

Eric Johnson - 4/13/2018

Low Rise - Apartments (South)

4424 E Baseline Rd Phoenix, AZ 85042

PV System Characteristics

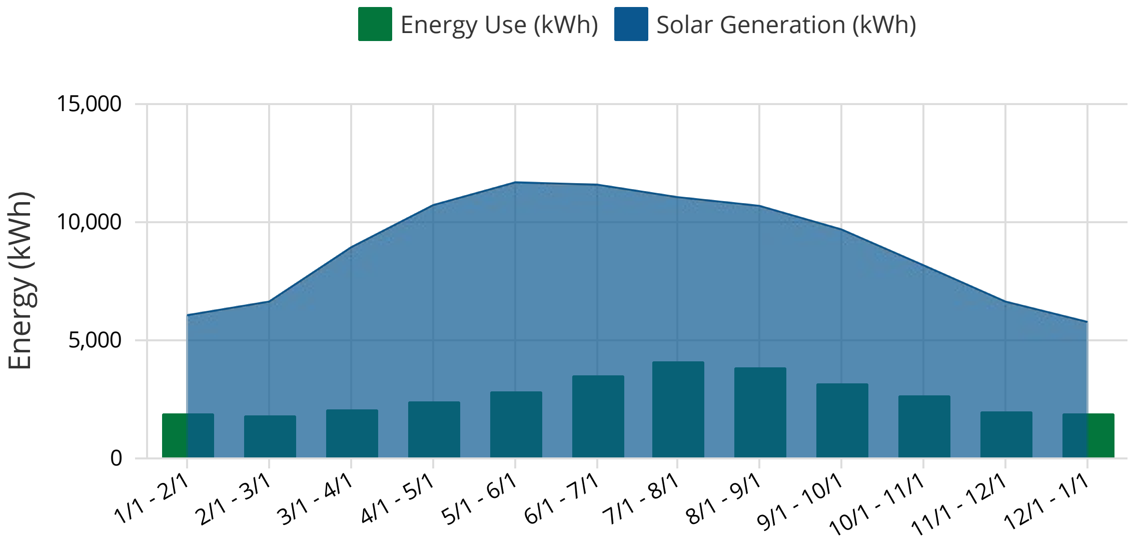
Power Rating (kW-DC):	58.8 kW-DC
Power Rating (kW-AC):	50.0 kW-AC
Energy kWh Offset (%):	340.6049
Solar PV Export (%):	85.0%

Total Annual Generation: 107,655 kWh

PV System Specifications

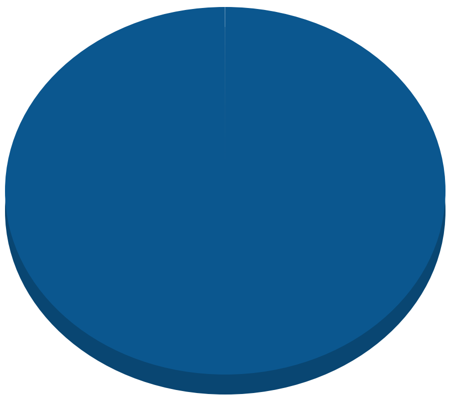
Solar Panels:	(125) SunPower SPR-X22-470_COM
Inverters:	(1) SMA SOLID-Q 50
Application Type:	Mid Rise - Apartments (South)

Monthly Energy Use Mix



Annual Energy Use Mix

🟩	Utility	-76,048 kWh (0.00%)
🟦	Solar PV	107,655 kWh (100.00%)



Utility Rate Analysis

Avoided Cost Summary

Avoided Cost (Energy):	0.0594
Avoided Cost (Demand):	0.0001
Avoided Cost (Blended):	0.0595

Avoided Cost: 0.0595

Utility Summary

Utility Company:	Salt River Project
Current Rate Schedule:	E-36
Proposed Rate Schedule:	E-36
Account Number:	
Meter Number:	

Utility Usage & Charges Before

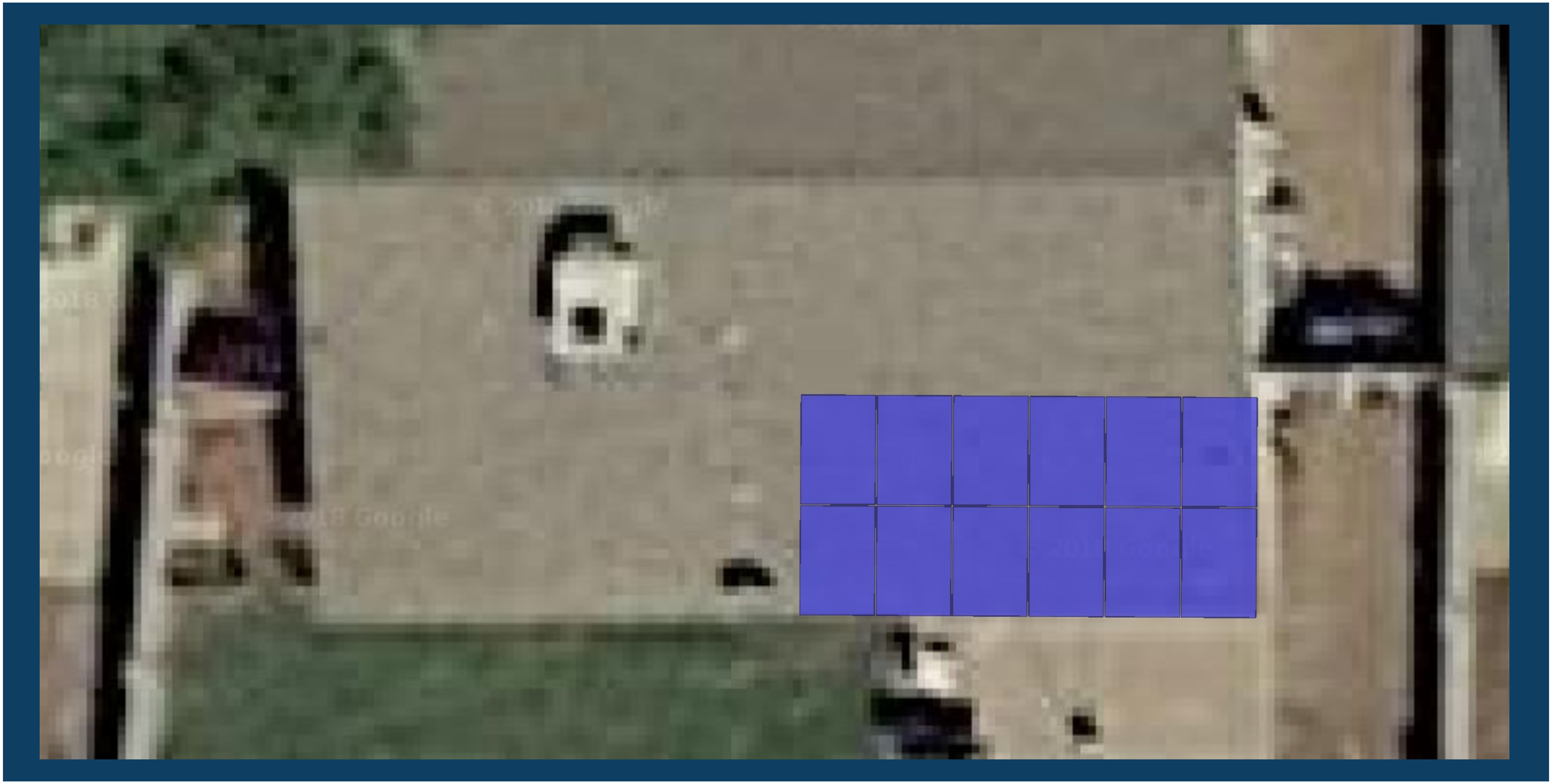
Time Periods	Energy Use (kWh)	Max Demand (kW)	Charges
Bill Ranges & Seasons	Total	NC / Max	Total
1/1/2017 - 2/1/2017 W1	1,842	5	$188
2/1/2017 - 3/1/2017 W1	1,777	6	$192
3/1/2017 - 4/1/2017 W1	2,019	5	$197
4/1/2017 - 5/1/2017 W1	2,350	7	$237
5/1/2017 - 6/1/2017 S1	2,760	8	$325
6/1/2017 - 7/1/2017 S1	3,492	8	$368
7/1/2017 - 8/1/2017 SP1	4,040	8	$463
8/1/2017 - 9/1/2017 SP1	3,796	8	$446
9/1/2017 - 10/1/2017 S2	3,112	8	$346
10/1/2017 - 11/1/2017 S2	2,617	7	$301
11/1/2017 - 12/1/2017 W1	1,969	5	$195
12/1/2017 - 1/1/2018 W1	1,833	5	$187
Totals:	31,607	-	$3,445

Utility Usage & Charges After

Time Periods	Energy Use (kWh)	Max Demand (kW)	Charges
Bill Ranges & Seasons	Total	NC / Max	Total
1/1/2017 - 2/1/2017 W1	-4,218	5	-$198
2/1/2017 - 3/1/2017 W1	-4,860	6	-$234
3/1/2017 - 4/1/2017 W1	-6,917	5	-$339
4/1/2017 - 5/1/2017 W1	-8,372	6	-$418
5/1/2017 - 6/1/2017 S1	-8,926	7	-$530
6/1/2017 - 7/1/2017 S1	-8,094	8	-$486
7/1/2017 - 8/1/2017 SP1	-7,019	8	-$484
8/1/2017 - 9/1/2017 SP1	-6,893	8	-$475
9/1/2017 - 10/1/2017 S2	-6,580	7	-$390
10/1/2017 - 11/1/2017 S2	-5,559	7	-$329
11/1/2017 - 12/1/2017 W1	-4,667	5	-$222
12/1/2017 - 1/1/2018 W1	-3,943	5	-$184
Totals:	-76,048	-	-$2,966

Low - Residential Batter

4424 E Baseline Rd , Phoenix, AZ 85042



PV System Size

Power Rating (kW-DC):	3.6 kW-DC
Power Rating (kW-AC):	3.0 kW-AC

Energy kWh Offset (%):

103.1728%

PV System Production

DC/AC Ratio:	1.2
Production Ratio:	1,725 kWh/kW-DC

Eric Johnson - 4/13/2018

Low - Residential

4424 E Baseline Rd Phoenix, AZ 85042

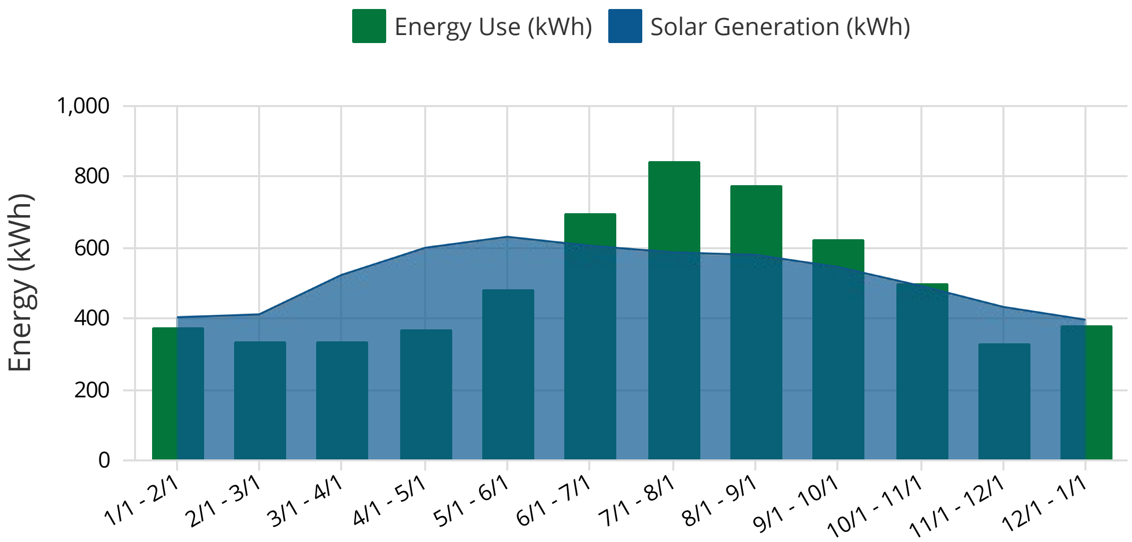
PV System Characteristics

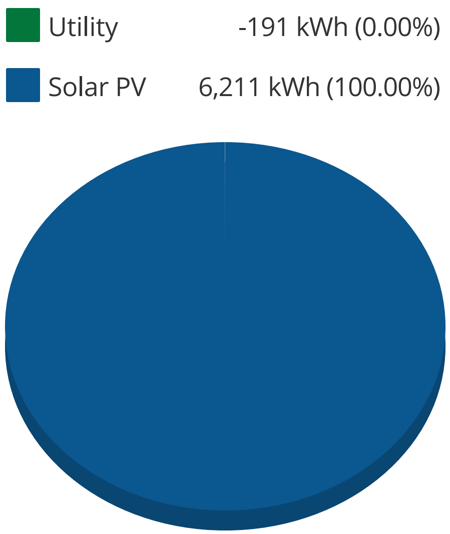
Power Rating (kW-DC):	3.6 kW-DC
Power Rating (kW-AC):	3.0 kW-AC
Energy kWh Offset (%):	103.1728
Solar PV Export (%):	24.6%

Total Annual Generation: 6,211 kWh

PV System Specifications

Solar Panels:	(10) Hyundai HiS-S360RI
Inverters:	(1) SMA Sunny Boy SB 3000TLUS-12 (240V AC)
Application Type:	Low - Residential


Monthly Energy Use Mix


Annual Energy Use Mix

Utility Rate Analysis

Avoided Cost Summary

Avoided Cost (Energy):	0.1019
Avoided Cost (Demand):	-0.0174
Avoided Cost (Blended):	0.0845

Avoided Cost: 0.0845

Utility Summary

Utility Company:	Salt River Project
Current Rate Schedule:	E-21
Proposed Rate Schedule:	E-27
Account Number:	
Meter Number:	

Utility Usage & Charges Before

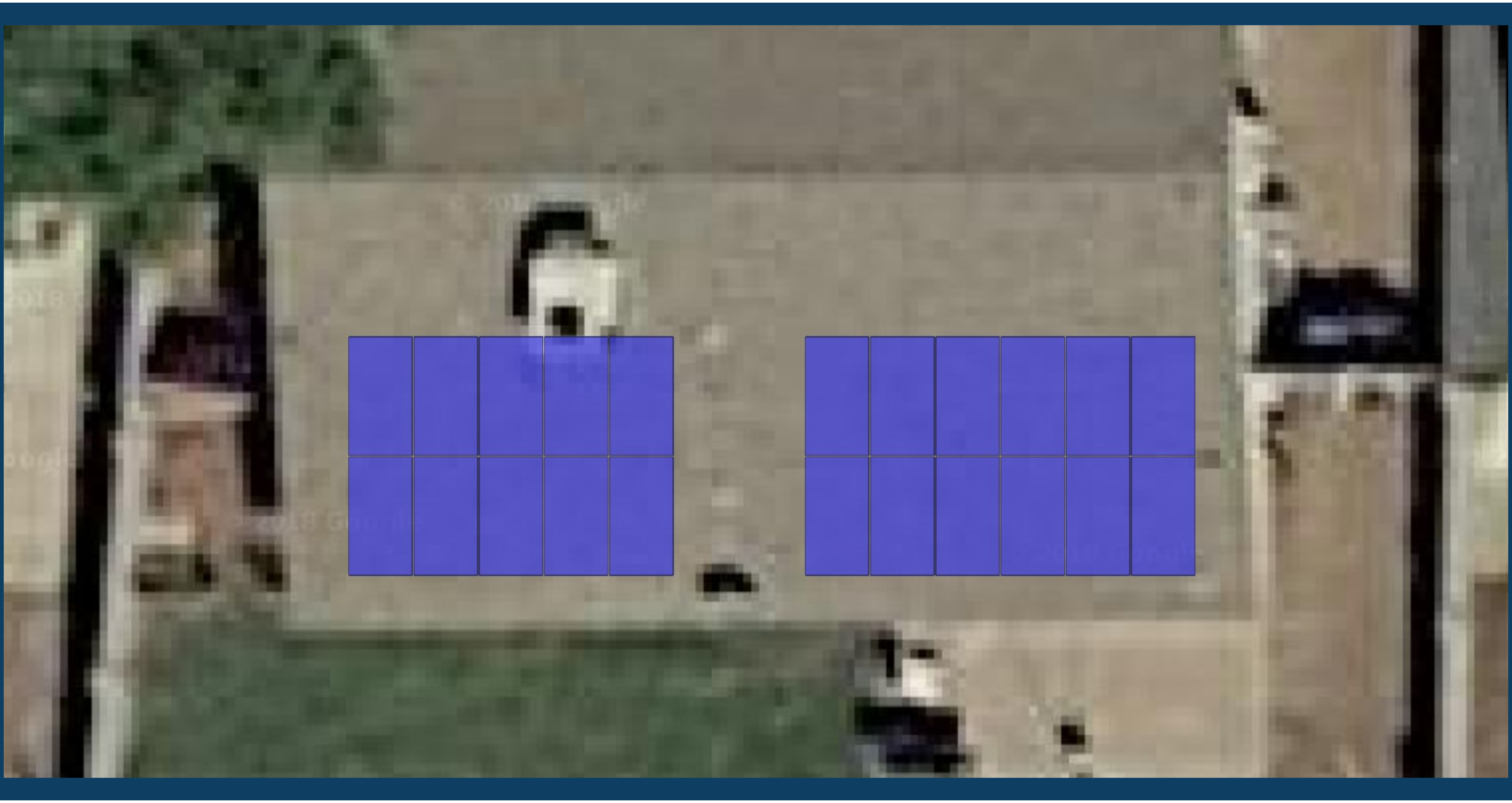
Time Periods	Energy Use (kWh)	Charges	Charges
Bill Ranges & Seasons	Total	Total	
1/1/2017 - 2/1/2017 W	375	$50	
2/1/2017 - 3/1/2017 W	331	$46	
3/1/2017 - 4/1/2017 W	334	$46	
4/1/2017 - 5/1/2017 W	369	$50	
5/1/2017 - 6/1/2017 S1	479	$75	
6/1/2017 - 7/1/2017 S1	693	$100	
7/1/2017 - 8/1/2017 SP1	842	$121	
8/1/2017 - 9/1/2017 SP1	773	$115	
9/1/2017 - 10/1/2017 S2	622	$90	
10/1/2017 - 11/1/2017 S2	500	$76	
11/1/2017 - 12/1/2017 W	325	$46	
12/1/2017 - 1/1/2018 W	377	$50	
Totals:	6,020	$863	

Utility Usage & Charges After

Time Periods	Energy Use (kWh)	Max Demand (kW)	Charges
Bill Ranges & Seasons	Total	NC / Max	Total
1/1/2017 - 2/1/2017 W	7	-	$33
2/1/2017 - 3/1/2017 W	-48	-	$31
3/1/2017 - 4/1/2017 W	-159	-	$26
4/1/2017 - 5/1/2017 W	-201	1	$28
5/1/2017 - 6/1/2017 S1	-114	1	$35
6/1/2017 - 7/1/2017 S1	134	1	$45
7/1/2017 - 8/1/2017 SP1	309	1	$55
8/1/2017 - 9/1/2017 SP1	241	1	$52
9/1/2017 - 10/1/2017 S2	121	1	$36
10/1/2017 - 11/1/2017 S2	48	1	$42
11/1/2017 - 12/1/2017 W	-77	-	$29
12/1/2017 - 1/1/2018 W	18	1	$37
Totals:	279	-	$450

Base - Residential Batter

4424 E Baseline Rd , Phoenix, AZ 85042



PV System Size

Power Rating (kW-DC):	7.9 kW-DC
Power Rating (kW-AC):	7.0 kW-AC

Energy kWh Offset (%):

105.3182%

PV System Production

DC/AC Ratio:	1.1314
Production Ratio:	1,718 kWh/kW-DC

Eric Johnson - 4/13/2018

Base - Residential

4424 E Baseline Rd Phoenix, AZ 85042

PV System Characteristics

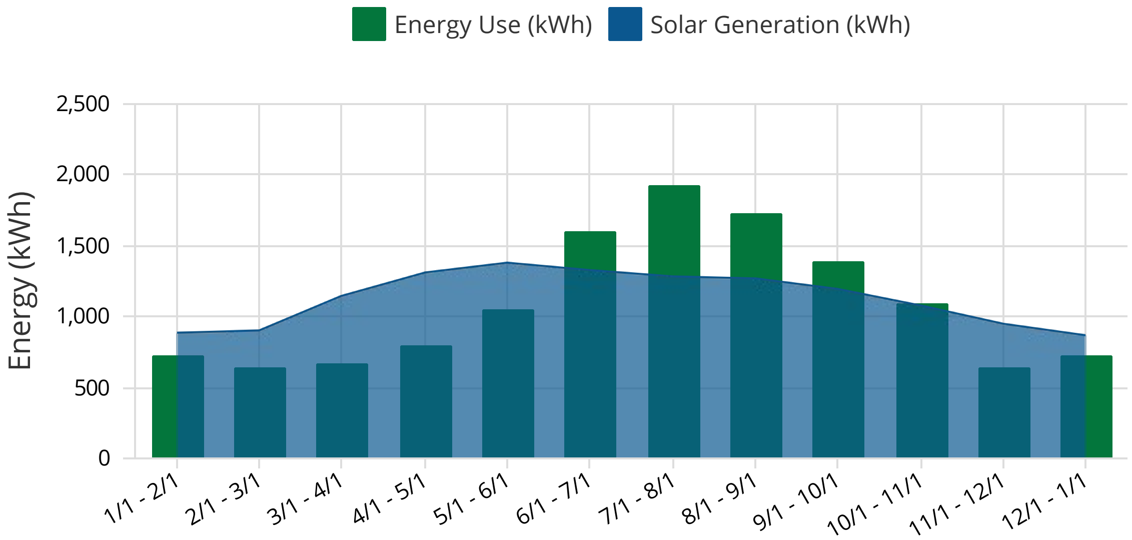
Power Rating (kW-DC):	7.9 kW-DC
Power Rating (kW-AC):	7.0 kW-AC
Energy kWh Offset (%):	105.3182
Solar PV Export (%):	32.1%

Total Annual Generation: 13,605 kWh

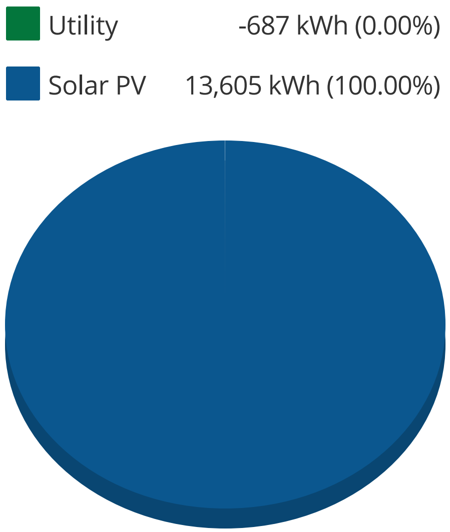
PV System Specifications

Solar Panels:	(22) Hyundai HiS-S360RI
Inverters:	(1) SMA Sunny Boy SB 7000-US-12 (240V AC)
Application Type:	Base - Residential (South)

Monthly Energy Use Mix



Annual Energy Use Mix



Utility Rate Analysis

Avoided Cost Summary

Avoided Cost (Energy):	0.1028
Avoided Cost (Demand):	-0.0195
Avoided Cost (Blended):	0.0833

Avoided Cost: 0.0833

Utility Summary

Utility Company:	Salt River Project
Current Rate Schedule:	E-21
Proposed Rate Schedule:	E-27
Account Number:	
Meter Number:	

Utility Usage & Charges Before

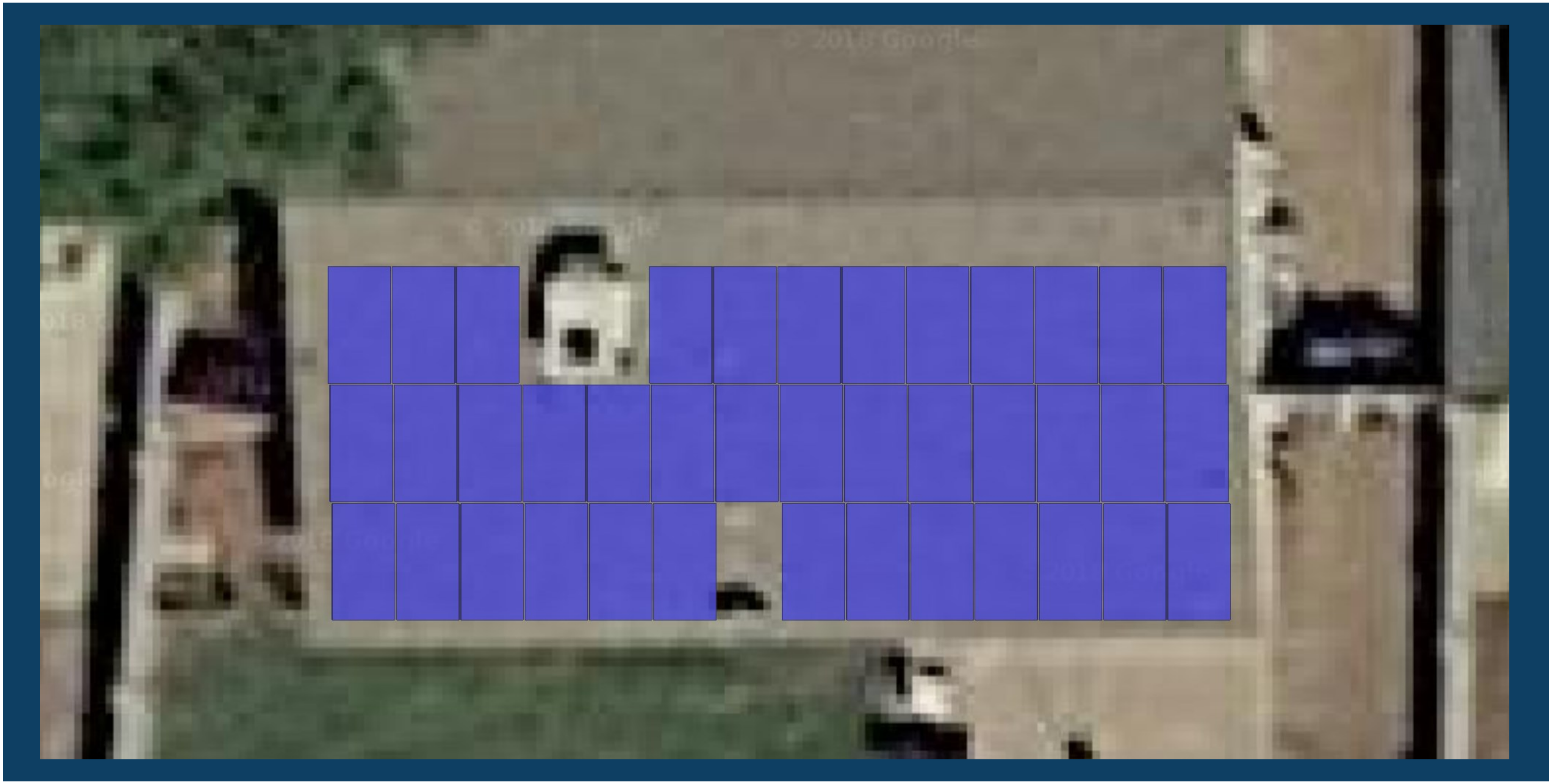
Time Periods	Energy Use (kWh)	Charges	Charges
Bill Ranges & Seasons	Total	Total	
1/1/2017 - 2/1/2017 W	723	$77	
2/1/2017 - 3/1/2017 W	631	$70	
3/1/2017 - 4/1/2017 W	666	$73	
4/1/2017 - 5/1/2017 W	794	$84	
5/1/2017 - 6/1/2017 S1	1,041	$141	
6/1/2017 - 7/1/2017 S1	1,590	$203	
7/1/2017 - 8/1/2017 SP1	1,926	$250	
8/1/2017 - 9/1/2017 SP1	1,730	$234	
9/1/2017 - 10/1/2017 S2	1,383	$178	
10/1/2017 - 11/1/2017 S2	1,083	$145	
11/1/2017 - 12/1/2017 W	635	$71	
12/1/2017 - 1/1/2018 W	716	$77	
Totals:	12,918	$1,604	

Utility Usage & Charges After

Time Periods	Energy Use (kWh)	Max Demand (kW)	Charges
Bill Ranges & Seasons	Total	NC / Max	Total
1/1/2017 - 2/1/2017 W	-107	1	$32
2/1/2017 - 3/1/2017 W	-218	1	$28
3/1/2017 - 4/1/2017 W	-432	1	$19
4/1/2017 - 5/1/2017 W	-476	1	$17
5/1/2017 - 6/1/2017 S1	-282	2	$36
6/1/2017 - 7/1/2017 S1	325	3	$68
7/1/2017 - 8/1/2017 SP1	707	3	$92
8/1/2017 - 9/1/2017 SP1	523	3	$83
9/1/2017 - 10/1/2017 S2	250	3	$65
10/1/2017 - 11/1/2017 S2	67	2	$50
11/1/2017 - 12/1/2017 W	-262	1	$26
12/1/2017 - 1/1/2018 W	-96	1	$33
Totals:	-1	-	$549

High - Residential Batter

4424 E Baseline Rd , Phoenix, AZ 85042



PV System Size

Power Rating (kW-DC):	13.3 kW-DC
Power Rating (kW-AC):	12.0 kW-AC

Energy kWh Offset (%):

107.7556%

PV System Production

DC/AC Ratio:	1.11
Production Ratio:	1,741 kWh/kW-DC

Eric Johnson - 4/13/2018

High - Residential

4424 E Baseline Rd Phoenix, AZ 85042

PV System Characteristics

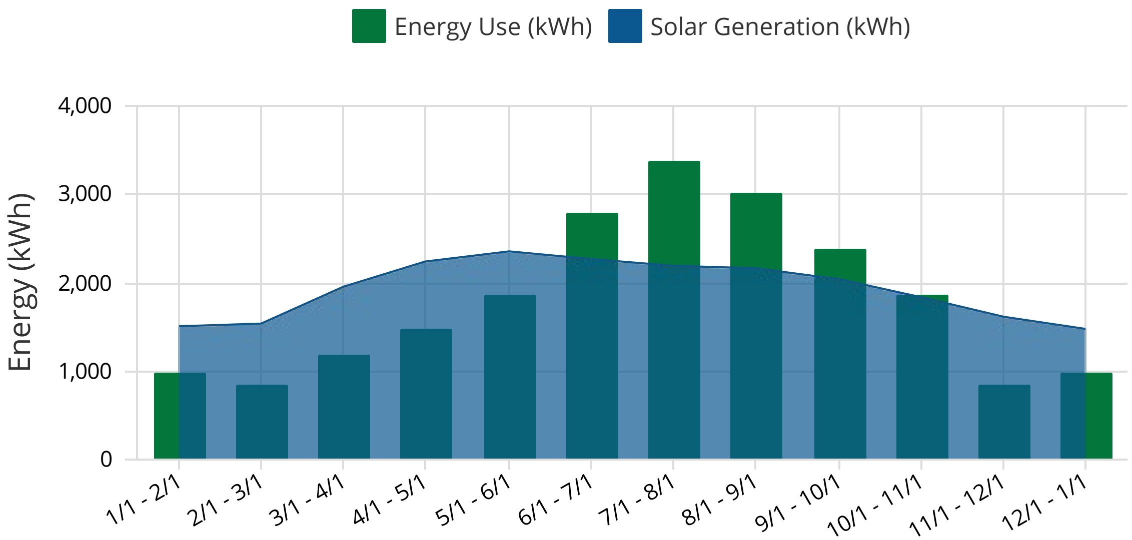
Power Rating (kW-DC):	13.3 kW-DC
Power Rating (kW-AC):	12.0 kW-AC
Energy kWh Offset (%):	107.7556
Solar PV Export (%):	16.3%

Total Annual Generation: 23,189 kWh

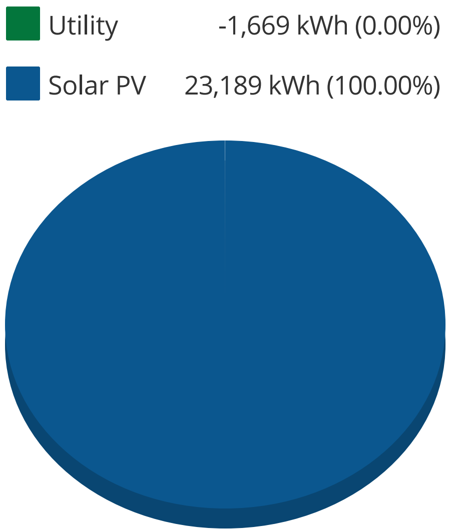
PV System Specifications

Solar Panels:	(37) Hyundai HiS-S360RI
Inverters:	(1) SMA STP 12000TL-10
Application Type:	High - Residential Battery

Monthly Energy Use Mix



Annual Energy Use Mix



Utility Rate Analysis

Avoided Cost Summary

Avoided Cost (Energy):	0.1022
Avoided Cost (Demand):	-0.0246
Avoided Cost (Blended):	0.0776

Avoided Cost: 0.0776

Utility Summary

Utility Company:	Salt River Project
Current Rate Schedule:	E-21
Proposed Rate Schedule:	E-27
Account Number:	
Meter Number:	

Utility Usage & Charges Before

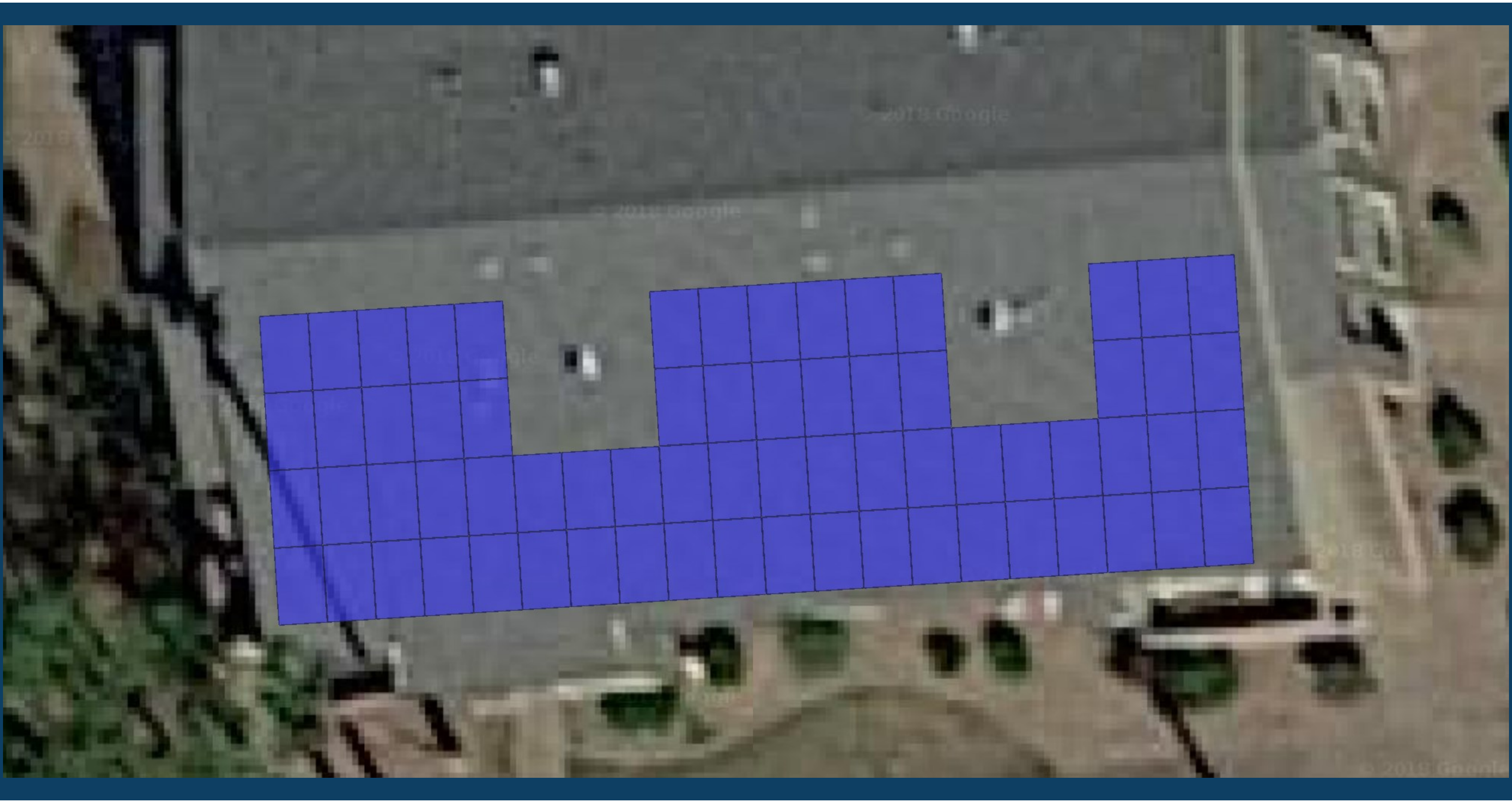
Time Periods	Energy Use (kWh)	Charges	Charges
Bill Ranges & Seasons	Total	Total	
1/1/2017 - 2/1/2017 W	979	$98	
2/1/2017 - 3/1/2017 W	840	$86	
3/1/2017 - 4/1/2017 W	1,166	$114	
4/1/2017 - 5/1/2017 W	1,480	$141	
5/1/2017 - 6/1/2017 S1	1,862	$238	
6/1/2017 - 7/1/2017 S1	2,776	$336	
7/1/2017 - 8/1/2017 SP1	3,362	$415	
8/1/2017 - 9/1/2017 SP1	3,015	$389	
9/1/2017 - 10/1/2017 S2	2,365	$290	
10/1/2017 - 11/1/2017 S2	1,849	$235	
11/1/2017 - 12/1/2017 W	847	$88	
12/1/2017 - 1/1/2018 W	979	$98	
Totals:	21,520	$2,527	

Utility Usage & Charges After

Time Periods	Energy Use (kWh)	Max Demand (kW)	Charges
Bill Ranges & Seasons	Total	NC / Max	Total
1/1/2017 - 2/1/2017 W	-397	-	$17
2/1/2017 - 3/1/2017 W	-578	-	$10
3/1/2017 - 4/1/2017 W	-640	-	$7
4/1/2017 - 5/1/2017 W	-610	-	$8
5/1/2017 - 6/1/2017 S1	-298	1	$27
6/1/2017 - 7/1/2017 S1	716	2	$76
7/1/2017 - 8/1/2017 SP1	1,383	2	$115
8/1/2017 - 9/1/2017 SP1	1,059	2	$101
9/1/2017 - 10/1/2017 S2	515	1	$60
10/1/2017 - 11/1/2017 S2	208	1	$48
11/1/2017 - 12/1/2017 W	-645	-	$7
12/1/2017 - 1/1/2018 W	-354	-	$19
Totals:	359	-	$496

Single Family Attached Batter

4424 E Baseline Rd , Phoenix, AZ 85042



PV System Size

Power Rating (kW-DC):	25.4 kW-DC
Power Rating (kW-AC):	24.1 kW-AC

Energy kWh Offset (%):

101.0307%

PV System Production

DC/AC Ratio:	1.0549
Production Ratio:	1,800 kWh/kW-DC

Eric Johnson - 4/13/2018

Single Family Attached

4424 E Baseline Rd Phoenix, AZ 85042

PV System Characteristics

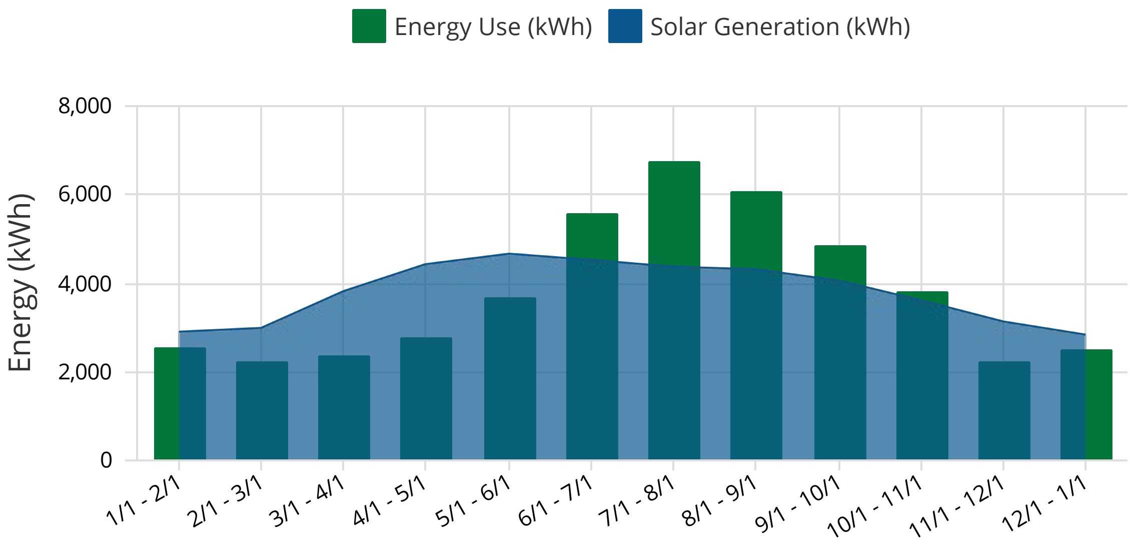
Power Rating (kW-DC):	25.4 kW-DC
Power Rating (kW-AC):	24.1 kW-AC
Energy kWh Offset (%):	101.0307
Solar PV Export (%):	14.0%

Total Annual Generation: 45,676 kWh

PV System Specifications

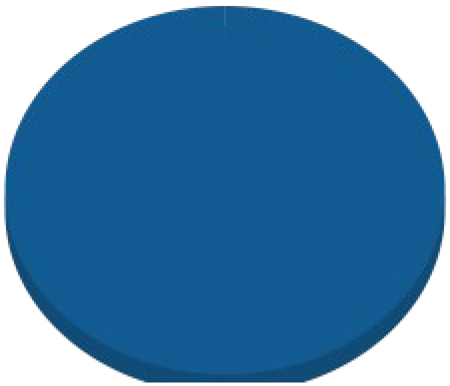
Solar Panels:	(54) SunPower SPR-X22-470_COM
Inverters:	(1) SMA Sunny Tripower 24000TL-US
Application Type:	Low Rise - Apartment

Monthly Energy Use Mix



Annual Energy Use Mix

🟩 Utility	-466 kWh (0.00%)
🟦 Solar PV	45,676 kWh (100.00%)



Utility Rate Analysis

Avoided Cost Summary

Avoided Cost (Energy):	0.1021
Avoided Cost (Demand):	-0.0381
Avoided Cost (Blended):	0.064

Avoided Cost: 0.064

Utility Summary

Utility Company:	Salt River Project
Current Rate Schedule:	E-21
Proposed Rate Schedule:	E-27
Account Number:	
Meter Number:	

Utility Usage & Charges Before

Time Periods	Energy Use (kWh)	Charges	Charges
Bill Ranges & Seasons	Total	Total	
1/1/2017 - 2/1/2017 W	2,530	$219	
2/1/2017 - 3/1/2017 W	2,207	$193	
3/1/2017 - 4/1/2017 W	2,332	$204	
4/1/2017 - 5/1/2017 W	2,779	$243	
5/1/2017 - 6/1/2017 S1	3,642	$432	
6/1/2017 - 7/1/2017 S1	5,562	$650	
7/1/2017 - 8/1/2017 SP1	6,742	$814	
8/1/2017 - 9/1/2017 SP1	6,056	$755	
9/1/2017 - 10/1/2017 S2	4,840	$563	
10/1/2017 - 11/1/2017 S2	3,791	$447	
11/1/2017 - 12/1/2017 W	2,223	$195	
12/1/2017 - 1/1/2018 W	2,506	$217	
Totals:	45,210	$4,932	

Utility Usage & Charges After

Time Periods	Energy Use (kWh)	Max Demand (kW)	Charges
Bill Ranges & Seasons	Total	NC / Max	Total
1/1/2017 - 2/1/2017 W	-80	3	$40
2/1/2017 - 3/1/2017 W	-511	3	$23
3/1/2017 - 4/1/2017 W	-1,200	4	$2
4/1/2017 - 5/1/2017 W	-1,342	4	-$17
5/1/2017 - 6/1/2017 S1	-609	6	$71
6/1/2017 - 7/1/2017 S1	1,473	9	$200
7/1/2017 - 8/1/2017 SP1	2,819	9	$294
8/1/2017 - 9/1/2017 SP1	2,165	10	$282
9/1/2017 - 10/1/2017 S2	1,182	8	$101
10/1/2017 - 11/1/2017 S2	562	7	$136
11/1/2017 - 12/1/2017 W	-635	3	$18
12/1/2017 - 1/1/2018 W	-14	3	$43
Totals:	3,810	-	$1,194

Low Rise - Apartments (South) Batter

4424 E Baseline Rd , Phoenix, AZ 85042

PV System Size

Power Rating (kW-DC):	58.8 kW-DC
Power Rating (kW-AC):	50.0 kW-AC

Energy kWh Offset (%):

340.6049%

PV System Production

DC/AC Ratio:	1.175
Production Ratio:	1,832 kWh/kW-DC

Eric Johnson - 4/13/2018

Low Rise - Apartments (South)

4424 E Baseline Rd Phoenix, AZ 85042

PV System Characteristics

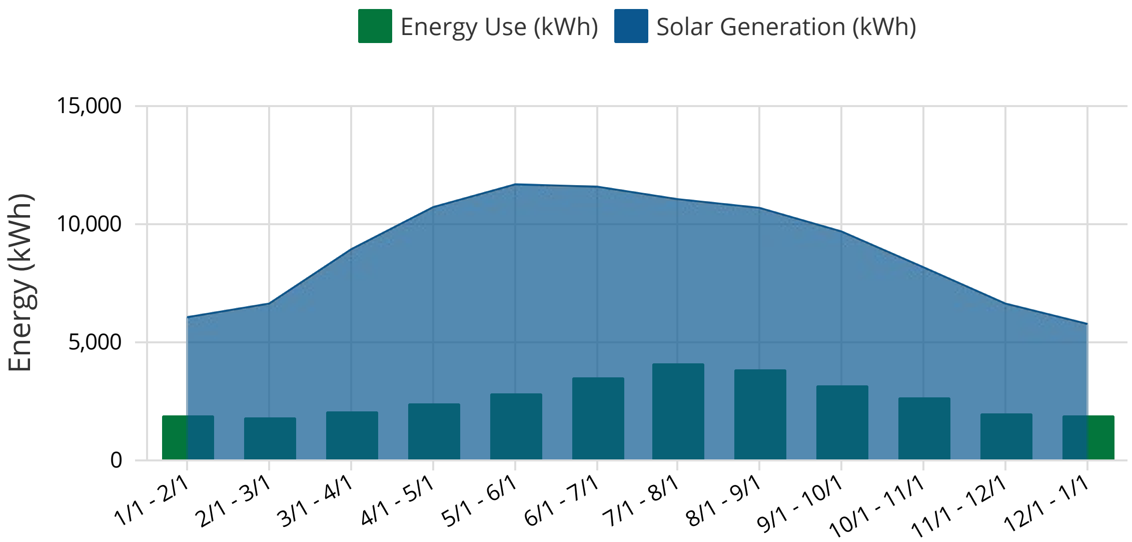
Power Rating (kW-DC):	58.8 kW-DC
Power Rating (kW-AC):	50.0 kW-AC
Energy kWh Offset (%):	340.6049
Solar PV Export (%):	67.3%

Total Annual Generation: 107,655 kWh

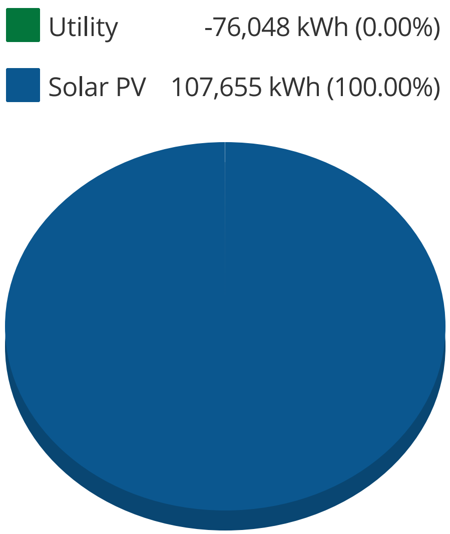
PV System Specifications

Solar Panels:	(125) SunPower SPR-X22-470_COM
Inverters:	(1) SMA SOLID-Q 50
Application Type:	Mid Rise - Apartments (South)

Monthly Energy Use Mix



Annual Energy Use Mix



Utility Rate Analysis

Avoided Cost Summary

Avoided Cost (Energy):	0.0594
Avoided Cost (Demand):	0.0001
Avoided Cost (Blended):	0.0595

Avoided Cost: 0.0595

Utility Summary

Utility Company:	Salt River Project
Current Rate Schedule:	E-36
Proposed Rate Schedule:	E-36
Account Number:	
Meter Number:	

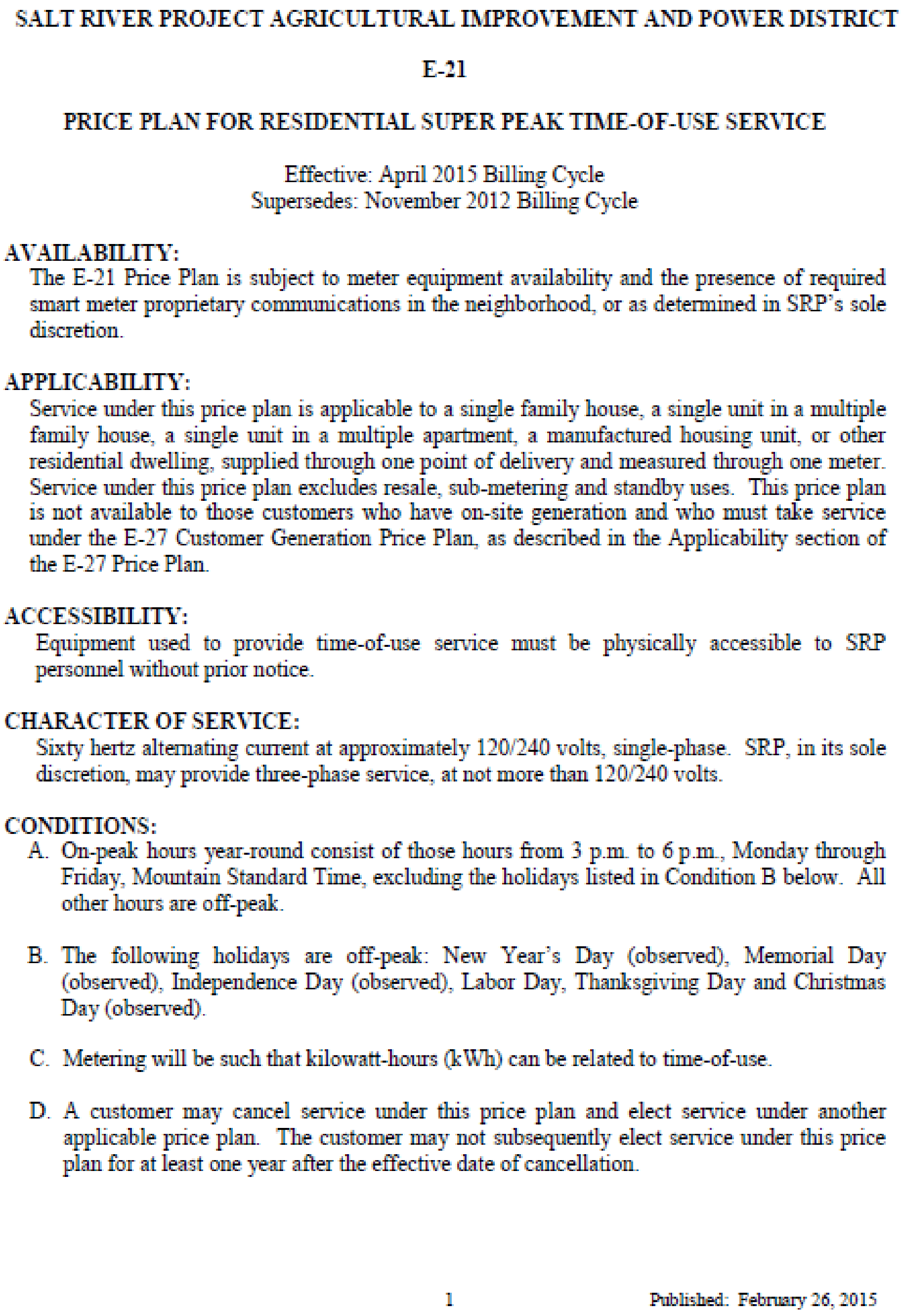
Utility Usage & Charges Before

Time Periods	Energy Use (kWh)	Max Demand (kW)	Charges
Bill Ranges & Seasons	Total	NC / Max	Total
1/1/2017 - 2/1/2017 W1	1,842	5	$188
2/1/2017 - 3/1/2017 W1	1,777	6	$192
3/1/2017 - 4/1/2017 W1	2,019	5	$197
4/1/2017 - 5/1/2017 W1	2,350	7	$237
5/1/2017 - 6/1/2017 S1	2,760	8	$325
6/1/2017 - 7/1/2017 S1	3,492	8	$368
7/1/2017 - 8/1/2017 SP1	4,040	8	$463
8/1/2017 - 9/1/2017 SP1	3,796	8	$446
9/1/2017 - 10/1/2017 S2	3,112	8	$346
10/1/2017 - 11/1/2017 S2	2,617	7	$301
11/1/2017 - 12/1/2017 W1	1,969	5	$195
12/1/2017 - 1/1/2018 W1	1,833	5	$187
Totals:	31,607	-	$3,445

Utility Usage & Charges After

Time Periods	Energy Use (kWh)	Max Demand (kW)	Charges
Bill Ranges & Seasons	Total	NC / Max	Total
1/1/2017 - 2/1/2017 W1	-3,967	-	-$150
2/1/2017 - 3/1/2017 W1	-4,628	-	-$185
3/1/2017 - 4/1/2017 W1	-6,664	-	-$291
4/1/2017 - 5/1/2017 W1	-8,135	-	-$368
5/1/2017 - 6/1/2017 S1	-8,659	-	-$453
6/1/2017 - 7/1/2017 S1	-7,773	-	-$400
7/1/2017 - 8/1/2017 SP1	-6,607	-	-$389
8/1/2017 - 9/1/2017 SP1	-6,480	-	-$380
9/1/2017 - 10/1/2017 S2	-6,241	-	-$308
10/1/2017 - 11/1/2017 S2	-5,224	-	-$248
11/1/2017 - 12/1/2017 W1	-4,395	-	-$173
12/1/2017 - 1/1/2018 W1	-3,664	-	-$134
Totals:	-72,437	-	-$2,880

Appendix C. Salt River Project Rate Schedules



SALT RIVER PROJECT AGRICULTURAL IMPROVEMENT AND POWER DISTRICT

E-21

PRICE PLAN FOR RESIDENTIAL SUPER PEAK TIME-OF-USE SERVICE

Effective: April 2015 Billing Cycle
Supersedes: November 2012 Billing Cycle

AVAILABILITY:

The E-21 Price Plan is subject to meter equipment availability and the presence of required smart meter proprietary communications in the neighborhood, or as determined in SRP's sole discretion.

APPLICABILITY:

Service under this price plan is applicable to a single family house, a single unit in a multiple family house, a single unit in a multiple apartment, a manufactured housing unit, or other residential dwelling, supplied through one point of delivery and measured through one meter. Service under this price plan excludes resale, sub-metering and standby uses. This price plan is not available to those customers who have on-site generation and who must take service under the E-27 Customer Generation Price Plan, as described in the Applicability section of the E-27 Price Plan.

ACCESSIBILITY:

Equipment used to provide time-of-use service must be physically accessible to SRP personnel without prior notice.

CHARACTER OF SERVICE:

Sixty hertz alternating current at approximately 120/240 volts, single-phase. SRP, in its sole discretion, may provide three-phase service, at not more than 120/240 volts.

CONDITIONS:

A. On-peak hours year-round consist of those hours from 3 p.m. to 6 p.m., Monday through Friday, Mountain Standard Time, excluding the holidays listed in Condition B below. All other hours are off-peak.

B. The following holidays are off-peak: New Year's Day (observed), Memorial Day (observed), Independence Day (observed), Labor Day, Thanksgiving Day and Christmas Day (observed).

C. Metering will be such that kilowatt-hours (kWh) can be related to time-of-use.

D. A customer may cancel service under this price plan and elect service under another applicable price plan. The customer may not subsequently elect service under this price plan for at least one year after the effective date of cancellation.

1 Published: February 26, 2015

E. A customer requiring additional interconnection, metering or other equipment beyond what is necessary for SRP to provide basic service applicable under this price plan must pay SRP for the costs of such additional equipment.

F. Applicable monthly charges or credits may be converted to daily amounts. The amounts would be annualized and then converted to daily charges or credits.

PRICE PER METER:

Monthly Service Charge	Summer 2015 and Summer Peak 2015 Billing Cycles	All Other Billing Cycles
Billing, Collections	$2.69	$2.69
Meter	$2.10	$2.10
Competitive Customer Service	$11.01	$11.01
Distribution Facilities	$2.70	$4.20
Total	$18.50	$20.00

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SALT RIVER PROJECT AGRICULTURAL IMPROVEMENT AND POWER DISTRICT

E-27

CUSTOMER GENERATION PRICE PLAN FOR RESIDENTIAL SERVICE

Effective: April 2015 Billing Cycle

AVAILABILITY:

The E-27 Price Plan is subject to equipment availability, as determined in SRP's sole discretion.

APPLICABILITY:

Service under this price plan is limited to residential customers with on-site generation who do not purchase all of their energy requirements from SRP. Participation in this plan is required for all such customers, except for those customers who originally installed the on-site generation at a residence on or before December 8, 2014, or who (i) by such date, either delivered to SRP a fully-executed contract for the installation of the on-site generation or had an SRP Residential Solar Electric Program Application for the on-site generation pending with SRP, and (ii) interconnect the generating facility with SRP's electrical grid by February 26, 2016. If a customer meets this exception, that customer will be exempt from required participation in this plan, for service at the residence where the system was originally installed, until the later of (a) March 31, 2025, or (b) the date that is 20 years after the date on which SRP initially interconnected the generating facility on which the exemption is based to SRP's electrical service grid. The foregoing exemption will run with the property, such that it will apply to the initial customer of record for the residence (meaning the person(s) in whose name(s) the account is held) and any subsequent customer of record for that same residence.

This plan is applicable to a single family house, a single unit in a multiple family house, a single unit in a multiple apartment, a manufactured housing unit, or other residential dwelling, where the on-site generation is installed. Service is supplied through one point of delivery and measured through one meter. Service under this price plan excludes resale, sub-metering and standby uses.

ACCESSIBILITY:

Equipment used to provide time-of-use service must be physically accessible to SRP personnel without prior notice.

CHARACTER OF SERVICE:

Sixty hertz alternating current at approximately 120/240 volts, single-phase. SRP, in its sole discretion, may provide three-phase service, at not more than 120/240 volts.

CONDITIONS:

A. On-peak hours from May 1 through October 31 consist of those hours from 1 p.m. to 8 p.m., Monday through Friday, Mountain Standard Time, excluding the holidays listed in Condition B below. On-peak hours from November 1 through April 30 consist of those hours from 5 a.m. to 9 a.m. and from 5 p.m. to 9 p.m., Monday through Friday, Mountain Standard Time, excluding the holidays listed in Condition B below. All other hours are off-peak.

B. The following holidays are off-peak: New Year's Day (observed), Memorial Day (observed), Independence Day (observed), Labor Day, Thanksgiving Day and Christmas Day (observed).

C. Metering will be such that kilowatts (kW) and kilowatt-hours (kWh) can be related to time-of-use.

D. A customer assigned to this price plan is required to maintain service under this price plan for the duration of the time the customer uses on-site generation and does not purchase all of their energy requirements from SRP.

E. A customer requiring additional interconnection, metering, or other equipment beyond what is necessary for SRP to provide basic service applicable under this price plan must pay SRP for the costs of such additional equipment.

F. Applicable monthly charges or credits may be converted to daily amounts. The amounts would be annualized and then converted to daily charges or credits.

G. The kWh delivered to SRP shall be subtracted from the kWh delivered from SRP for each billing cycle. If the kWh calculation is net positive for the billing cycle, SRP will bill the net kWh to the customer under this price plan. If the kWh calculation is net negative for the billing cycle, SRP will credit customer for the net kWh at the retail per-kWh price under this price plan. For the purposes of this calculation, excess generation will be tracked by time-of-use period.

PRICE PER METER:

Monthly Service Charge	Summer 2015 and Summer Peak 2015 Billing Cycles		All Other Billing Cycles	
	Amp Service 0-200	Amp Service 200+	Amp Service 0-200	Amp Service 200+
Billing, Collections	$2.69	$2.69	$2.69	$2.69
Meter	$2.10	$2.10	$2.10	$2.10
Competitive Customer Service	$11.01	$11.01	$11.01	$11.01
Distribution Facilities	$15.14	$28.14	$16.64	$29.64
Total	$30.94	$43.94	$32.44	$45.44

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E-27

On-Peak per kW Charges

SUMMER	First 3 kW	Next 7 kW	All Add'l kW
Distribution Delivery	$2.70	$4.83	$9.58
Transmission Delivery	$1.93	$3.51	$6.66
Transmission Cost Adjustment	$0.00	$0.00	$0.00
Ancillary Services 1-2	$0.09	$0.18	$0.35
System Benefits	$0.09	$0.18	$0.34
Environmental Programs Adjustment	$0.77	$1.38	$2.62
Competitive Customer Service	$0.00	$0.00	$0.00
Energy (Generation)	$2.45	$4.55	$8.22
Total	$8.03	$14.63	$27.77

SUMMER PEAK	First 3 kW	Next 7 kW	All Add'l kW
Distribution Delivery	$2.79	$5.05	$10.40
Transmission Delivery	$2.57	$4.77	$9.11
Transmission Cost Adjustment	$0.00	$0.00	$0.00
Ancillary Services 1-2	$0.13	$0.25	$0.49
System Benefits	$0.12	$0.21	$0.36
Environmental Programs Adjustment	$0.88	$1.64	$3.16
Competitive Customer Service	$0.00	$0.00	$0.00
Energy (Generation)	$3.10	$5.90	$10.67
Total	$9.59	$17.82	$34.19

WINTER	First 3 kW	Next 7 kW	All Add'l kW
Distribution Delivery	$0.31	$0.52	$0.98
Transmission Delivery	$0.96	$1.56	$2.68
Transmission Cost Adjustment	$0.00	$0.00	$0.00
Ancillary Services 1-2	$0.06	$0.11	$0.19
System Benefits	$0.08	$0.15	$0.21
Environmental Programs Adjustment	$0.72	$1.09	$1.84
Competitive Customer Service	$0.00	$0.00	$0.00
Energy (Generation)	$1.42	$2.25	$3.84
Total	$3.55	$5.68	$9.74

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E-27

Per kWh Charges

	On-Peak	Off-Peak
SUMMER	All kWh	All kWh
Ancillary Services 3-6	$0.0022	$0.0003
Energy (Generation)	$0.0169	$0.0073
Fuel and Purchased Power	$0.0295	$0.0295
Total	$0.0486	$0.0371

	On-Peak	Off-Peak
SUMMER PEAK	All kWh	All kWh
Ancillary Services 3-6	$0.0026	$0.0003
Energy (Generation)	$0.0312	$0.0125
Fuel and Purchased Power	$0.0295	$0.0295
Total	$0.0633	$0.0423

	On-Peak	Off-Peak
WINTER	All kWh	All kWh
Ancillary Services 3-6	$0.0012	$0.0003
Energy (Generation)	$0.0198	$0.0167
Fuel and Purchased Power	$0.0220	$0.0220
Total	$0.0430	$0.0390

Summer is defined as the May, June, September and October billing cycles. Summer Peak is defined as the July and August billing cycles. Winter is defined as the November through April billing cycles.

ANCILLARY SERVICES:

Ancillary services provided include:

1) Scheduling, System Control and Dispatch Service
2) Reactive Supply and Voltage Control from Generation Sources Service
3) Regulation and Frequency Response Service
4) Energy Imbalance Service
5) Operating Reserve – Spinning Reserve Service
6) Operating Reserve – Supplemental Reserve Service

Direct access customers must secure Ancillary Services 3-6 from an alternative energy supplier or from SRP under the terms and conditions outlined in SRP's Open Access Transmission Tariff.

MINIMUM BILL:

The Monthly Service Charge.

DETERMINATION OF DEMAND IN KILOWATTS:

The billing demand is the maximum thirty-minute integrated kW demand occurring during the on-peak periods of the billing cycle, as measured by the meter.

ADJUSTMENTS:

A. SRP may increase or decrease the price for Fuel and Purchased Power based on changes in the average cost of fuel and purchased power. The price for Fuel and Purchased Power is calculated for the summer and winter season based on the projected cost of fuel and purchased power, adjusted for the actual over- or under-collection of fuel and purchased power revenues relative to fuel and purchased power expenses from prior periods.

B. SRP may adjust the Transmission Cost Adjustment Factor to recover transmission related costs or charges incurred by SRP resulting from standardized wholesale market designs, regional transmission organizations or related activities.

C. SRP may increase or decrease the Environmental Programs Cost Adjustment Factor based on changes in the cost of providing energy efficiency, renewable energy and other environmental programs. The price for Environmental Programs is calculated based on the projected cost of the programs, adjusted for the actual over- or under-collection of the programs relative to expenses from prior periods.

D. SRP will increase or decrease billings under this price plan in proportion to any taxes, fees, or charges (excluding federal or state income taxes) levied or imposed by any governmental authority and payable by SRP for any services, power, or energy provided under this price plan.

RULES AND REGULATIONS:

A. Service under this price plan and all associated riders shall be in accordance with the terms of SRP's Rules and Regulations, as they may be amended or revised by SRP from time to time. Failure by a customer to comply in all material respects with SRP's Rules and Regulations may result in SRP terminating electric service to the customer.

B. For direct access customers, service under this price plan is in accordance with the terms of SRP's Direct Access Program, as set forth in the Rules and Regulations, including any amendments.

SPECIAL RIDERS:

A. Limited-income customers may qualify for a discount under the Economy Discount Rider.

B. Customers with medical life support equipment may qualify for a discount under the Medical Life Support Equipment Discount Rider, if and to the extent that rider is available for participation by such customers.

C. Customers who wish to support the development of renewable energy may elect to participate in the Renewable Energy Credit Pilot Rider.

D. Customers who wish to support the development of solar energy may elect to participate in the Residential Community Solar Pilot Rider, if and to the extent that rider is available for participation by such customers.

E. Customers may be eligible to participate in SRP's Renewable Energy Service Pilot Rider.

SALT RIVER PROJECT AGRICULTURAL IMPROVEMENT AND POWER DISTRICT

E-36

STANDARD PRICE PLAN FOR GENERAL SERVICE

Effective: April 2015 Billing Cycle
Supersedes: November 2012 Billing Cycle

APPLICABILITY:

Service under this price plan is applicable to commercial, business, professional, small industrial and recreational facilities, supplied through one point of delivery and measured through one meter. This schedule applies to any service for which no other standard price plan is available.

CHARACTER OF SERVICE:

Sixty hertz alternating current. SRP, in its sole discretion, may provide three-phase or single-phase, at one standard voltage of approximately 120/208; 120/240; 277/480; 2,400/4,160; or 7,200/12,000 volts.

CONDITIONS:

A. A customer requiring additional interconnection, metering, or other equipment beyond what is necessary for SRP to provide basic service applicable under this price plan must pay SRP for the costs of such additional equipment.

B. Applicable monthly charges or credits may be converted to daily amounts. The amounts would be annualized and then converted to daily charges or credits.

PRICE PER METER:

Monthly Service Charge	
Billing, Collections	$3.25
Distribution Delivery	$18.83
Total	$22.08

Meter
The type of meter will be solely determined by SRP based on customer usage and character of service.

Meter	
Non Demand	$6.75
Demand	$6.75
CT/PT	$17.52

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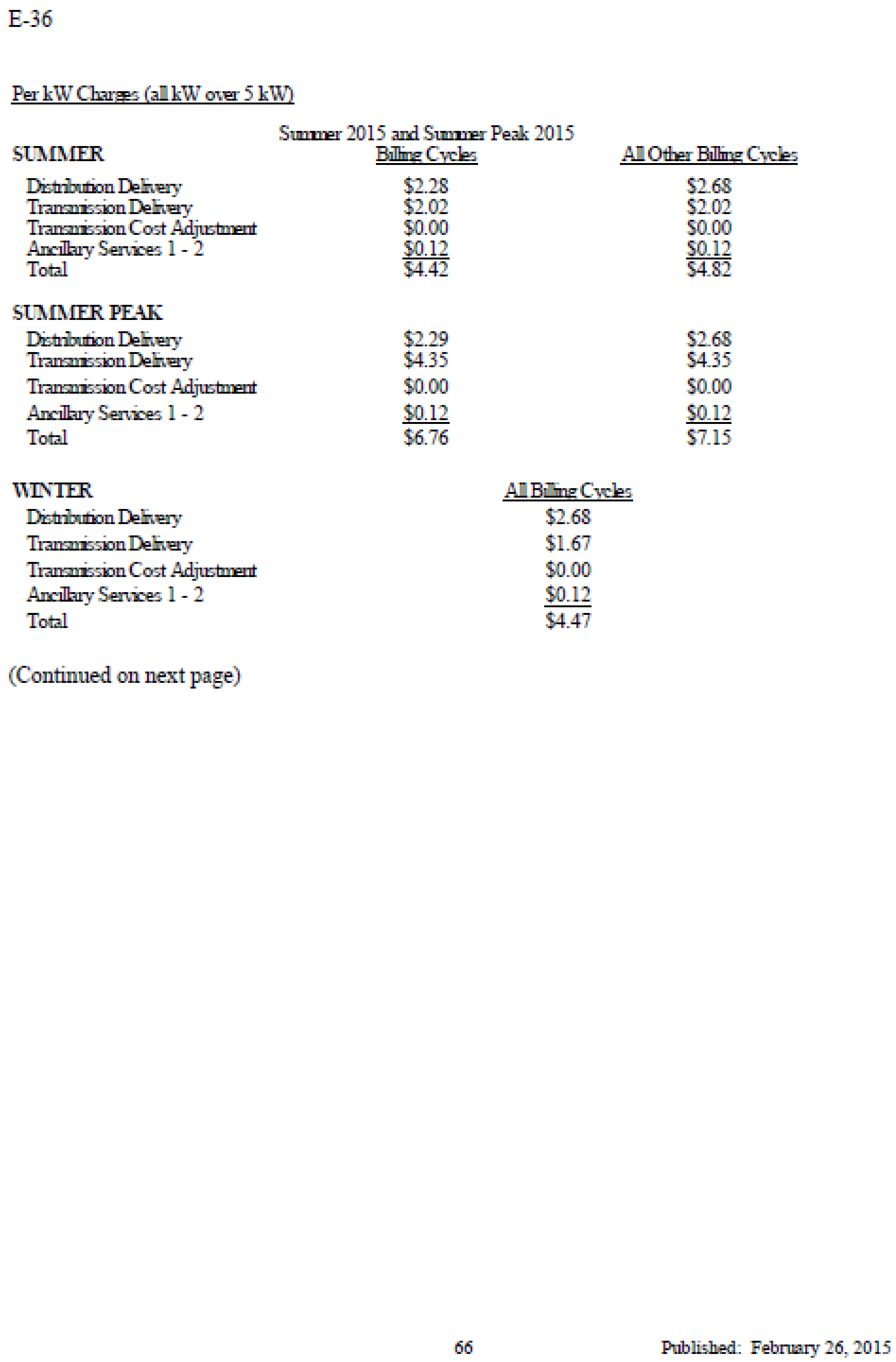

E-36

Per kW Charges (all kW over 5 kW)

SUMMER	Summer 2015 and Summer Peak 2015 Billing Cycles	All Other Billing Cycles
Distribution Delivery	$2.28	$2.68
Transmission Delivery	$2.02	$2.02
Transmission Cost Adjustment	$0.00	$0.00
Ancillary Services 1 - 2	$0.12	$0.12
Total	$4.42	$4.82
SUMMER PEAK		
Distribution Delivery	$2.29	$2.68
Transmission Delivery	$4.35	$4.35
Transmission Cost Adjustment	$0.00	$0.00
Ancillary Services 1 - 2	$0.12	$0.12
Total	$6.76	$7.15

WINTER	All Billing Cycles
Distribution Delivery	$2.68
Transmission Delivery	$1.67
Transmission Cost Adjustment	$0.00
Ancillary Services 1 - 2	$0.12
Total	$4.47

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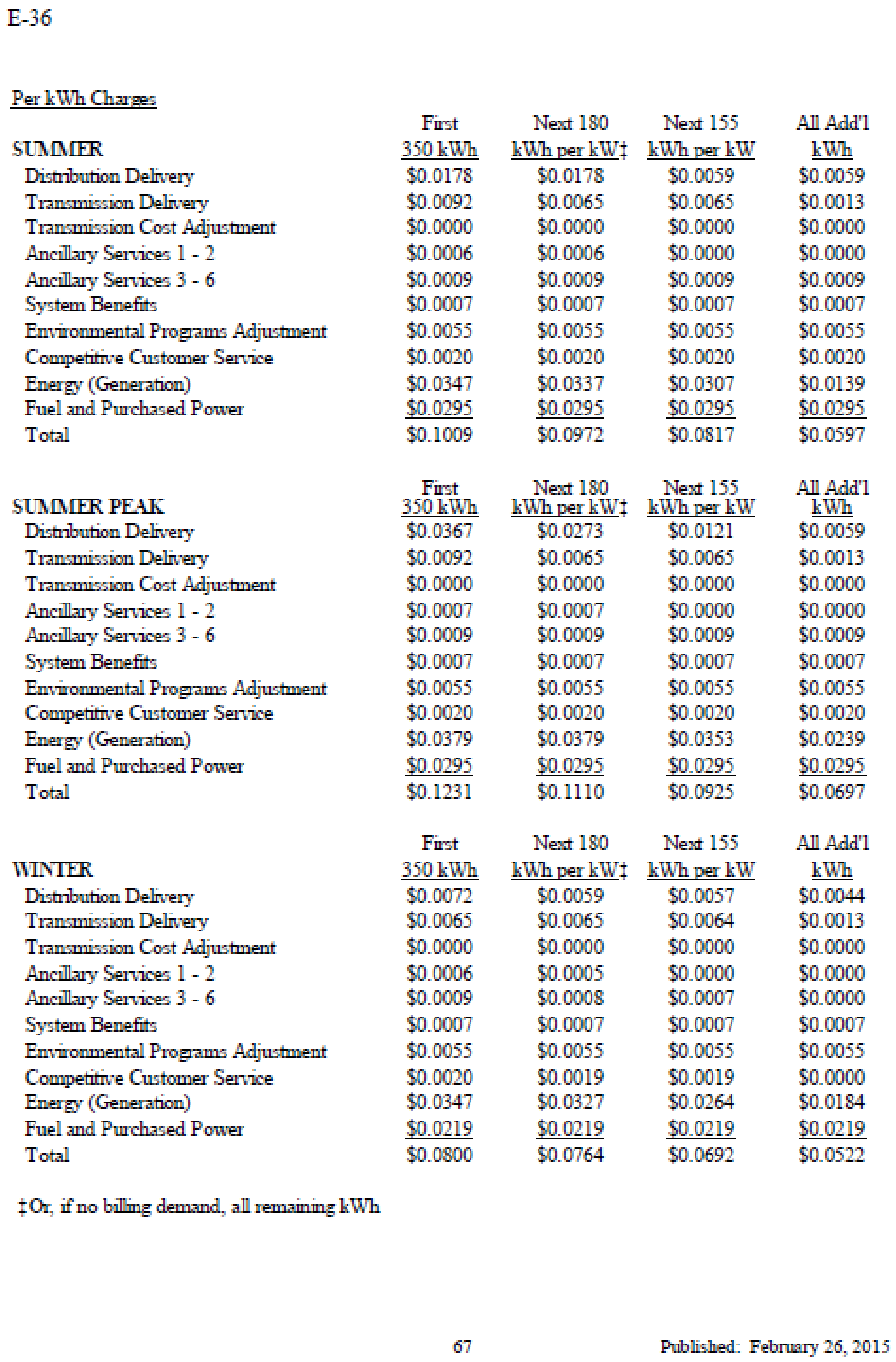


E-36

Per kWh Charges

SUMMER	First 350 kWh	Next 180 kWh per kW‡	Next 155 kWh per kW	All Add'l kWh
Distribution Delivery	$0.0178	$0.0178	$0.0059	$0.0059
Transmission Delivery	$0.0092	$0.0065	$0.0065	$0.0013
Transmission Cost Adjustment	$0.0000	$0.0000	$0.0000	$0.0000
Ancillary Services 1 - 2	$0.0006	$0.0006	$0.0000	$0.0000
Ancillary Services 3 - 6	$0.0009	$0.0009	$0.0009	$0.0009
System Benefits	$0.0007	$0.0007	$0.0007	$0.0007
Environmental Programs Adjustment	$0.0055	$0.0055	$0.0055	$0.0055
Competitive Customer Service	$0.0020	$0.0020	$0.0020	$0.0020
Energy (Generation)	$0.0347	$0.0337	$0.0307	$0.0139
Fuel and Purchased Power	$0.0295	$0.0295	$0.0295	$0.0295
Total	$0.1009	$0.0972	$0.0817	$0.0597

SUMMER PEAK	First 350 kWh	Next 180 kWh per kW‡	Next 155 kWh per kW	All Add'l kWh
Distribution Delivery	$0.0367	$0.0273	$0.0121	$0.0059
Transmission Delivery	$0.0092	$0.0065	$0.0065	$0.0013
Transmission Cost Adjustment	$0.0000	$0.0000	$0.0000	$0.0000
Ancillary Services 1 - 2	$0.0007	$0.0007	$0.0000	$0.0000
Ancillary Services 3 - 6	$0.0009	$0.0009	$0.0009	$0.0009
System Benefits	$0.0007	$0.0007	$0.0007	$0.0007
Environmental Programs Adjustment	$0.0055	$0.0055	$0.0055	$0.0055
Competitive Customer Service	$0.0020	$0.0020	$0.0020	$0.0020
Energy (Generation)	$0.0379	$0.0379	$0.0353	$0.0239
Fuel and Purchased Power	$0.0295	$0.0295	$0.0295	$0.0295
Total	$0.1231	$0.1110	$0.0925	$0.0697

WINTER	First 350 kWh	Next 180 kWh per kW‡	Next 155 kWh per kW	All Add'l kWh
Distribution Delivery	$0.0072	$0.0059	$0.0057	$0.0044
Transmission Delivery	$0.0065	$0.0065	$0.0064	$0.0013
Transmission Cost Adjustment	$0.0000	$0.0000	$0.0000	$0.0000
Ancillary Services 1 - 2	$0.0006	$0.0005	$0.0000	$0.0000
Ancillary Services 3 - 6	$0.0009	$0.0008	$0.0007	$0.0000
System Benefits	$0.0007	$0.0007	$0.0007	$0.0007
Environmental Programs Adjustment	$0.0055	$0.0055	$0.0055	$0.0055
Competitive Customer Service	$0.0020	$0.0019	$0.0019	$0.0000
Energy (Generation)	$0.0347	$0.0327	$0.0264	$0.0184
Fuel and Purchased Power	$0.0219	$0.0219	$0.0219	$0.0219
Total	$0.0800	$0.0764	$0.0692	$0.0522

‡Or, if no billing demand, all remaining kWh

Published: February 26, 2015

Summer is defined as the May, June, September and October billing cycles. Summer Peak is defined as the July and August billing cycles. Winter is defined as the November through April billing cycles.

ANCILLARY SERVICES:

Ancillary services provided include:

1) Scheduling, System Control and Dispatch Service
2) Reactive Supply and Voltage Control from Generation Sources Service
3) Regulation and Frequency Response Service
4) Energy Imbalance Service
5) Operating Reserve – Spinning Reserve Service
6) Operating Reserve – Supplemental Reserve Service

Direct access customers must secure Ancillary Services 3-6 from an alternative energy supplier or from SRP under the terms and conditions outlined in SRP's Open Access Transmission Tariff.

MINIMUM BILL:

The greater of:

A. The Monthly Service Charge or
B. The minimum monthly dollar amount specified in a written Agreement for Electric Service, if any.

DETERMINATION OF DEMAND IN KILOWATTS:

A. The billing demand, when applicable, is the maximum fifteen-minute integrated kW demand occurring during the billing cycle, as measured by meter.
B. SRP may require demand metering for any service.

ADJUSTMENTS:

A. SRP may increase or decrease the price for Fuel and Purchased Power based on changes in the average cost of fuel and purchased power. The price for Fuel and Purchased Power is calculated for the summer and winter season based on the projected cost of fuel and purchased power, adjusted for the actual over- or under-collection of fuel and purchased power revenues relative to fuel and purchased power expenses from prior periods.

B. SRP may adjust the Transmission Cost Adjustment Factor to recover transmission related costs or charges incurred by SRP resulting from standardized wholesale market designs, regional transmission organizations, or related activities.

C. SRP may increase or decrease the Environmental Programs Cost Adjustment Factor based on changes in the cost of providing energy efficiency, renewable energy and other environmental programs. The price for Environmental Programs is calculated based on the projected cost of the programs, adjusted for the actual over- or under-collection of the programs relative to expenses from prior periods.

D. SRP will increase or decrease billings under this price plan in proportion to any taxes, fees, or charges (excluding federal or state income taxes) levied or imposed by any governmental authority and payable by SRP for any services, power, or energy provided under this price plan.

E. If the power factor falls below 85 percent lagging at any metering point during any billing period, SRP may:

   1. Adjust kilowatt-hours (kWh) and/or kW during this period, for billing purposes, to equal 85 percent of kilovolt-ampere-hours (kVAh) and 85 percent of kilovolt-amperes (kVA).

   2. Require the customer to correct the power factor to an acceptable level.

   3. Require the customer to be continuously metered with a separate meter that registers kVA, kilovars (kvar), or actual power factor.

   At SRP's discretion, customer may be required to pay all costs associated with additional metering.

F. If, at any time, the current in any phase exceeds the average of the currents in the three phases by more than 5 percent, at SRP's option, SRP may increase the bill for the period during which the imbalance occurs by a percentage equal to that of the imbalance.

G. Customers within the SRP distribution service territory who receive all electric services from SRP under the E-32, E-36, E-47, E-48, E-61, E-63, E-65 or E-66 Price Plans who meet minimum usage requirements will receive an aggregation discount on their monthly bill(s).

   Aggregation Discount = $0.0003/kWh

   Single accounts meeting minimum usage levels can qualify for aggregation discounts.

   Aggregate usage must meet a minimum usage requirement of 300,000 kWh per month for three consecutive months. Only those accounts receiving energy and delivery services from SRP will count towards the minimum usage requirements. If aggregate usage falls below 300,000 kWh for twelve consecutive months, SRP, at its option, may cancel the aggregation discount.

   The discount will be applied only to kWh sold under the applicable price plan. The discount will be applied before the application of any credits, penalties, fees, or premiums.

H. For customers metered for billing purposes at primary voltage, SRP will deduct 1 percent of the per kW and per kWh charges from each billing. Primary voltage is defined as the same voltage found at the low side of a substation transformer, typically 12,470 volts or 4,160 volts. The deduction does not apply to monthly service charges, facilities charges (where applicable), taxes, penalties, fees, or other adjustments.

RULES AND REGULATIONS:

A. Service under this price plan and all associated riders shall be in accordance with the terms of SRP's Rules and Regulations, as they may be amended or revised by SRP from time to time. Failure by a customer to comply in all material respects with SRP's Rules and Regulations may result in SRP terminating electric service to the customer.

B. At SRP's request, Customer shall sign SRP's then-current form of Agreement for Electric Service as a condition of service under this price plan.

C. For direct access customers, service under this price plan is in accordance with the terms of SRP's Direct Access Program, as set forth in the Rules and Regulations, including any amendments.

SPECIAL RIDERS:

A. Customers who wish to support the development of renewable energy may elect to participate in the Renewable Energy Credit Pilot Rider.

B. Customers with cogeneration or small power production who purchase power and energy from SRP may qualify to sell power and energy back to SRP under the Buyback Service Rider.

C. Customers with qualifying renewable energy generation systems who purchase power and energy from SRP may qualify to sell power and energy back to SRP under the Renewable Net Metering Rider, if and to the extent that rider is available for participation by such customers.

D. Customers who qualify may choose to participate in SRP's Energy for Education Pilot Rider.

E. Customers who wish to support the development of solar energy may elect to participate in the Business Community Solar Pilot Rider, if and to the extent that rider is available for participation by such customers.

F. Customers who qualify who wish to support the development of solar energy may elect to participate in the Community Solar for Schools Pilot Rider, if and to the extent that rider is available for participation by such customers.

G. Customers may be eligible to participate in SRP's Renewable Energy Services Pilot Rider.

H. Customers who have un-metered service under the E-36 Price Plan may qualify for meter and meter reading credits under the Un-metered Credit Rider.

I. Non-governmental customers utilizing public lighting facilities owned by SRP will be subject to lighting equipment charges pursuant to the Non-Municipal Public Lighting Equipment Rider, if such customers currently participate in that rider, or otherwise the Lighting Equipment Rider.

J. Municipal, state, county, or other governmental customers utilizing public lighting facilities owned by SRP will be subject to lighting equipment charges pursuant to the Municipal Public Lighting Equipment Rider, if such customers currently participate in that rider, or, if applicable, pursuant to a separate written contract with SRP.

K. Customers utilizing private security lighting facilities owned by SRP will be subject to lighting equipment charges pursuant to the Private Security Lighting Equipment Rider or the Lighting Equipment Rider, whichever rider in which any such customer currently participates.

L. Customers with a minimum annual load of 100 kW and who have the flexibility to curtail load may qualify for service under the Use Fee Interruptible Rider.

M. Customers with curtailable load are eligible to participate in the Customized Interruptible Rider.

N. Customers with individual accounts or aggregated loads of 1 MW or more, who have energy alternatives and who are willing to sign a term contract, may qualify for service under the Full Electric Service Requirements Rider.

Appendix D - Building Characteristics for Hourly Load Data

Adapted from EERE (2013).

Table E-1: Residential Mixed Dry / Hot Dry Base Load Model Characteristics

Building Fuel	
Space heating	Natural gas
Air conditioning	Yes
Water heating	Natural gas
Building Structure	
Total size (sq ft)	2000
Urban / Rural	Urban
Metropolitan or Micropolitan	Metro
# of stories	1
Major outside wall construction	Stucco
Major roofing material	Ceramic / Clay tile
Foundation	Concrete slab
Bedrooms	3
Full bathrooms	2
Half bathrooms	None
Basement	No
Finished Basement	No basement
Type of glass in windows	Single-pane
Building Design	

All other options set to B10 Benchmark House (Hendron & Engelbrecht, 2010)

Table E-2: Residential Mixed Dry / Hot Dry High Load Model Characteristics

Building Fuel	
Space heating	Natural gas
Air conditioning	Yes
Water heating	Natural gas
Building Structure	
Total size (sq ft)	3000
Urban / Rural	Urban
Metropolitan or Micropolitan	Metro
# of stories	2
Major outside wall construction	Stucco
Major roofing material	Ceramic / Clay tile
Foundation	Crawlspace
Bedrooms	4
Full bathrooms	2
Half bathrooms	1
Basement	No
Finished Basement	Crawlspace
Type of glass in windows	Single-pane
Building Design	
Heating set point (*F)	74
Cooling set point (*F)	74

Water flow rate (showers / sinks)	Benchmark
Natural ventilation	None
Wall insulation type	R7
Unfinished Attic insulation type	R19
Finished basement wall insulation	8ft R5 Rigid
Exposed floor (%)	80
Infiltration	Leaky
Refrigerator	Energy Star Side-by-Side
Cooking Range	Electric Conventional
Dishwasher	Standard
Clothes Washer	Standard
Clothes Dryer	Electric
Lighting	20% Fluor, 80% Incand
A/C Unit Type	SEER 10
Water Heater	Gas standard
Furnace	Gas, AFUE 78%

Table E-3: Residential Mixed Dry / Hot Dry Low Load Model Characteristics

Building Fuel	
Space heating	Natural gas
Air conditioning	Yes

Water heating	Natural gas
Building Structure	
Total size (sq ft)	1000
Urban / Rural	Urban
Metropolitan or Micropolitan	Metro
# of stories	1
Major outside wall construction	Stucco
Major roofing material	Ceramic / Clay tile
Foundation	Slab
Bedrooms	2
Full bathrooms	1
Half bathrooms	0
Basement	No
Finished Basement	No
Type of glass in windows	Double-pane
Building Design	
Heating set point (*F)	66
Cooling set point (*F)	78
Water flow rate (showers / sinks)	Low flow
Natural ventilation	B10 Benchmark (Hendron & Engelbrecht, 2010)
Wall insulation type	R21 Foam
Unfinished Attic insulation type	R38
Finished basement wall insulation	N/A

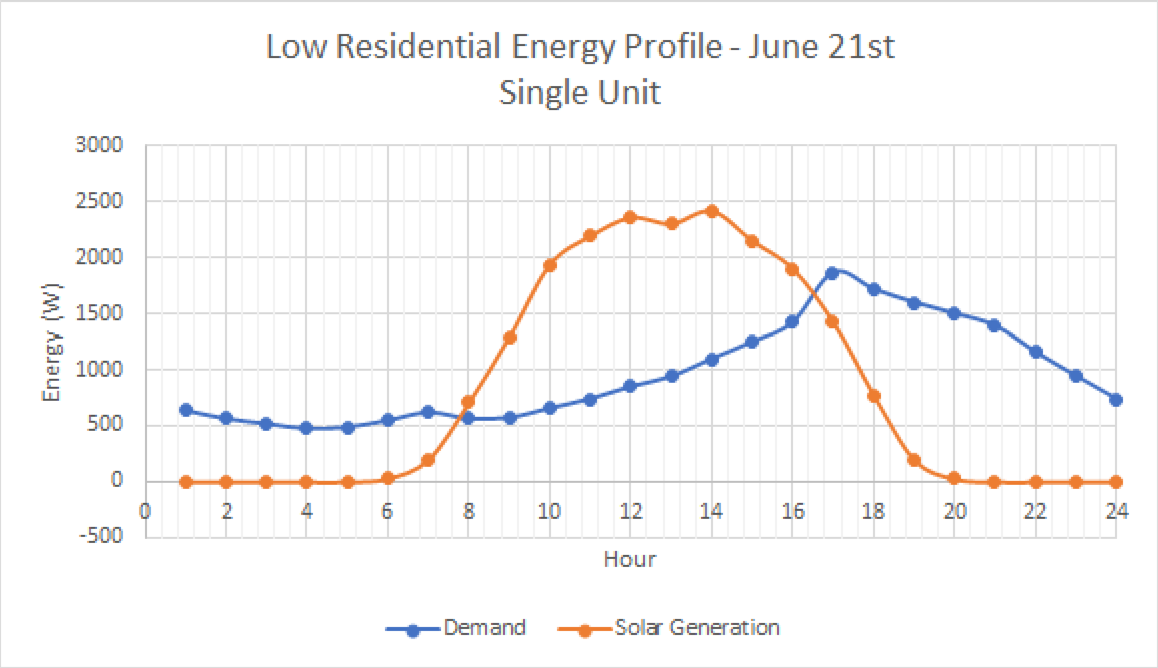
Exposed floor (%)	20
Infiltration	Tight
Refrigerator	Energy Star Top-Mount
Cooking Range	Gas conventional
Dishwasher	Energy Star
Clothes Washer	Energy Star
Clothes Dryer	None (clothes line)
Lighting	100% Fluor
A/C Unit Type	SEER 16
Water Heater	Gas premium
Furnace	Gas, AFUE 92.5%

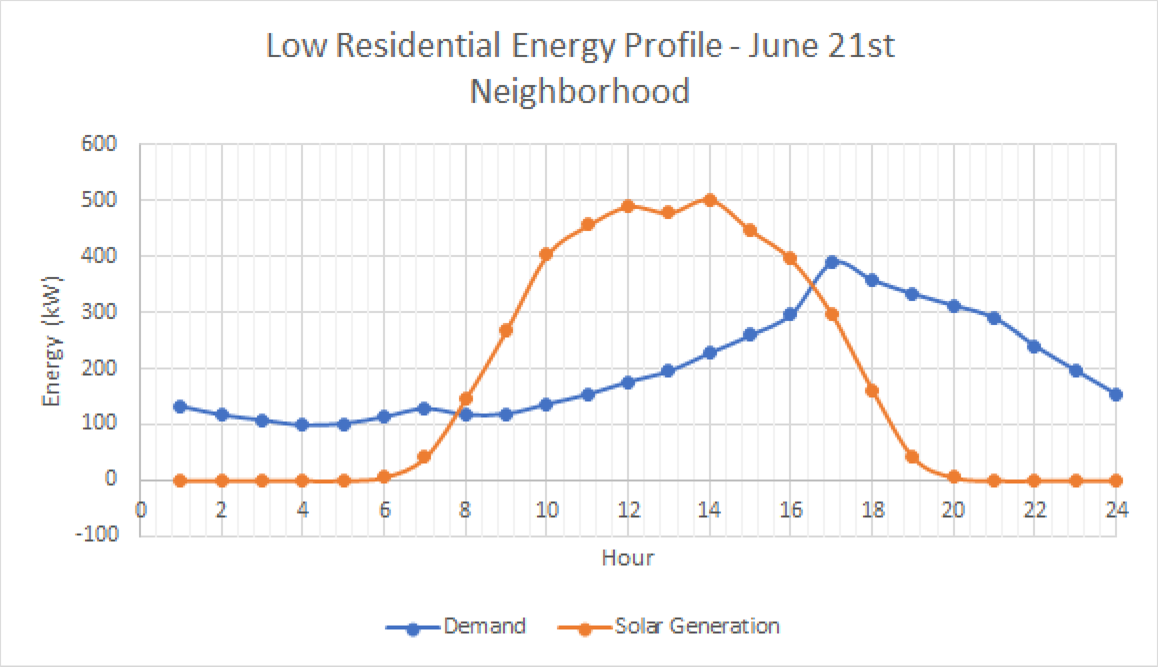
Table E-4: Mid-rise Apartment Building
Adapted from Deru et al. (2011).

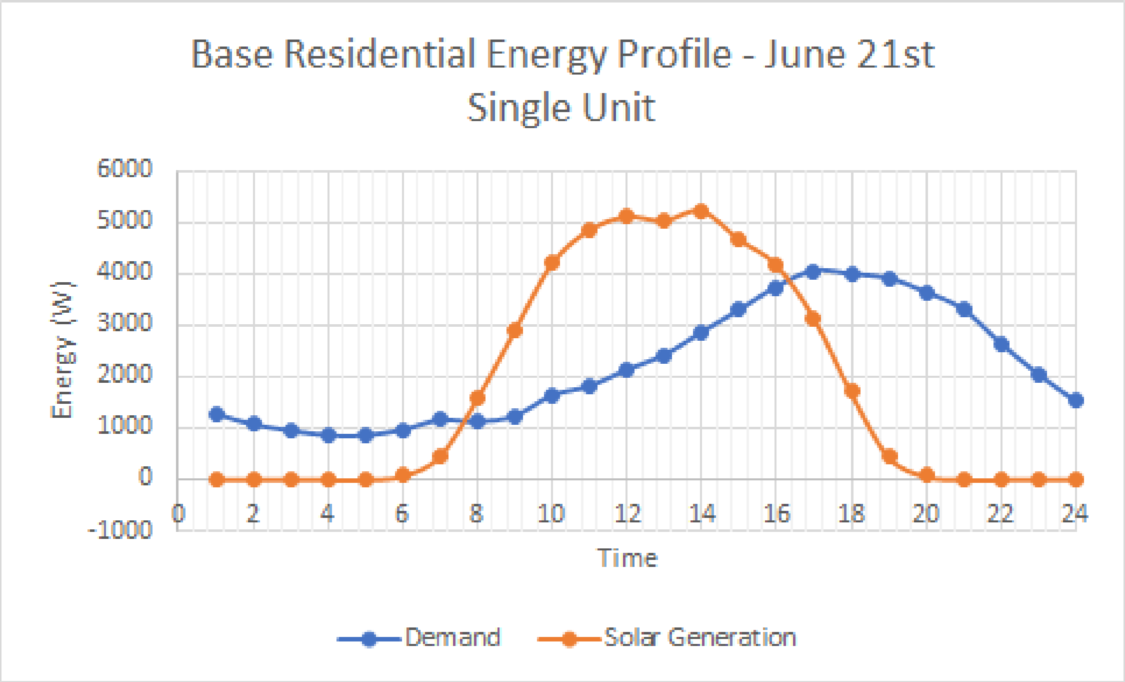
Floor Area	33,740 sqft
Aspect Ratio	2.7
# of Floors	4
Floor-to-floor Height	10
Floor-to-Ceiling Height	10
Glazing Fraction	0.15
Frame	Steel
Parking Lot Area	28,578 sqft
Parking Lot Lighting Level	5,144 W

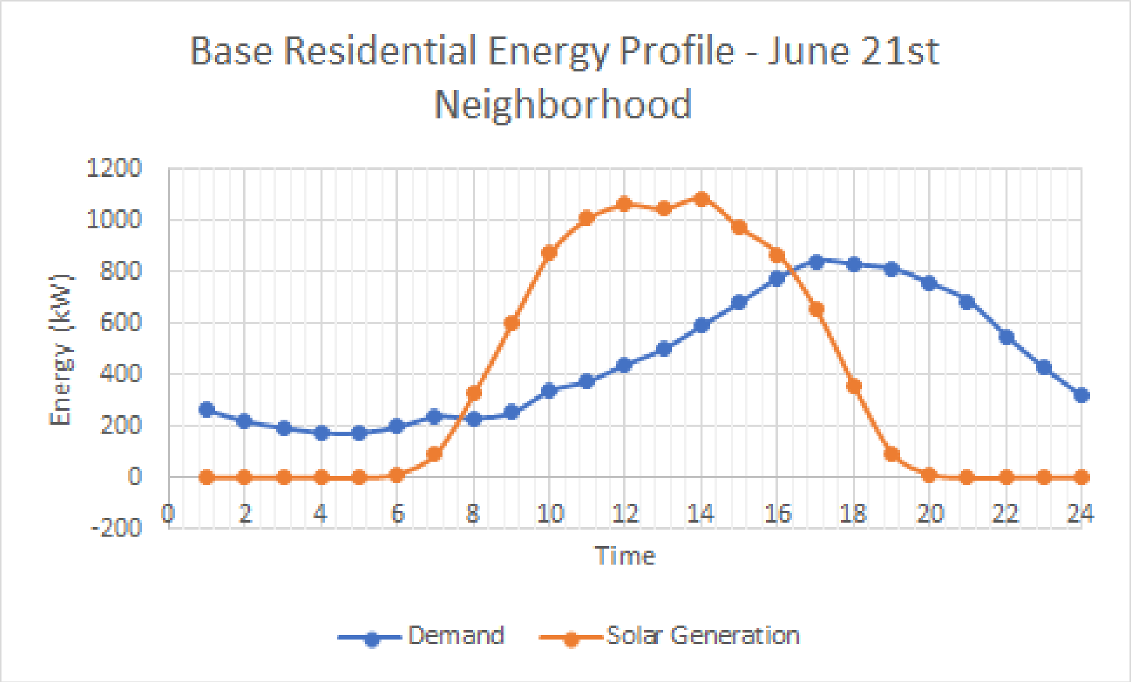
Heating	Furnace
Cooling	Packaged Air-Conditioning Unit (Split System)
Air Distribution	Single-Zone Constant Air Volume

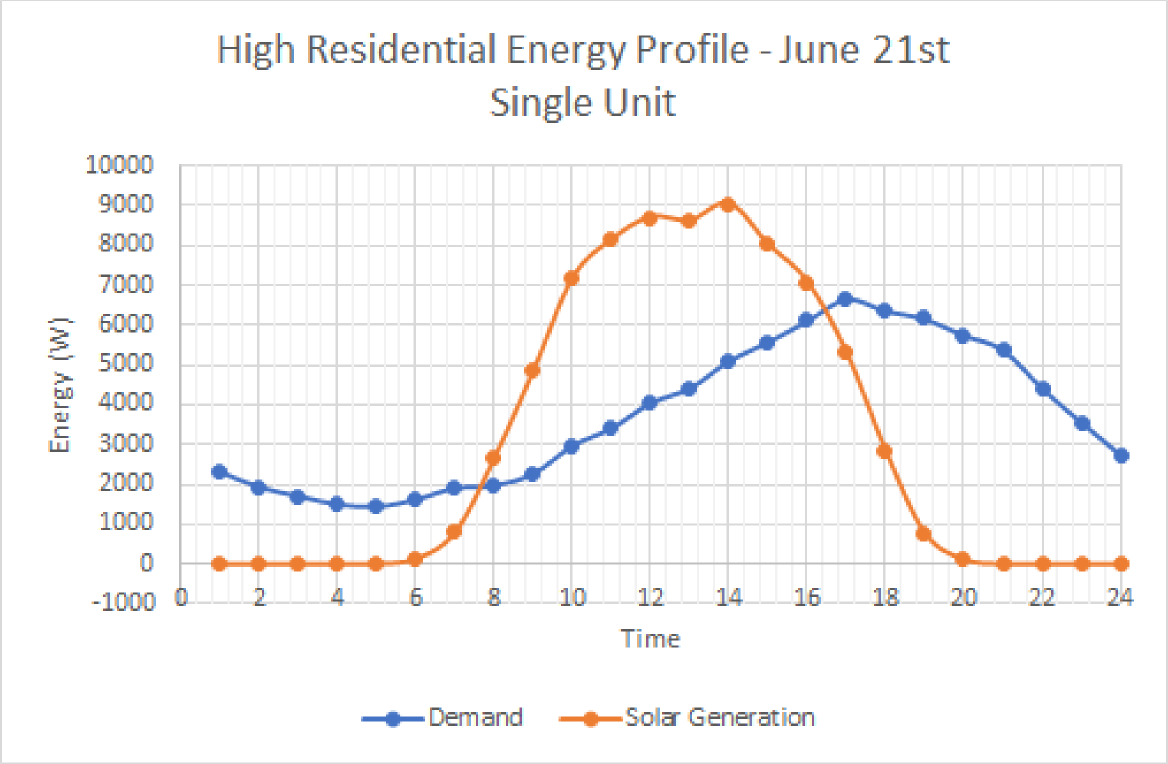
Appendix E - Energy Profiles

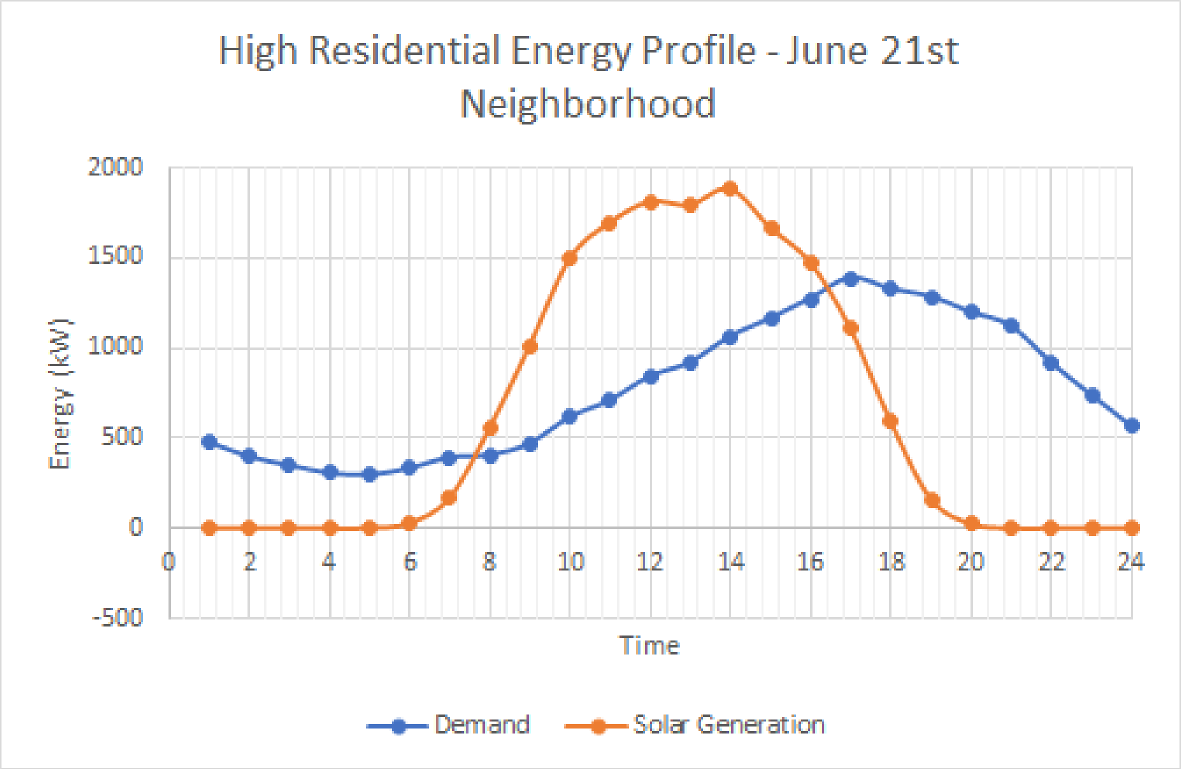


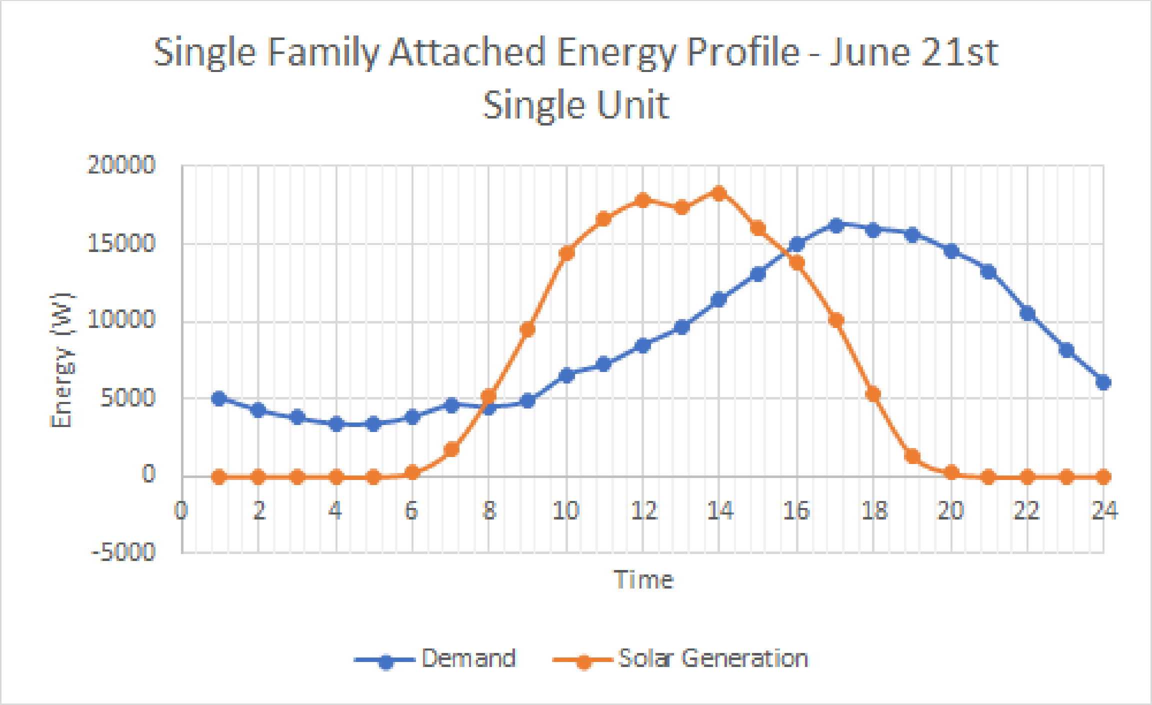


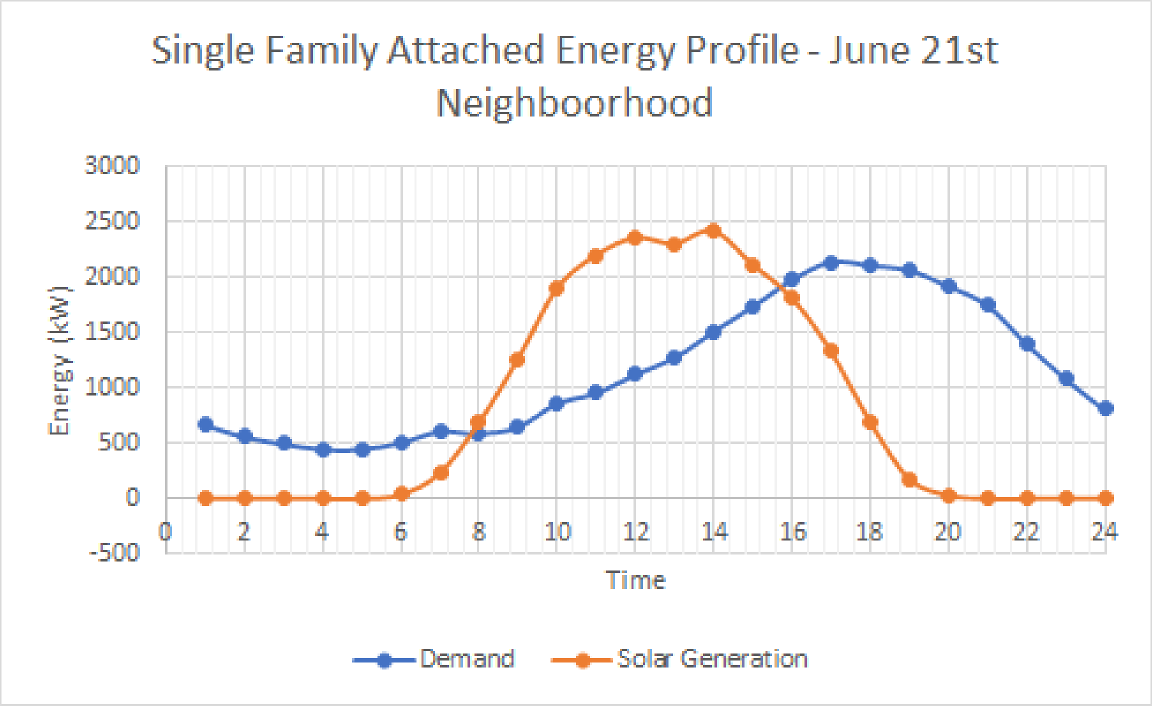

Base Residential Energy Profile - June 21st
Single Unit
Energy (W)
6000
5000
4000
3000
2000
1000
0
-1000
0
2
4
6
8
10
12
14
16
18
20
22
24
Time
Demand
Solar Generation

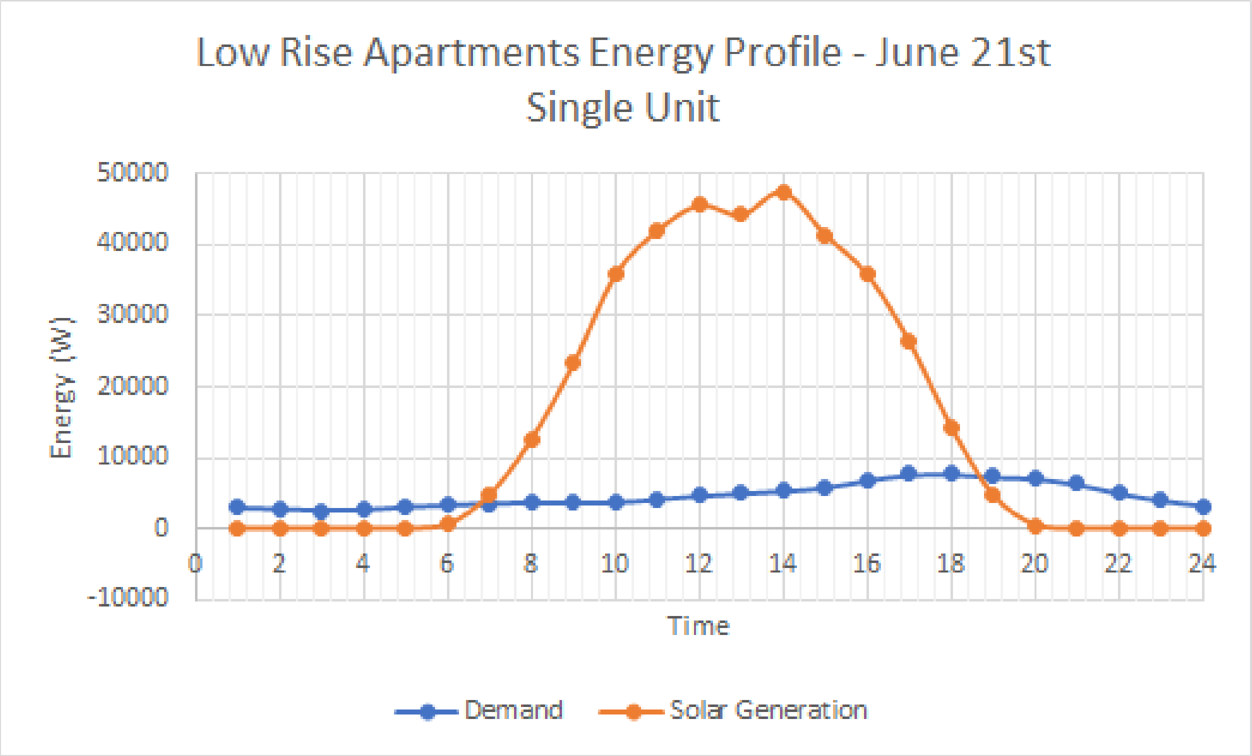

Base Residential Energy Profile - June 21st
Neighborhood
Energy (kW)
1200
1000
800
600
400
200
0
-200
0
2
4
6
8
10
12
14
16
18
20
22
24
Time
Demand
Solar Generation

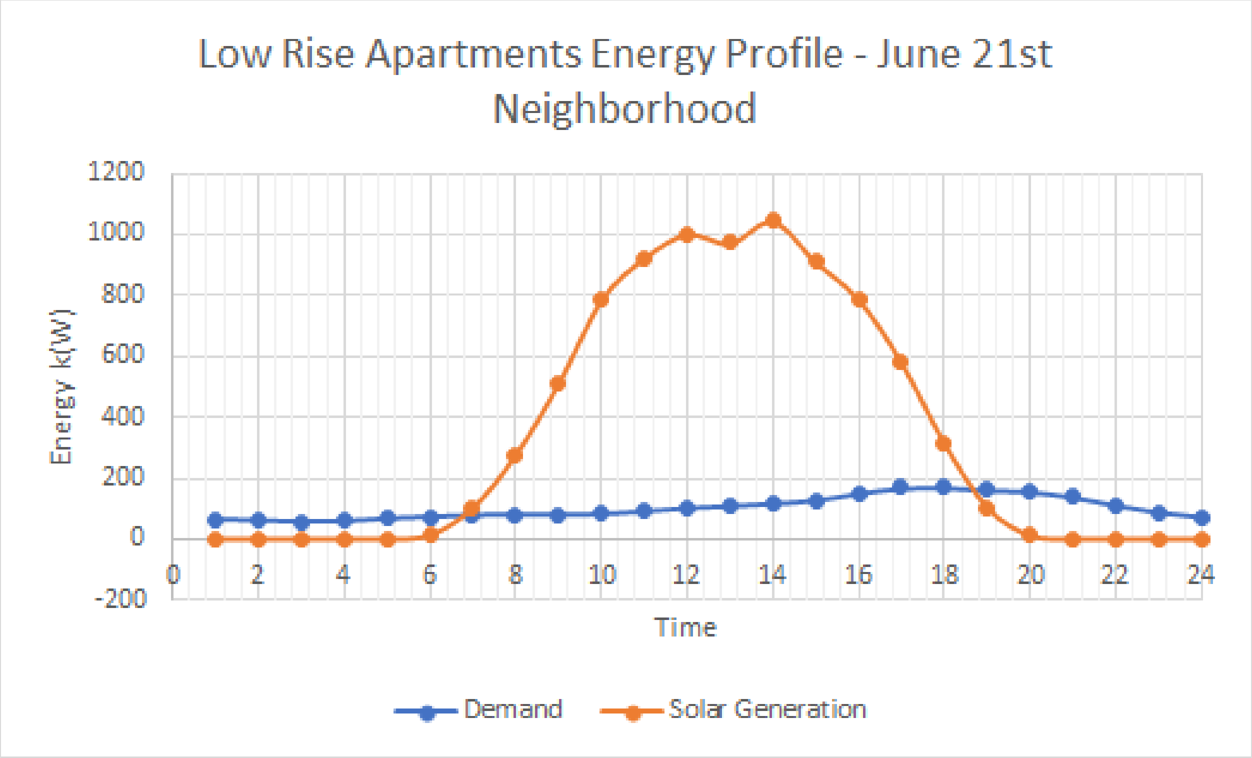

High Residential Energy Profile - June 21st
Single Unit
Energy (W)
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-1000
0
2
4
6
8
10
12
14
16
18
20
22
24
Time
Demand
Solar Generation

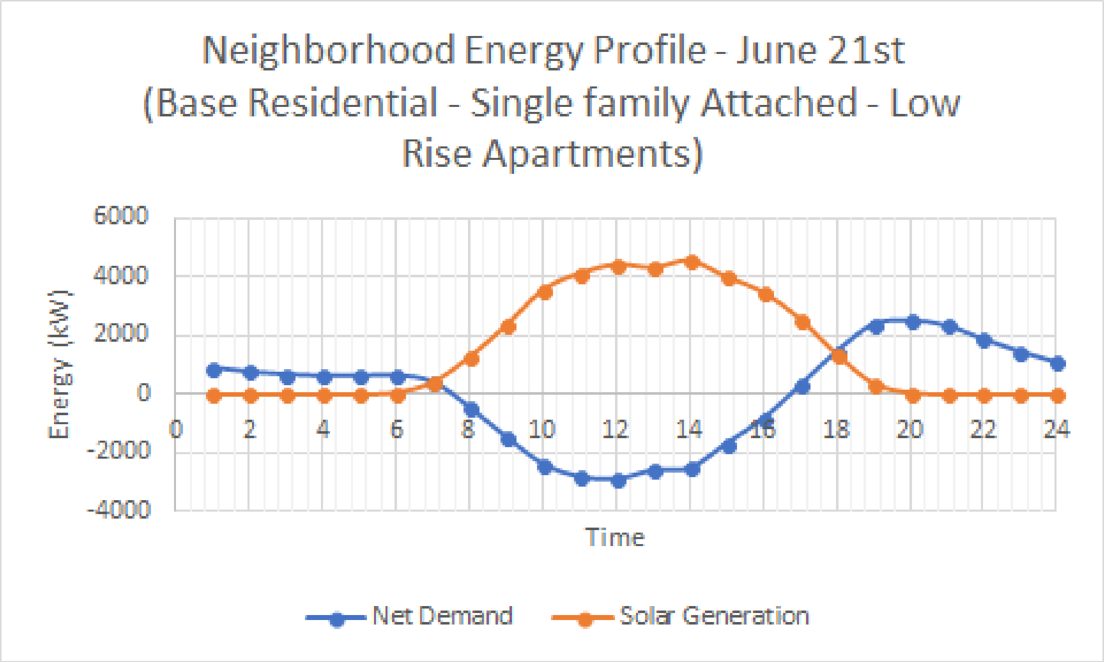

High Residential Energy Profile - June 21st
Neighborhood
Energy (kW)
2000
1500
1000
500
0
-500
0
2
4
6
8
10
12
14
16
18
20
22
24
Time
Demand
Solar Generation


Single Family Attached Energy Profile - June 21st
Single Unit
Energy (W)
20000
15000
10000
5000
0
-5000
0
2
4
6
8
10
12
14
16
18
20
22
24
Time
Demand
Solar Generation

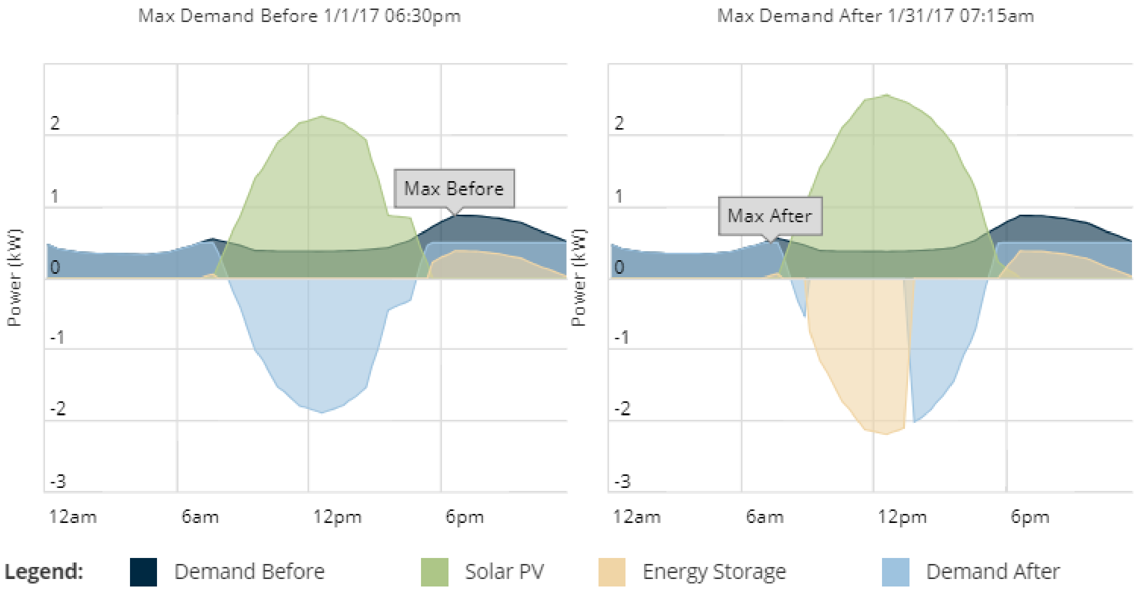

Single Family Attached Energy Profile - June 21st
Neighboorhood
Energy (kW)
3000
2500
2000
1500
1000
500
0
-500
0
2
4
6
8
10
12
14
16
18
20
22
24
Time
Demand
Solar Generation


Low Rise Apartments Energy Profile - June 21st
Single Unit
Energy (W)
50000
40000
30000
20000
10000
0
-10000
0
2
4
6
8
10
12
14
16
18
20
22
24
Time
Demand
Solar Generation


Low Rise Apartments Energy Profile - June 21st
Neighborhood
Energy k(W)
1200
1000
800
600
400
200
0
-200
0
2
4
6
8
10
12
14
16
18
20
22
24
Time
Demand
Solar Generation

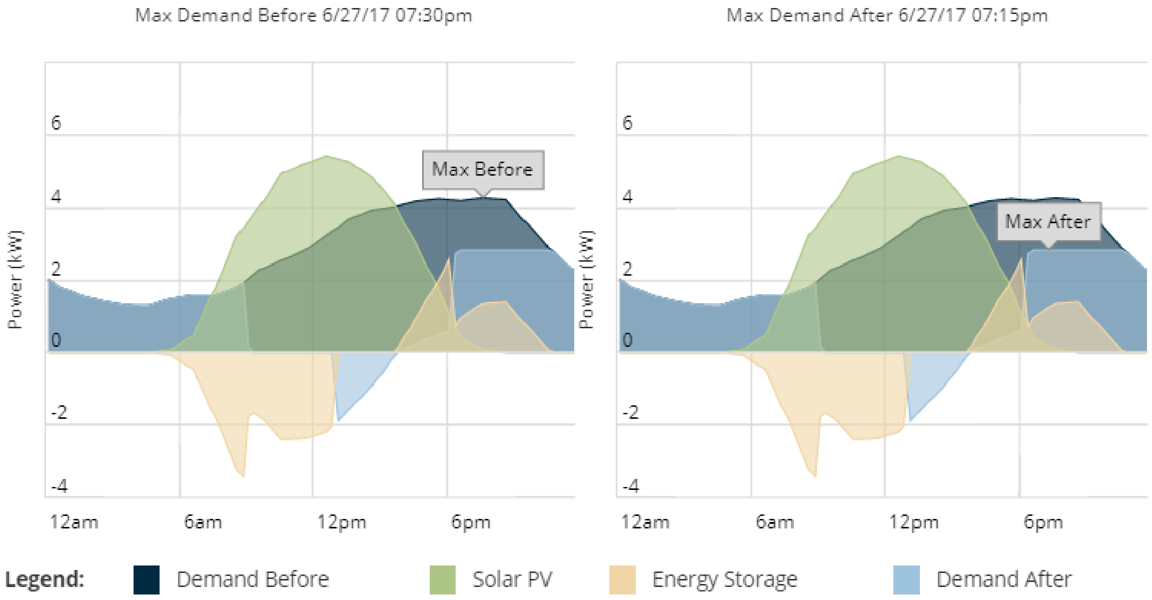


Energy Profile Low Residential with Battery System



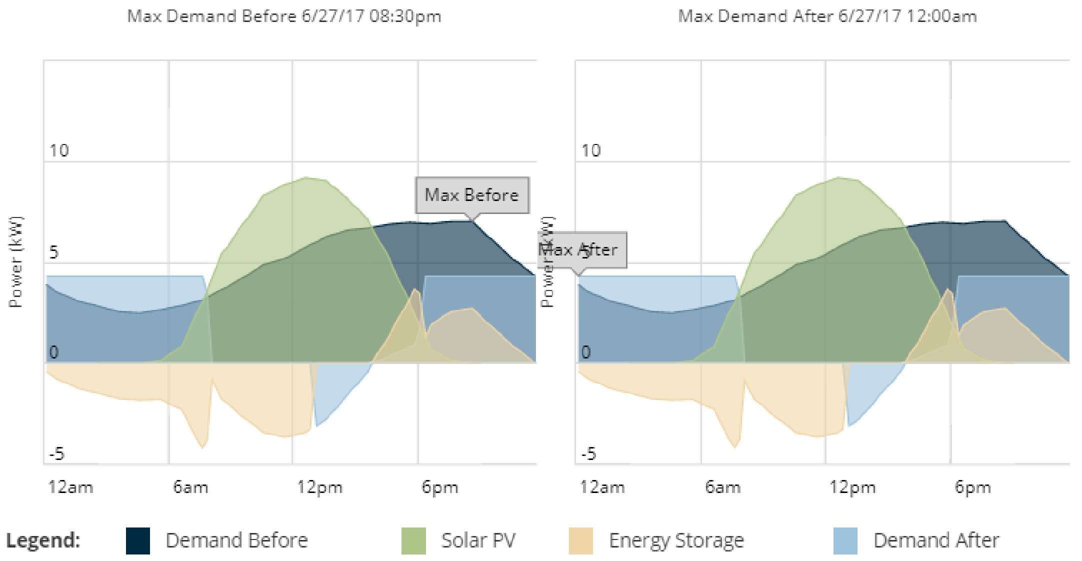
Max On-Peak Demand: The charts below show when the maximum on-peak demand for this facility occurred before and after the hybrid Solar PV with Storage system simulation.

Energy Profile Base Residential with Battery System



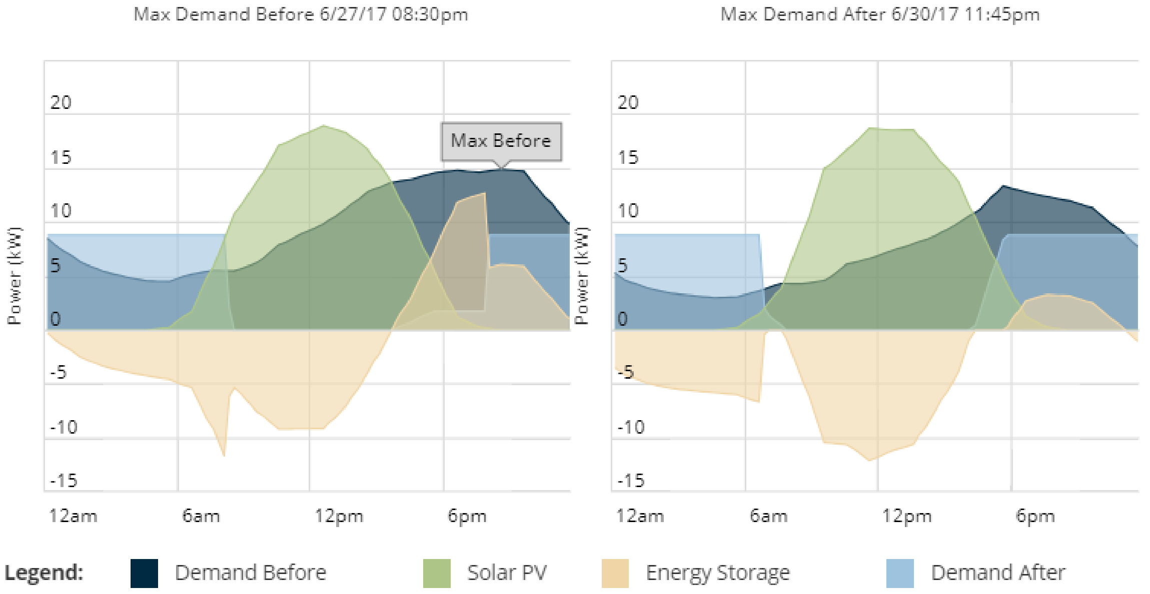
Max On-Peak Demand: The charts below show when the maximum on-peak demand for this facility occurred before and after the hybrid Solar PV with Storage system simulation.

Energy Profile High Residential with Battery System



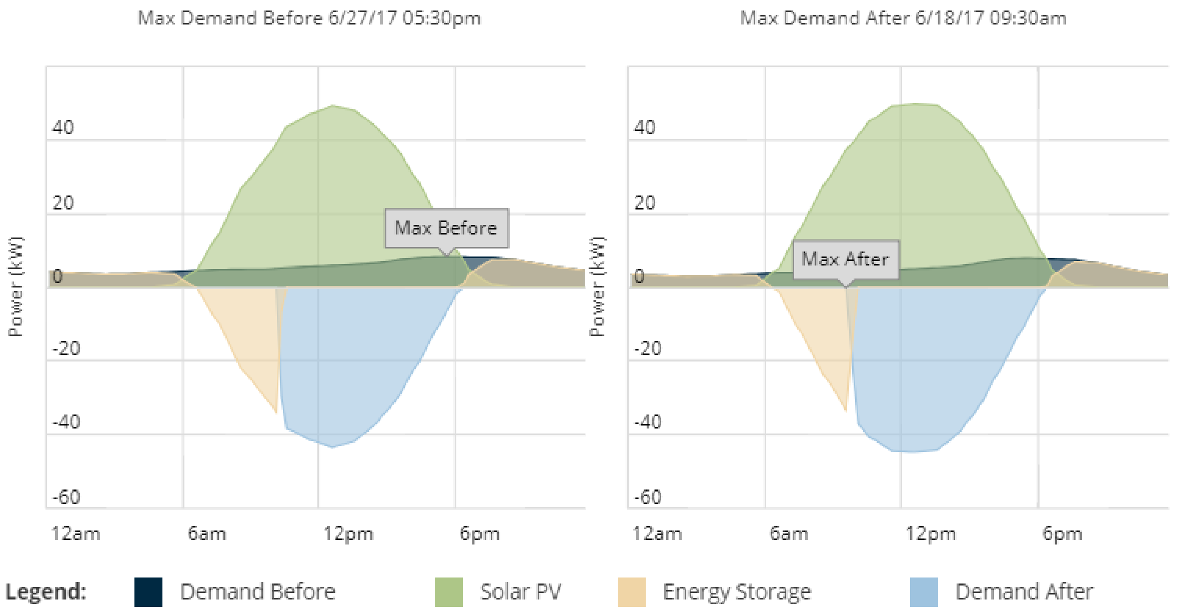
Max On-Peak Demand: The charts below show when the maximum on-peak demand for this facility occurred before and after the hybrid Solar PV with Storage system simulation.

Energy Profile Single Family Attached with Battery System

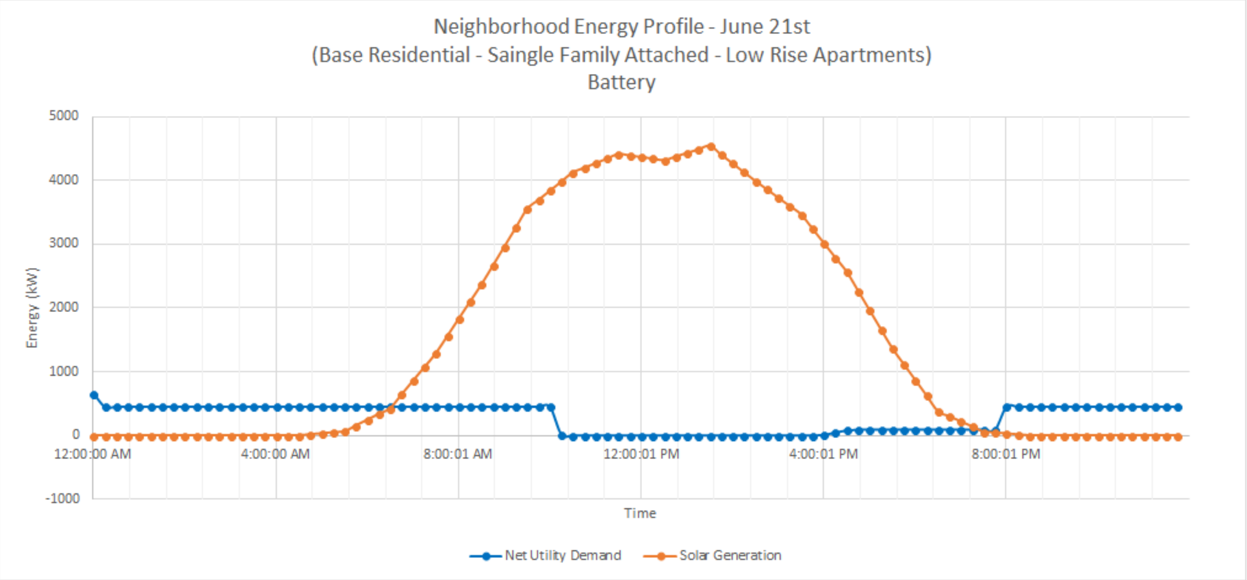


Max On-Peak Demand: The charts below show when the maximum on-peak demand for this facility occurred before and after the hybrid Solar PV with Storage system simulation.

Energy Profile Low Rise Apartments with Battery System



Max On-Peak Demand: The charts below show when the maximum on-peak demand for this facility occurred before and after the hybrid Solar PV with Storage system simulation.



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