Renewable Energy in Rural Southeastern Arizona: Decision Factors:

A Comparison of the Consumer Profiles of Homeowners

Who Purchased Renewable Energy Systems With Those

Who Performed Other Home Upgrades or Remodeling Projects

by

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ABSTRACT

Arizona has an abundant solar resource and technologically mature systems are available to capture it, but solar energy systems are still considered to be an innovative technology. Adoption rates for solar and wind energy systems rise and fall with the political tides, and are relatively low in most rural areas in Arizona. This thesis tests the hypothesis that a consumer profile developed to characterize the adopters of renewable energy technology (RET) systems in rural Arizona is the same as the profile of other area residents who performed renovations, upgrades or additions to their homes. Residents of Santa Cruz and Cochise Counties who had obtained building permits to either install a solar or wind energy system or to perform a substantial renovation or upgrade to their home were surveyed to gather demographic, psychographic and behavioristic data. The data from 133 survey responses (76 from RET adopters and 57 from non-adopters) provided insights about their decisions regarding whether or not to adopt a RET system. The results, which are statistically significant at the 99% level of confidence, indicate that RET adopters had smaller households, were older and had higher education levels and greater income levels than the non-adopters. The research also provides answers to three related questions: First, are the energy conservation habits of RET adopters the same as those of non-adopters? Second, what were the sources of information consulted and the most important factors that motivated the decision to

purchase a solar or wind energy system? And finally, are any of the factors which influenced the decision to live in a rural area in southeastern Arizona related to the decision to purchase a renewable energy system? The answers are provided, along with a series of recommendations that are designed to inform marketers and other promoters of RETs about how to utilize these results to help achieve their goals.

ACKNOWLEDGMENTS

First, I would like to express my deep appreciation for the efforts of my thesis committee members. Linda Kennedy, the Director of the Audubon Society's Appleton-Whittell Research Ranch and my fellow Practical Energy for Rural Communities team member, was instrumental in the initial discussions about how to describe and measure rural residents' attitudes and actions taken regarding energy conservation and renewable energy technologies. Kelli Larson, Assistant Professor, School of Geographical Sciences and Urban Planning and School of Sustainability, directed me to several important information sources about surveys and provided invaluable advice and counsel to me during the initial survey design phase and feedback during the subsequent fine-tuning of the survey instrument. Martin "Mike" Pasqualetti, Professor, School of Geographical Sciences and Urban Planning and Graduate Faculty, Global Technology and Development, was always available to provide a point of contact or a response to a question about energy technologies as they have been implemented in Arizona and elsewhere in the southwest. A fourth, although unofficial, member of my committee who should also be recognized here was Norma Hubele, Professor Emeritus, Department of Industrial Engineering, Ira A. Fulton School of Engineering. Dr. Hubele was my chief statistical advisor and she helped me design the data analysis procedures used to analyze the null hypotheses. Finally, Agami Reddy, Professor, School of Sustainability and SRP Professor of

Energy and Environment, The Design School, and also my Committee Chair, was there throughout the process, even before I decided to focus my thesis research on the same rural communities with which I had begun working under a fellowship in Santa Cruz County. Without his guidance, advice and feedback, this research would have never have come close to completion.

Speaking of the research fellowship which first brought me from Phoenix down to the rural communities in southeastern Arizona, I would like to acknowledge the financial support provided by the Audubon Society's TogetherGreen initiative, funded by Toyota. Without the hard work by Dr. Kennedy and Jeanne Horsmann to promote energy conservation principles and the more widespread adoption of renewable energy technologies in their own community, which ultimately led to the award of the TogetherGreen grant which paid the stipend for my fellowship, my thesis would have been totally unrelated to rural communities.

During the initial data collection phase of my research, I spent a lot of time in the Santa Cruz County (SCC) Complex in Nogales and the Cochise County (CC) Complex in Bisbee. The courteous and always-cheerful assistance of Corinna Carbajal and Sonia Lopez of the CC Planning Department and Sylvia Jontow in the SCC Building Department helped make the tedious work of reviewing building permits a lot more enjoyable. The patience and assistance of CC Community Development Department Aide Beverly Bullington was also instrumental to my effort to secure enough names and addresses of county residents for me to complete my research.

Special thanks also to the 133 residents of the two counties who were kind enough to spend from ten minutes to, in a few cases, over an hour answering my survey questions. In many cases, they engaged me in stimulating conversations about renewable energy systems and sometimes about sustainability in general and my research and studies in particular. Specifically, I would like to thank the folks who were willing to help me pilot the initial version of the survey. Among them were Marshall Magruder, Steve and Gail Getzwiller and Jim and Rita Johnson. The insights and suggestions they provided as the initial group of respondents proved to be eminently valuable to the design of the survey instrument I used for the bulk of the responses.

Finally, I cannot finish this section without recognizing the support and contributions made by my beautiful wife Maria. The early brainstorming and other discussion sessions, then helping with the call sheets and phone script, and finally her role as my chief proofreader were necessary and instrumental ingredients to the successful completion of this work. Her patience (not always but often enough), the help around the house, particularly in the late-thesis-writing crunch time, and the other words and thoughts she contributed during the entirety of this research, analysis and writing effort were most gratefully accepted and appreciated. I therefore dedicate this thesis to her.

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INTRODUCTION

1.1 Background

The challenges of living in a rural area are many. Among them are the relative difficulty involved with accessing a variety of basic resources, including some government and business services, and the minimal amount of political clout wielded by rural residents. For example, city residents commonly have a choice of transportation options ranging from walking and riding bicycles to mass transit and personal vehicles, while in rural areas personal vehicles are often the only option. For people living in an unincorporated area, opportunities to interact with the area's political representatives can be rare, and frequently the priorities of politicians are dominated by larger population centers. Even in the academic literature, articles that focus on rural problems and urban-rural comparisons are less prevalent than those that study urban issues, at least in the United States.

Rural residents comprise about 20% of the population of the U.S. but they occupy a much larger proportion of the land area than do their urban counterparts. Due to the diffuse nature of wind and solar energy, there are large land requirements for systems that convert those renewable energy resources into electricity or hot water. Rural residents are thus more likely than city dwellers to be directly exposed to the impacts of the increasing implementation of wind and solar energy systems. Both the increasing market penetration of small-scale residential energy-generation technologies and the construction of larger, utility-scale systems that are likely to provide the supply for an increasing portion of U.S. energy demand are causing concerns for some rural residents. The opportunities to implement renewable energy systems of their own, however, are sometimes less accessible for rural dwellers than for their urban counterparts.

Arizona is blessed with abundant sunshine which gives most of the state a good-to-excellent solar energy resource. Many locations in southeast Arizona, including some in Cochise and Santa Cruz Counties, also have adequate wind energy resources to make wind turbines a viable electricity generation option. Therefore it is important to understand the decision processes undertaken by rural southeastern Arizona residents when they decided to purchase and install renewable energy generation systems. This thesis will add to the body of knowledge that will help other researchers and policymakers, as well as the promoters, marketers and installers of renewable energy systems, to better understand the challenges that face all Americans, and rural residents in particular, as the country continues to move toward a more sustainable energy future. It starts with some history and geography of the study area, followed by an overview of the renewable energy and other resources available there. The introduction then concludes with a description of consumer profiles and how they will be used to test the hypotheses developed herein.

1.1.1 Rural southeast Arizona

The area that is now designated as Cochise and Santa Cruz Counties contains portions of the San Pedro and Santa Cruz River valleys. The two rivers flowed constantly throughout most years and archaelogical evidence indicates the area was occupied by prehistoric cultures dating to around 9,000 BCE (Waters and Stafford). The area was subsequently populated by Hohokam, dating to about 1450 CE, and later by Sobaípuri and other Piman peoples who occupied the area during the early explorations by Fray Marcos de Niza and Francisco Vázquez de Coronado, who were the first European explorers of the southwestern United States, in 1539-40 (Seymour).

Southeastern Arizona has a long, rich history of cattle and horse ranching, dating back to the days of Father Kino, who is considered to be the father of ranching in southern Arizona, in the late 17th century. Ranching continues to be an important part of the economic and social fabric of these sparsely populated borderland counties. Santa Cruz County is the location of the first commercial vineyard in Arizona, which was planted in Elgin in 1979. Mining for gold, silver and copper has also been an important economic activity in the area, and there are currently efforts to establish large open-pit and underground mining operations in the Santa Rita and Patagonia Mountain areas.

Santa Cruz County, with a 2010 population of 47,420, is one of the least populous counties, and at 1,238 square miles is the smallest in Arizona. Cochise County is larger in both area and population at 6,169 square miles and 131,346 residents (U.S. Census Bureau 2010 data). More detailed demographic data are included in Chapter 4. The two population centers are Nogales, located on the Mexican border in Santa Cruz County, and the Sierra Vista-Fort Huachuca area in western Cochise County (see Figure 1).

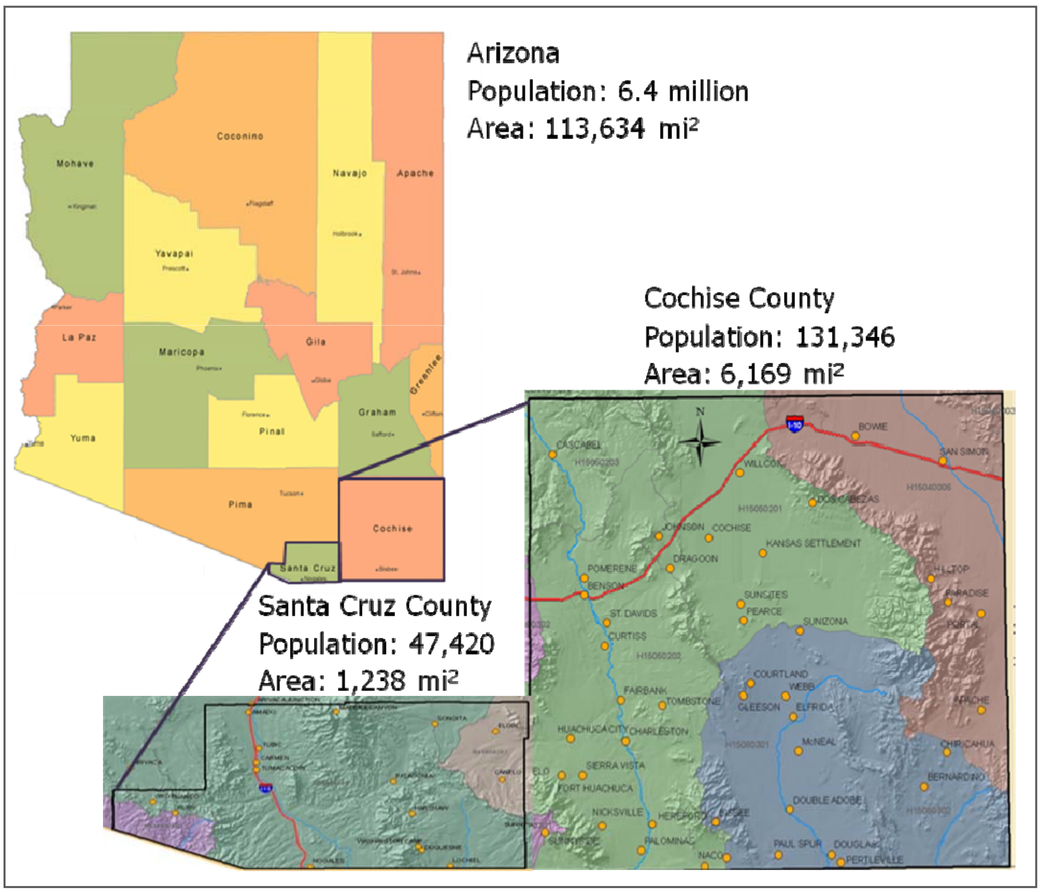


Figure 1. Maps of Arizona and Santa Cruz and Cochise Counties. Population figures based on U.S. Census Bureau 2010 data.

1.1.1.1 Solar and wind energy resources

The southwestern U.S. receives an abundant amount of solar energy, theoretically enough to provide many times the country's total electricity consumption. According to the U.S. Energy Information Administration, Arizona electricity consumption was 76.3 billion kWh in 2008. A back-of-the-envelope calculation can be used to estimate the land area needed to produce all of the electricity consumed in Arizona using photovoltaic (PV) panels. Based on actual production figures for several utility-scale PV facilities in Arizona and southern Nevada, assume that 10 acres of land are required for each megawatt (MW) of a PV facility and 2 kilowatt-hours (kWh) per year are generated for each rated Watt for the PV panels. The result is a land requirement of about 596 square miles, or 0.5% of Arizona's total land area, to provide all of its electricity consumption by direct PV-powered generation. Granted that this simplified calculation ignores the losses that would be incurred to transmit the electricity to the existing grid infrastructure and a handful of other technical and regulatory issues, including the fact that PV panels do not produce electricity at night, but the implication is clear: solar energy is a valuable resource in Arizona. Figure 2 shows that all of southern and western Arizona has an excellent level of insolation, which specifies the amount of solar energy that can be captured per unit area of a PV or solar-thermal collector.

The wind energy resources available in Arizona are not nearly as impressive as the solar energy that shines on the state. Nevertheless, some areas of Cochise and Santa Cruz Counties are perceived as being very windy and a number of small wind energy systems have been installed there. There is also a 127 MW wind-powered facility near Holbrook: the Dry Lake Wind Power Project. Figure 3 provides a representation of the average wind resources available across Arizona.

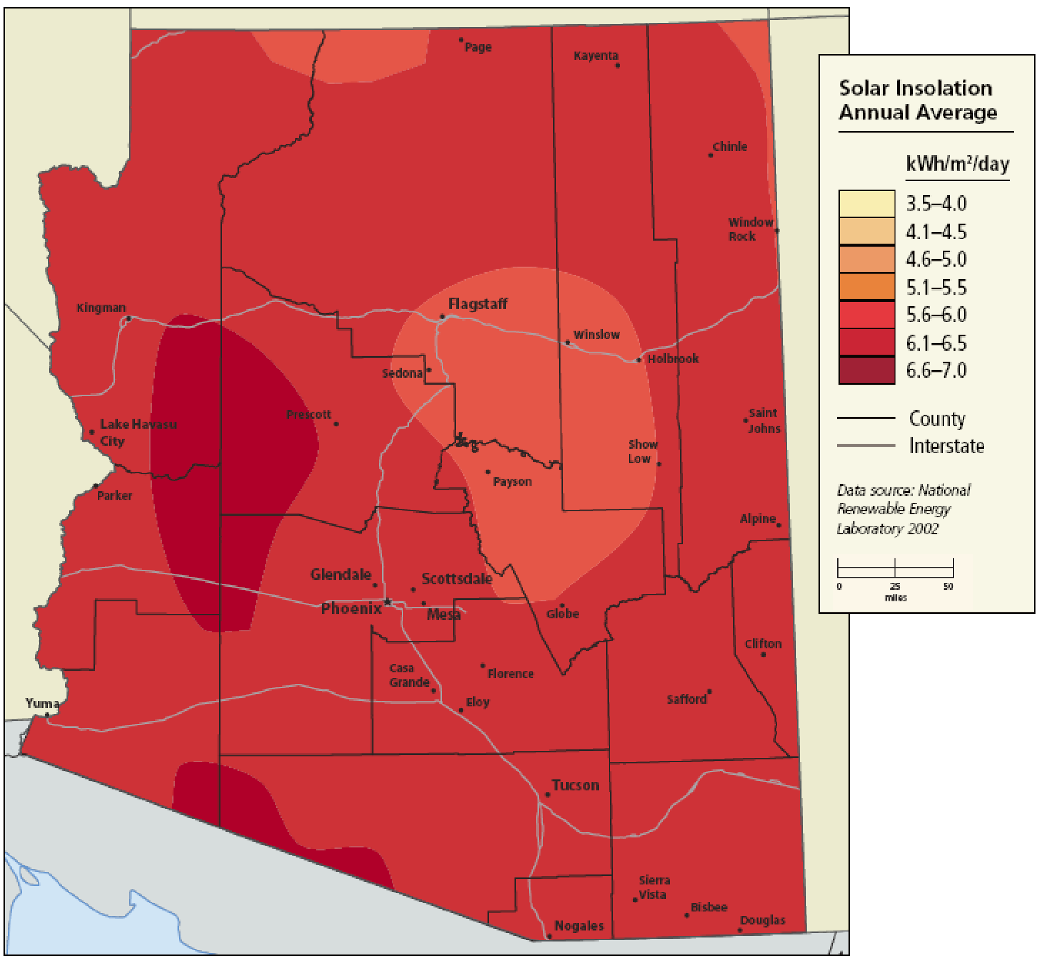


Figure 2. Arizona average annual insolation. Source: Nielsen et al.

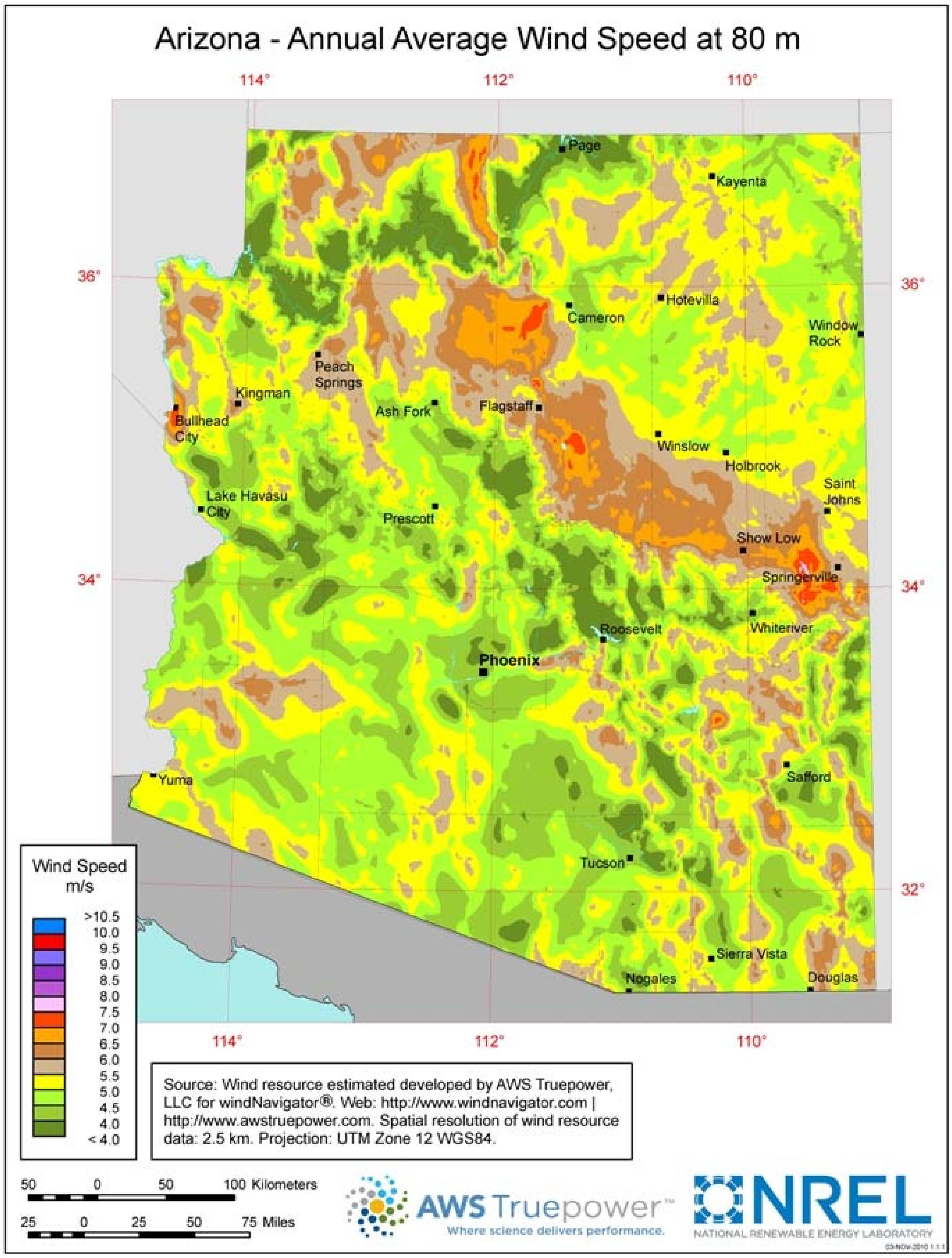


Figure 3. Wind energy resources at 80 meters (262 feet) above ground levels in Arizona. Note: 1 m/s = 2.2 mph. Source: AWS Truepower.

1.1.1.2 Institutional and community-based resources

In addition to the physical energy resources, e.g. sunlight and wind, that are necessary to implement an electricity-generating or solar-thermal energy system at a given location, there are a variety of other resources that an individual, family or business might wish to access before such a system can be selected, designed, purchased and/or installed. These resources can be characterized as institutional and community-based. Institutional resources include the array of financial incentives, online and printed information, and sources of technical advice on the specifications and requirements for these highly complex and costly systems. Community-based resources include relatives, friends, and neighbors, as well as local organizations and government programs.

Based primarily on the potential economic and environmental impacts of human society's widespread use of coal and other fossil fuels, many governmental institutions have established policies to encourage and facilitate the implementation of renewable energy systems to reduce the use of those fuels. These policies have resulted in the codification of a variety of direct and indirect financial incentives that are available to purchasers of many types of solar and wind energy systems. Direct financial incentives available to residents of Arizona include a 30% federal Renewable Energy Tax Credit and a state Residential Solar and Wind Energy Systems Tax Credit.

Indirect incentives are established by the agencies that exist in U.S. states to regulate electricity generating and other utilities, which in most cases operate as monopolies in their specified geographic areas. Many of these regulatory agencies have established renewable portfolio standards (RPSs) which require electricity providers to obtain or generate a minimum percentage of their power from renewable energy resources by a certain date. Arizona is one of 29 states that has already defined an RPS. The Arizona Corporation Commission (ACC) now requires that by 2025 at least 15% of the electricity needs in the state be derived from renewable sources. In order to achieve that goal, Arizona electricity providers were ordered by the ACC to develop rebate programs that provide an additional financial incentive for residents of the state to implement solar and wind energy systems. These rebates can cover half the cost of the systems and are funded by monthly payments by all utility customers. When rebates are combined with the state and federal tax incentives, a purchaser of a RE system can often recover about 80% of its “sticker price.”

Two other categories of institutional resources are informational and technical. A wide variety of information about renewable energy systems is available on the Internet. The U.S. Department of Energy (DOE) administers the Office of Energy Efficiency and Renewable Energy, or EERE, which facilitates the adoption of new renewable energy technologies by leveraging partnerships among the private sector, state and local governments, DOE national laboratories, and universities. The National Renewable Energy Laboratory (NREL) develops renewable energy technologies and practices, both directly and by funding academic and industry research, and is the principal research laboratory for the EERE. NREL also works to advance related science and engineering and the transfer of knowledge and innovations to address the nation's energy-related goals. Each of those agencies has a wealth of online as well as printed information available. A valuable information-providing program that is partially funded by the EERE is the Database of State Incentives for Renewables & Efficiency (DSIRE; www.dsireuse.org), a project of the North Carolina Solar Center and the Interstate Renewable Energy Council that provides up-to-date information about federal, state and utility incentive programs for renewable energy systems.

Solar- and wind-powered electricity generation systems, as well as the programs that provide the financial incentives to purchase them, are in general quite complex. They require a considerable amount of technical expertise to plan, design, install and connect to the electrical grid. The sales people and system designers and installers, who commonly call themselves integrators, are the primary sources of technical knowledge for residence and business owners who are considering the purchase of a renewable energy system. Many electricians are also knowledgeable about solar and wind energy systems, as are plumbers who install solar-thermal systems for producing hot water. Another source of technical expertise for both the interconnection of renewable energy systems to the grid and the rebate programs they offer are the employees of the local electricity provider. Finally, the inspectors from the county or municipal department that provide and certify building permits are familiar with local codes and construction regulations and requirements, and their approval is necessary before a renewable energy system can be connected to the grid or otherwise go online.

Another potential resource, particularly for individuals or families who live in rural areas and wish to install a renewable energy system, is the community itself. Friends or neighbors who have already put in a solar or wind energy system can provide the benefit of their experience. Locally-based clubs or community organizations and local government initiatives or programs can also be valuable resources.

There is, of course, a considerable amount of crossover among the various categories of institutional and community resources. Obviously many of them involve some aspect of the dissemination of information to a potential purchaser of a renewable energy system. In the next section, a type of resource that could be used by a seller, instead of a purchaser, of an energy system will be described.

1.1.2 Overview of consumer profiles

A consumer profile, also referred to as a customer profile, is an outline or description of a set of demographic, psychographic, behavioristic and geographic information about the users or purchasers of a particular product. Consumer profiles are used by sales, marketing and advertising people as one of the strategic tools they employ in their efforts to reach potential customers and to design successful advertising programs and sales techniques for their products or services.

In this thesis, consumer profiles are described for two sets of residents of Cochise and Santa Cruz Counties. The profiles contain several demographic characteristics (age, household size, education and income levels) plus a few from the psychographic (personal values, motivations for conserving energy) and behavioristic (energy conservation habits) categories, but no geographic variables are included.

1.2 Objective, design and scope of research

The primary objective of this research is to identify the residents of Cochise and Santa Cruz Counties who have installed solar and/or wind energy systems, and then to develop and describe a consumer profile for that sub-population. The profile is composed of the most representative age, family size, education and income levels for the households included in the study, along with some behavioristic and psychographic characteristics. Beyond the academic interest in the characterization of such a profile, it is hoped that the results obtained herein might be useful to the operators and/or sales and marketing people who represent the companies which design and install solar and wind energy systems and to other organizations which encourage and support the widespread implementation of those technologies. The two-county area included in the analysis is primarily rural, and it represents a relatively small portion of even the state of Arizona. But it is hoped that the results might also be applicable to other rural areas across Arizona and elsewhere in the U.S.

A primary source of data for the analysis was county building permit records. In order to install a wind or solar energy system on a home or business, a property owner or tenant must obtain a building permit from the Cochise County Department of Planning and Zoning or the Santa Cruz County Building Department. These public county records were used to determine the owners and locations of renewable energy (RE) systems that have been installed in these counties.

The second source of data was a survey of the owners of some of the RE systems located in the two counties and of other residents who filed permits to remodel or install upgrades or additions to their homes. The survey responses were used to characterize residents' attitudes about RE and some of their routine energy conservation behavior patterns and to develop the consumer profiles which describe the typical RE system owner. A second profile was also developed to characterize the residents who made other types of upgrades, additions or remodels to their homes.

A subset of the information contained in the consumer profiles was developed for the two types of households surveyed: those who had already implemented an RE system and those who had performed some other upgrade, addition or remodel to their home. This subset of the data collected during the survey was statistically analyzed to demonstrate the degree of difference between the two types of households.

The results obtained from the analysis of the survey responses specifically describe only the consumer profiles of Cochise and Santa Cruz County residents who have solar or wind energy technology. It is possible, however, that knowledge gained from this study will also be useful to other academic researchers and perhaps to those who market, design and install renewable energy systems and others who are working to help promote and achieve their widespread adoption across the U.S.

1.3 Chapter summaries

The next chapter provides a review of a broad sampling of the relevant literature that motivated and informed the research and survey design, as well as the analytical procedures used in this thesis. A review of the development of the theory of diffusion of innovations provides a basis for better understanding how new technologies, and renewable energy technologies in particular, are adopted into societies. A brief introduction to consumer profiles is then presented.

Chapter 3 describes the research design and methodologies used to collect the data from survey respondents and to perform the statistical analysis on the data. It is followed by a chapter containing the results of that analysis, which leads to the descriptions of the consumer profiles for the renewable energy adopters and the Santa Cruz and Cochise County permittees who chose not to purchase and install solar or wind energy systems. Appendix D contains summaries of all of the survey responses and provides a supplement to the charts and tables used to describe the survey results. Chapter 4 concludes with a series of recommendations for the promoters and marketers who are working to achieve the widespread adoption of renewable energy technologies and some observations about the implications of such a scenario. Finally, a brief summary of the results and a few suggestions for further research are presented in Chapter 5.

2. LITERATURE REVIEW

Two major areas are covered in this chapter. First is a review of the research on the diffusion of renewable energy technologies in the U.S., along with in-depth descriptions of the barriers that inhibit their widespread adoption. Second, an overview of consumer profiles and a brief review of some of the literature describing how they are presently being used are presented.

2.1 Research on adoption of renewable energy technologies

Before considering research that is focused specifically on the adoption of renewable energy technologies (RETs), an overview of the history of the development of theories regarding the diffusion of innovations (DOIs), which is more general and can include ideas as well as technologies, is presented. It is important to consider RETs within the framework of DOI theory because they are innovative on two different levels. First, although photovoltaic (PV) cells have been in relatively widespread use for several decades, some of the newer technologies and manufacturing processes used in solar-electric systems, such as the recent advances that have led to the mass-production of thin-film PV cells, are innovations. Second, and perhaps less relevant to the individual decision processes made by rural Arizona residents but important to understanding the widespread diffusion of RETs, is what may eventually become a disruptive paradigm shift from the present centralized electricity generation regime, via a number of possible scenarios, to one in which distributed generation becomes the dominant electricity production scheme.

2.1.1 Development of theories on the diffusion of innovations

One of the earliest, and probably the most voluminously documented, cultural innovations in human history is the tradition of Christianity. Included in the huge body of literature that has described and attempted to explain its early expansion are numerous references to a letter written by Pliny the Younger to the Emperor of Rome in the year 112 CE. Pliny reports that the Christians have been drawn from "all ages, from all ranks of society, and from women as well as men (*omnis aetatis omnis ordinis utriusque sexus*)" (Sherwin-White 709). Pliny's letter represents one of the earliest documented historical accounts of an analysis of the diffusion of an innovation, although neither he nor any other researcher would recognize it as such until almost two millennia later.

The word diffusion has been commonly used by anthropologists and ethnologists when referring to the diffusion of cultures, and in fact there was once even a diffusionist school of thought within cultural anthropology (Smith et al.). The French sociologist Gabriel Tarde was also an early pioneer of the concept, introducing the S-shaped diffusion curve (see Figure 4) and describing the role played by opinion leaders in what he termed the process of imitation.

One of the classic articles in the sociological literature on diffusion is Ryan and Gross's description of the successful introduction of hybrid seed corn in Iowa. The first use of the term "diffusion of innovations," however, is attributed to Everett Rogers, who published the first edition of the book with that title in 1962. Four editions later, it is one of the most widely cited books in the social sciences. Rogers' work on diffusion began with his study of social changes in rural societies and the rates of adoption of new seed strains and technologies by U.S. farmers. Griliches and Lionberger also made significant contributions in those areas.

Other early works describing research on the diffusion of innovations indicated that many of the elements involved with its analysis had been used, often independently and with differing terminologies and areas of emphasis, in the broad fields of anthropology, education, marketing and public health, along with the rural, medical and mass communications sub-disciplines within sociology. Katz et al. developed a framework, primarily from a sociological viewpoint, for analyzing the diffusion of innovations and included recommendations for considering such analyses from a more multi-disciplinary perspective.

In the 1970s, sociologists were still performing the bulk of the research on the diffusion of innovations (Rogers and Shoemaker) but economists had by then begun to delve more deeply into its analysis.

The various disciplines in which the study of diffusion was important were still, for the most part, isolated from one another. Kenneth Warner notes that:

> In general, sociologists have concentrated on studying characteristics related to the degree of innovativeness of individual adopters, while most of the economic work has focused on the aggregate of individual adopters' decisions, namely diffusion. The potential complementarity of the two approaches is clear, but the divergent perspectives and variables and the virtual isolation of the disciplines from one another has thus far failed to produce meaningful assimilation of the ideas of the one into the thinking of the other (439-40).

Based on his 1974 review of the literature, he concluded that "the art of research on diffusion and other aspects of technological change has advanced from infancy to adolescence" (Warner 450) and looked forward to seeing it continue to grow. Two years later, however, Everett Rogers argued that following a turning point in 1960, "the disciplinary boundaries that had previously isolated the old disciplinary boundaries began to break down, and diffusion research began to emerge as a single, integrated body of concepts and generalizations" (1976: 292). But in the same paper, he also identified several methodological biases that continued to characterize communication research and advocated for the routine use of network analysis and longitudinal panel designs in diffusion research in order to better define the social structures and understand the flows of communication that promote or inhibit the adoption of innovations over time in a society.

The participants within the various disciplines who were involved with research on the diffusion of innovations in 1984 witnessed the birth of the *Journal of Product Innovation Management*, the first peer-reviewed periodical to focus specifically on the topic. During the next two decades, a half-dozen more major international journals which covered various aspects of innovation and its management debuted, and many others were launched that more narrowly focused on the innovations within a particular specialty. A number of books and articles (cf. Mahajan and Peterson; Silverberg; Alderman) which described theoretical or applied models with which to analyze and/or predict the diffusion of innovations, particularly of new consumer technologies, appeared during the 1980s. Many of the topics in the articles were based on the mathematical model of new product growth and adoption developed in 1969 by Bass, who included the distinction between innovators and imitators, and later by Kalish, who added the potential effects of advertising and uncertainty to his model. Several of the articles reached conclusions such as this: "Diffusion theory represents an important perspective on communication effects. It is robust in scope and has been useful in explaining the spread of new ideas, new practices, and new products," (863) by Gatignon and Robertson, who are diffusion modelers. They used the term "diffusion theory" to denote the results of consumer research-based analyses that focused on individual behavior and "diffusion modeling" to describe a more market-analysis-based, mathematically-oriented approach, and argued that the integration of the two domains would be beneficial to both.

Perhaps not surprisingly, for as students of sustainability we have seen the difficulties that are commonly encountered by interdisciplinary teams, the number of researchers who crossed over from the sociological/communications behavior domain to that of economic/marketing/diffusion research was relatively small. The diffusion modelers (cf. Mahajan et al.; Frenkel and Shefer) did begin to include some of the consumer-related parameters such as communications channels and the social and personal characteristics of the individuals who are potential adopters of new technologies into their models. Very few sociologists and other analysts of consumer behavior, however, integrated the use of mathematical models into their work. One of the few adaptations of diffusion models by social scientists was done by van den Belt and Rip in their analysis of the adoption of synthetic dye manufacturing processes. They relied heavily on the theories of technological innovation that had been developed by the economists Giovanni Dosi, who introduced the term "technological paradigm," and Nelson and Winter.

Geoffrey Moore contributed one of the key concepts to the theory of diffusion of innovations in 1991. His book *Crossing the Chasm: Marketing and Selling Technology Products to Mainstream Customers* introduced and described the "chasm" between two groups of high technology product adopters: the visionary early adopters and the pragmatic early majority, sequentially the next group of adopters as described by Everett Rogers. The chasm (see Figure 4) occurs because the early majority are not influenced by the early adopters'

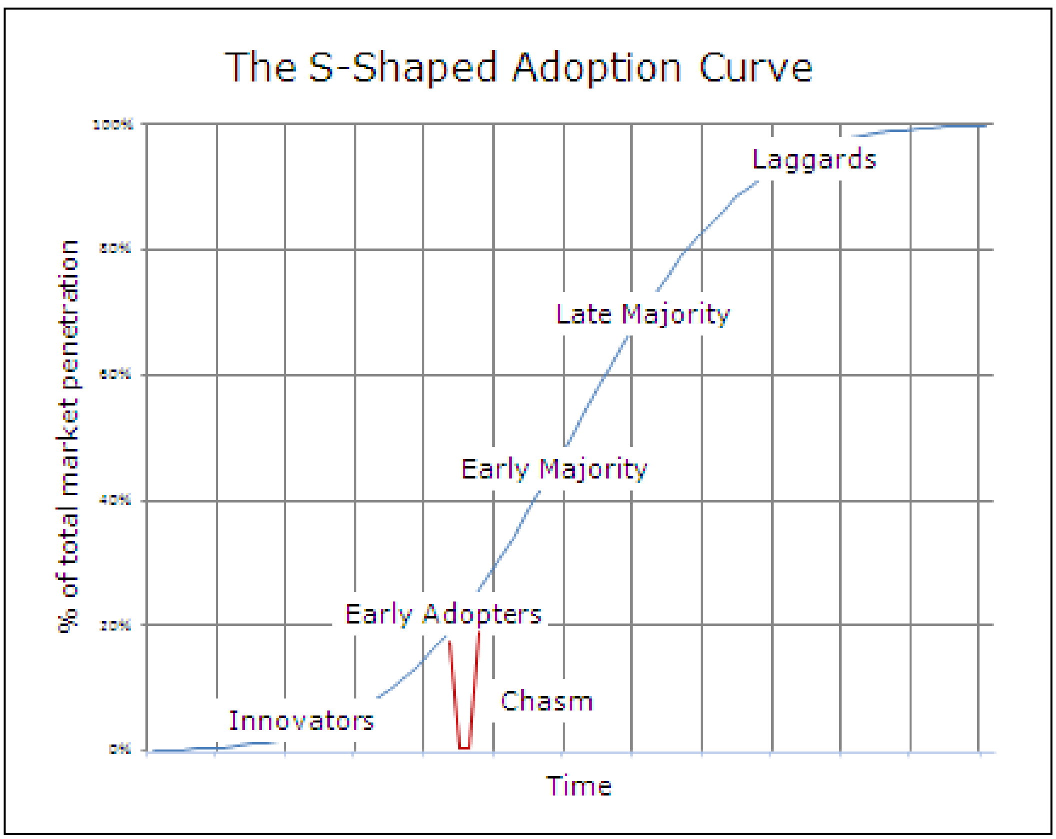


Figure 4. Adoption of a new technology over time.

opinions and actions, preferring to rely on other pragmatists for advice and information. Thus a key challenge for marketers of innovations is to cross the chasm by successfully diffusing them to enough members of the early majority to achieve a critical mass of adopters, so that other pragmatists will follow.

Throughout the 1990s, the lack of interdisciplinary work among economists and specialists in other social science domains, including the academic and industry researchers who study the marketing and diffusion of new technologies, was noted by a number of scholars. Bruun and Hukkinen observed that:

> Science and technology are studied by both economists and sociologists. Yet the level of interaction between the two disciplines seems to be low, and the relation between economic and sociological approaches is rarely discussed…. Considering the complexity of technological change - and thus the likelihood that there are no simple explanations to be found – we feel that the exclusive either-or approach is a poor strategy" (96).

Economist Christopher Freeman reached a similar conclusion in an extensive critical survey of the literature on the economics of the development of technology and its diffusion. Most of the articles he cited were written by economists, but he included references to a variety of other disciplines. He concluded that his views on the economics of technological change were biased, however, and suggested that an innovative, more comprehensive interdisciplinary assessment of the topic be performed by "well-qualified people *outside* the discipline of economics, i.e. an international panel of engineers, biologists, physicists, historians, geographers, sociologists, political scientists, psychologists and scholars from business studies" (Freeman 492). Freeman's suggestion is based on a review of research in a number of fields, and he seems to refer to the traditional top-down conception of interdisciplinary research, whereby specialists each contribute their work, which is synthesized at the end of the process. In the field of sustainability, however, it is recognized that most interdisciplinary work should be bottom-up, whereby the participating researchers begin their collaborations early in the process and all contribute to both the research design and execution of the project.

During the most recent 10-year period, however, there does seem to be an increase in the publication of articles describing research and case studies in fields other than business and economics in which the theory of diffusion of innovation (DOI theory) is a key element. For example:

- Szabo and Sobon (2003) documented the implementation of a theory-based system of educational reform through instructional technology that was developed in Canada using DOI theory.

- Britto et al. (2006) used a combination of interventions, guided by evidence and DOI theory, to increase influenza immunization rates of children in Cincinnati.
- Dearing (2009) performed a review of diffusion theory with a focus on concepts with the potential to accelerate the spread of evidence-based practices, programs, and policies in the field of social work.
- Shareef et al. (2009) used DOI theory as part of a framework for policymakers to follow when implementing electronic government technologies.

Other examples that describe research in fields ranging from community development to pest management can be found in addition to the large numbers of studies that focus on business and information technology-related topics. An informal survey conducted using the Google Scholar search engine provides evidence that more researchers from different traditions are utilizing DOI theory in their work. Table 1 shows the results of searches based on the four most recent 5-year periods for the “Business, Administration, Finance, and Economics” and “Social Sciences, Arts, and Humanities” subject areas. The searches were based on the terms “theory” and “diffusion of innovation” within the title of an article or book. Although the results of this quick survey do not allow any formal conclusions to be drawn, and some of the resulting hits are for articles that describe the development of a theory while others its application, they are nonetheless indicative of the trend wherein more social scientists are using DOI theory in their work. And perhaps it also indicates a trend toward increasing interdisciplinarity.

Table 1.

Number of Hits: Google Scholar Searches for "theory" and "diffusion of innovations" in the Titles of Books and Articles in two Subject Areas.

Period	Business-related[1]	Social Sciences[2]	Total
1991-1995	3	2	5
1996-2000	4	3	7
2001-2005	11	6	17
2006-2010	15	21	36

[1] Includes administration, finance and economics.

[2] Includes arts and humanities.

Three examples of recently published research will wrap up this overview of the theory of diffusion of innovations. First, from the field of new product development and marketing theory comes an integrative model of *non*-adoption that also draws from innovation theory and sociological research. MacVaugh and Schiavone's analysis "highlights the need for academics to study technology adoption through a multidisciplinary lens" (209), and they provide a series of recommendations for business managers to use to more effectively orient their new product development strategies. Another industry that has benefited from the application of DOI theory is health care. Barbara Campbell used a participatory action research methodology to generate knowledge of children's health in a rural community in Ottawa. She then developed a knowledge-to-action framework based on a theoretical foundation rooted in DOI theory to more effectively translate the research knowledge into actions that both parents and children could use to improve the overall health of the community. Finally, it seems appropriate to close this section with a description of an article by a sociologist. Barbara Wejnert developed a conceptual framework with which to integrate several of the models of diffusion used by sociologists with others which had originated in other disciplines. The result was a grouping of the diverse sets of variables used by the various traditions that influence the diffusion of innovations into three components: characteristics of innovations, characteristics of innovators, and the environmental context. According to Google Scholar, Wejnert's article has been cited by 289 other papers. Not bad, perhaps, but only about 1% of the 28,132 citations reported for just the 4th edition Rogers' (1995) classic work.

Using some of the concepts described in this brief review of the last 50 years' literature on the topics of diffusion of innovations (DOIs) and the adoption of new technology by consumers as a framework, the next two sections will present reviews of articles that focus more specifically on the adoption of renewable energy technologies.

2.1.2 Adoption of renewable energy technologies

The volume of the literature on the adoption of RETs is not nearly so vast as that for the diffusion of innovations. One of the earliest treatments of the topic of the diffusion of solar energy systems, which at the time referred to only water and space heating technologies, was published in 1981. It opens with this statement: "Given the current interest in solar energy and its anticipated future growth, an unusual opportunity exists for the study of the consumer buying-behavior process surrounding solar energy products" (Labay and Kinnear, 271). The authors identified the owners of over 200 solar energy systems in Maine, then used survey responses to develop and analyze demographic and attitude perception profiles of the solar energy adopters, a group of knowledgeable non-adopters and a control group based on survey responses. Their seemingly bullish perception of the level of interest in solar energy systems was not justified, but I would characterize their research methodology as excellent. Similarly, in 1982 Stephen Sawyer surveyed some of the early adopters of solar-thermal technology and overestimated future demand for solar energy systems. Both studies found very high levels of satisfaction among solar technology owners and that a dominant motivation for adopting solar technology was concern about the possibility of rising energy prices in the future. These studies also predicted a relatively rapid rate of growth for the adoption of solar energy systems in the U.S which did not occur.

One reason for the researchers' misplaced optimism, and they were not alone, about the projected demand for solar energy technology from American consumers in the 1980s is found in the record for federal research and development (R&D) funding for solar energy. The Carter administration, following a trend set by Nixon after the OPEC (Organization of Petroleum Exporting Countries) crude oil price hikes and subsequent gasoline price increases and long lines of cars at gas stations in 1973, raised solar R&D funding levels from $152 million in 1976 to $579 million in 1981. The Reagan administration's policy toward solar energy was that private sources should provide more of the R&D funding, and he slashed funding for it to $227 million in 1982 and steadily decreased it to $92 million in 1989 (Clark). The high levels of federal R&D funding for solar and other so-called alternative sources of energy and fuels combined with several other factors to lead many observers in that era to over-project the adoption rate for solar technology. The dual oil price shocks of 1973 and 1980 raised overall energy prices and contributed to high rates of inflation. Following the Three Mile Island accident in 1979, there was an uneasiness in both the scientific community and the population at large with nuclear energy which made people more receptive to considering solar as an alternative. A pair of government reports in

1978 and ‘79 (Council on Environmental Quality; Dept. of Energy) stated that solar energy could provide 20-25% of total U.S. energy needs (not just electricity consumption) by 2000. Despite all of these positive indicators, the widespread adoption of solar energy technologies did not occur during the ‘80s and ‘90s, and direct solar energy even today produces only about 0.1% of total U.S. energy consumption.

A number of other articles published between 1976 and 1985 also used DOI theory to analyze existing adoption patterns and predict future purchases of solar and wind energy technologies. Everett Rogers et al. studied solar technology owners in California and proposed incentives that might accelerate adoption. Neslin and Assmus analyzed the effects of various methods of presenting information on respondents’ intent to purchase a solar water heating system. One study used discriminant analysis of the responses from a 16-page survey to discern the relative importance to the respondents of financial incentives as compared to other factors such as concerns about system reliability and possible changes to their lifestyles. It concluded that “[p]resent policies concentrate heavily on financial incentives while the public is actually influenced by a broader spectrum of issues. To encourage adoption a more comprehensive program is needed” (Guagnano et al. 63-4). A 1988 study by Durham et al that also focused on financial incentives following the expiration of federal tax credits for residential solar energy systems concluded that potential solar energy adopters' perceptions about future electricity prices are as important as the availability of tax credits with regard to the decision to purchase a system.

During the decade between 1986 and 1996, worldwide manufacture of photovoltaic (PV) panels went from 26 MW to 89 MW (WorldWatch Institute), which reflects a 13% annual growth rate but only represented a tiny fraction of U.S. electricity demand. This provides one indication of the relatively slow rate of adoption for solar energy technologies, which began to grow exponentially in the late 1990s; in 2009 over 10,000 MW of PV panels were manufactured (WorldWatch Institute). Many of the articles published during the late '80s and '90s described analyses that considered and discussed the slow growth of the renewable energy industry. A market diffusion model that incorporated the negative perceptions of products that are introduced prematurely was applied to a proposed Department of Energy (DOE) program to place PV systems on 100 homes starting in 1980. In the first demonstration home that was built, system failures, a rapid decline in electricity production and the lack of a commercially-available power conditioning unit had caused enough bad publicity that the program was shelved, even before the Reagan administration's solar energy research funding cutbacks began. Other applications of the model showed "that it is possible to quantify the effects of entry timing on ultimate product success in the market place. It also demonstrates the need to blend various types of data in calibrating such models" (Kalish and Lilien 203). Rich and Roessner analyzed the federal tax policy that was implemented in 1978 to promote solar technology development and incentivize its deployment in the U.S. They noted that over 1.1 million residential tax credit claims had been filed between 1978 and 1984, representing $1.7 billion (1985 dollars) and that the policy had benefited the solar industry and supported the objective of increasing the diffusion of solar energy technology in the U.S., but that no prior estimates had been made of the expected costs and benefits of the program. Furthermore, the costs and benefits of solar energy were realized over "vastly different time periods" (Rich and Roessner 197). The geographic differences in the available solar resource and other site-specific issues that are always significant factors in the solar energy industry made measuring the policy's effectiveness extremely difficult.

Starting in the late 1990s and continuing through the present, the installed power generating capacities of both PV and wind energy systems have grown steadily and at rapid rates. In the 10-year periods ending in 2009, worldwide PV capacity grew from 1,166 MW to 22,893 MW, averaging 35% annual growth, while installed wind-powered capacity grew from 13.6 GW (gigawatts) to 158.5 GW, an average of almost 28% annual growth (WorldWatch Institute). Thus the focus of the research in the academic literature on the diffusion of RETs changed (at least from the standpoint of proponents of continuing the rapid growth of RET implementation) from "why isn't this working" to "how can we keep this going?" The volume of pertinent literature published during this period has grown right along with the PV and wind energy systems the articles describe, and the next four sections describe a small but representative fraction of it.

2.1.2.1 Recent applications of DOI theory to RET adoption patterns

One of the indications that diffusion of innovations theory is still highly relevant to the analysis of the adoption of renewable energy technologies was included in a brief paper presented at a DOE solar energy conference in 2004. Hanley and Thornton, who were federal government researchers at national laboratories, described the importance of the policy to provide extensive technical adoption support to their partners in the solar energy industry as well as to other government agencies and the general public. The report concluded that "[t]he success of technology diffusion rests largely on communication, whether it is through public hearings, workshops, or lectures, or through technical assistance" (Hanley and Thornton, 1). The idea of establishing effective channels of communication and delivering understandable content among the various RET industry stakeholders will be a recurring theme throughout the rest of this thesis.

Electric utility managers represent one of the important groups of stakeholders within the energy industry. Their familiarity with and support for the small, grid-tied solar and wind energy systems that are becoming a larger and larger part of the electricity generation mix in the U.S. and elsewhere are vital to the widespread adoption of those technologies. A path analysis based on Everett Rogers' model of DOI was performed by Kaplan on the responses from a national survey of utility company managers. It revealed that their technical knowledge of PV systems is by itself insufficient for them to develop enough interest in the technology to support its widespread implementation. He determined that the managers' actual experience with PV and their motivation, which may need to be provided from outside their companies, are important for the more rapid diffusion of PV and other RETs. Ornetzeder and Rohracher studied the social learning processes that took place among the designers, distributors and adopters of two types of technological innovations and of sustainable buildings in Europe. In the case studies they described, knowledgeable, motivated users were cooperatively involved in the planning, design and production phases for innovative solar-thermal collectors, biomass-fueled domestic heating systems and the planning and development of an ecologically-minded residential community for 5,000 located in Freiburg, Germany. These user-led innovation processes led to both improvements in the technologies being developed and also to their rapid dissemination and high levels of social acceptance for sustainable but unconventional technologies.

Two recent studies that focused on residential electricity and fossil fuel consumers, who represent the vast majority of potential adopters of RETs, used DOI theory to help better understand and more effectively market RETs. The first was a study by Rundle-Thiele et al. of Australian households who had demonstrated low rates of subscription to programs under which they could purchase renewably-generated electricity. It contained to a series of recommendations for the marketers of these types of "green" programs: segment the market, build consumer awareness, and then educate the consumers. Michelson and Madlener developed an integrated framework that synthesized theories of decision-making from economics, technology adoption research, psychology, and sociology and applied it to purchase patterns exhibited by German consumers for various residential heating systems. The model they created incorporates perceived external economic factors such as energy prices, interest rates and the resulting payback periods along with non-economic factors including the space required and the available technologies. The external factors were then combined with the consumers' personal-sphere determinants within three categories: subjective norms, attitude/intention and perceived behavioral control. The authors suggest the framework could be used "as a starting point for empirical research on a homeowner's adoption decision in favor of a specific innovative" RET (Michelson and Madlener 31).

2.1.2.2 Analysis of social acceptance of RETs

The May 2007 issue of *Energy Policy* contained a dozen papers that focused on the social acceptance of renewable energy innovation. Wüsterhagen et al. wrote the lead article for the issue, an introduction to the concept, and noted that the lack of social acceptance of RETs, particularly wind turbines, represents a potential barrier to their widespread adoption. The authors described three dimensions of social acceptance: socio-political, community and market, employing a triangular symbology reminiscent of many of the iconic representations of sustainability to illustrate the dimensions and their components as shown in Figure 5. They also laid "the foundation for a conceptual integration of research findings from different social science disciplines on social acceptance of renewable energy innovation" (Wüsterhagen et al. 2689) which included the following key challenges:

- Reconciling national policy objectives with local political realities, including potentially unpopular siting decisions.
- Identification of the most crucial factors related to community acceptance of wind, solar and biofuel facilities.
- Gaining a better understanding for both the social acceptance and the potential for diffusion of RETs in developing countries.

- Developing consumer segmentation profiles in order to transfer successful projects from one country to another and to more fully understand the motivations that drive some people to buy RETs while others don't.

Heiskanen et al. developed a four-step methodology (see Figure 6) for researching societal acceptance of new energy technologies and listed the socially relevant technological characteristics of various energy-related technologies and processes. They also describe a fifth step with which to characterize successful projects or unsuccessful attempts to implement RETs in order to identify what did and didn't work for the projects' developers.

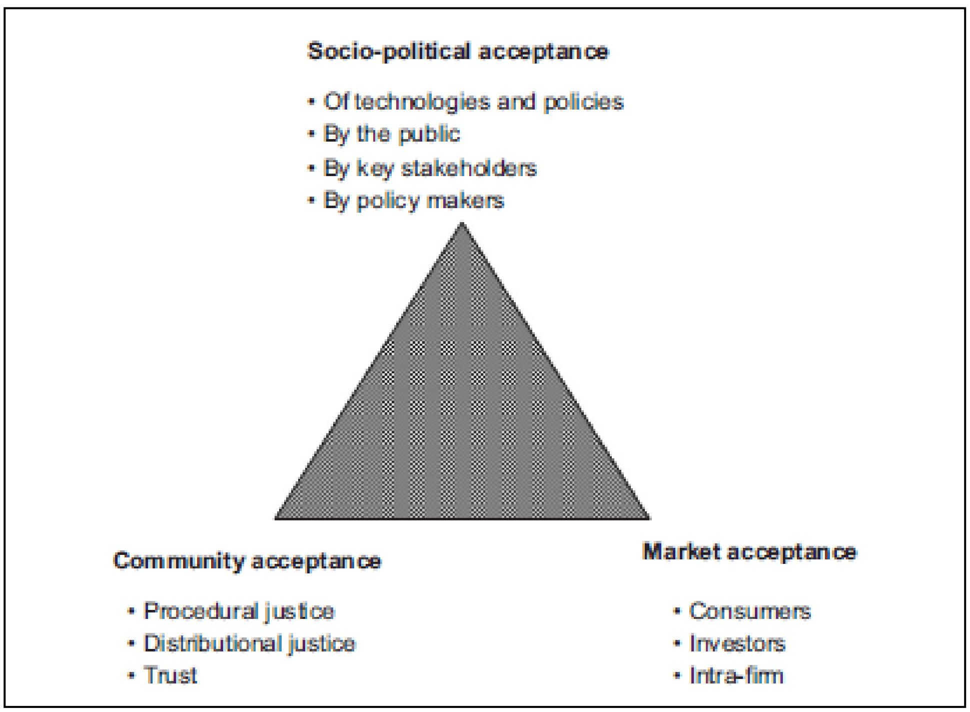


Figure 5. Dimensions of social acceptance. Source: Wüsterhagen et al.

A 2010 article by Bollinger and Gillingham used social learning theory and an analysis of peer effects and environmental preferences to explore the geographic clustering patterns that characterize the diffusion of RETs in California. They developed a hazard model that relates the RET adoption rate to demographic characteristics and measures of environmental preference such as the rate of hybrid vehicle ownership by zip code across the state. They then incorporated street-level data to shed additional light on the possible effects of peer influences on later adopters. In another application of the concept of societal acceptance of RETs, Egmond et al. developed and described a protocol with which to identify and then influence residents of communities which are locally regulated by housing associations. A key element of the protocol is to use market research techniques to identify a niche in the mainstream body of potential technology adopters and use the members of the niche to help cross the chasm

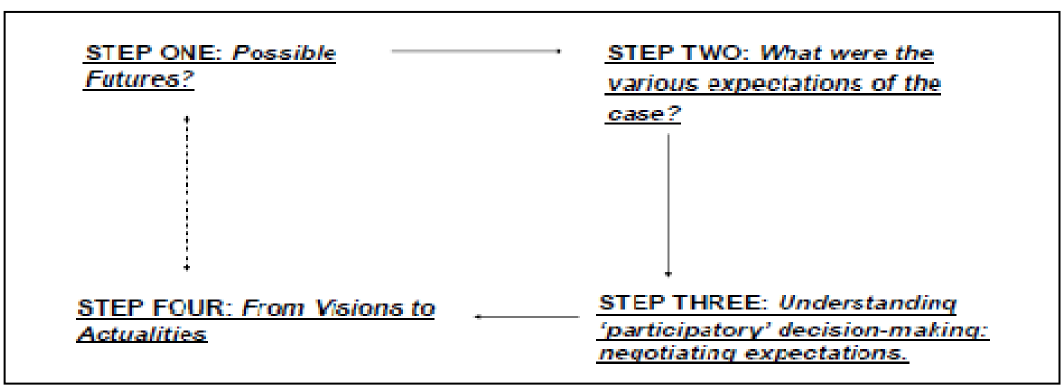


Figure 6. A four-step framework for analyzing societal acceptance of a new energy technology. Source: Heiskanen et al.

between the early adopters and the mainstream members of the communities.

2.1.2.3 Modeling studies

Many of the articles described in the previous two sections used models to formalize the relationships among the factors and variables their authors analyzed. The reviews included in this section focus more specifically on the use of modeling by government researchers and the application of the generalized Bass model to analyze and predict PV adoption patterns in European countries.

The administrators and researchers within the U.S. DOE's Office of Energy Efficiency and Renewable Energy (EERE) work to achieve the federal government's policy objectives, which include supporting the more widespread deployment of RETs. In a comprehensive review and analysis of the EERE's deployment programs, Cort et al. summarized the modeling efforts being used to characterize these programs. They identified gaps in the current knowledge and developed a list of recommendations for further research to expand and enhance some of the office's current modeling work within the National Energy Modeling System. Their conclusions included this statement:

> While it is typically sufficient to characterize R&D programs in terms of cost and performance, deployment programs are more appropriately characterized as impacting behavioral parameters within the model (typically consumer discount

> rates or investor risk premiums). While it may be possible to identify behavioral parameters that could be impacted by deployment, perhaps the most significant challenge facing programs relates to the lack of empirical data to determine how specific parameters should be changed (Cort et al. 77).

Among their specific recommendations for gathering empirical data are the completion of an analysis of the "financial decision-making criteria employed by end users of energy-using technologies" (Cort et al. 80) and an attempt to measure the effects of various government interventions to influence such decisions.

Using a DOI theory-based framework called the generalized Bass model (GBM; see Section 2.1.1), Guidolin and Mortarino analyzed the national adoption patterns for PV systems in several European countries, Japan and the U.S. They found that the flexibility provided by the GBM made it more suitable than the other modeling frameworks they analyzed, and that including rectangular negative shock effects, which can account for the implementation of specific government policies, improved the predictive performance of the models. Their interpretation of the data available through 2007 indicates that the rate of PV deployment has already peaked in Japan, Germany, Spain, Austria, Netherlands and the U.K., with Italy and the U.S. expected to continue their rapid rates of PV deployment.

2.1.2.4 Adoption of RETs in rural areas

One indication of the relative scarcity of academic literature that focuses on the adoption of RETs in rural areas is provided by a quick Google Scholar search for articles (excluding patents) published between 1991 and 2010 with "renewable energy" and "rural" in the titles, which returned a hit count of "about 175." By contrast, the same search without including rural in the titles returned "about 5,580" hits. There are certainly adequate numbers of journal articles, government and NGO reports, theses and dissertations available, however, to allow for a brief review of some of them in this section.

In a study by Bergmann et al. of the preferences expressed by urban vs. rural residents in Scotland regarding the potential environmental and employment impacts of RET developments, a choice experiment methodology was utilized. The authors developed a survey instrument and a set of 24 choice cards which were designed to quantify the observable and unobservable components of the respondents' perceptions of the utilities of a variety of hypothetical energy projects. Their analysis of 210 survey responses showed substantial differences between the responses from urban and rural residents:

> Urban residents prefer projects that have low or no landscape impacts, do not harm wildlife and do not generate air pollution. Creation of new permanent jobs is not a

> determinant of the choice in this sample due to the heterogeneous preferences associated with this attribute. Rural residents can be inferred to have greater support for renewable energy projects, … are very influenced by projects that create new permanent jobs and, unlike the urban sample, there is no significant heterogeneity associated with this attribute (Bergmann et al. 622-3).

In a study which focused on community-based RE projects, residents of the Thirlmere region in northwestern England were surveyed to gauge their attitudes about and expected participation levels in a planned sustainable energy project. Quantitative and qualitative analysis of survey responses indicated, not surprisingly, that community members overwhelmingly supported the project and that two-thirds of respondents were interested in participating. None of them, however, "seemed to identify with the role of project leader" (J.C. Rogers et al. 4225), indicating that this type of project is more likely to be developed and controlled by stakeholders outside the rural communities in which the projects are located.

Several of the sources identified during this review of the available literature on the adoption of RETs were in the form of theses and dissertations. Two of these are described in this section, and another provides substantial information in the next section on barriers to the more widespread adoption of sustainable energy systems.

Stayton Bonner described a case study in which 15 residents of McCamey, Texas were interviewed regarding their perceptions on the development of two large wind farms in the area. A qualitative analysis was performed to characterize residents' opinions and insights before, during and after construction of the wind turbines. Two of the primary conclusions of the case study regarded a lack of infrastructure in two very different areas: technological, in terms of transmission capacity to export the wind-generated electricity, and educational, as described by one of the interviewees: "a rural population like McCamey was probably not able to take advantage of wind energy's opportunities as well as they should due to lacking a trained workforce" (Bonner 111). The researcher found that the levels of support and acceptance for the wind energy projects were high in this oil-belt community that still receives most of its tax revenue from oil production, and recommends that a similar study be conducted in an area with no prior history of energy resource exploitation.

In a study of renewable energy development in Saskatchewan, Julia Hardy used new social movement theory to provide a framework to analyze a unique energy project that was initiated by a group of rural community leaders there. She identified the factors that either facilitated or constrained the development of the Craik Sustainable Living Project (CSLP), "the first comprehensive environmental project in Saskatchewan employing a long-term sustainable living plan that involved implementing alternative energy practices for an entire community" (Hardy 1). The CSLP was conceived in response to two perceived crises, a steady decline in the population and economic activity in Craik and a concurrent decline in the surrounding area's agricultural production that was caused, or at least exacerbated, by rising chemical and fuel costs. Community leaders developed a plan that would be a catalyst for economic development while also achieving a set of social and ecological objectives. Based on an idea and guidance contributed by an ecologist from outside their community, Craik's leaders organized the construction of an energy efficient housing development and "Eco-Centre[1]" building along with the creation of educational programs on living more sustainably and a community-wide transition to more ecologically friendly living. The key facilitating factors that coincided with the crisis-motivated actions by the local leaders were the availability of grant and loan funding from the federal government for municipalities to develop "green projects" and the resilient spirit of community members, which was supported by the ideas and experience contributed by outside leaders. Local support for the CSLP was strong enough to overcome the constraining factors that worked to oppose the project, including a petition and misinformation campaign circulated by a group of local naysayers and

[1]The Eco-Centre opened in 2004 and still "serves as a focal point for indoor and outdoor demonstration and educational programming on sustainability. Its construction also provided the opportunity to increase local expertise in alternative building and system design" (Craik Sustainable Living Project).

the burnout of several of its early organizers. Hardy concludes by stating that her "study of one small rural Saskatchewan town provides hope that it is possible for people to act to improve their social and economic circumstances" (126).

2.1.3 Barriers that inhibit RET adoption

In her thesis, Hardy described a number of constraining factors that represented barriers encountered by the community leaders who were implementing RETs and other innovative measures. In his thesis, Christopher Adachi systematically identified and categorized the potential barriers to adoption of PV systems by residents of Ontario, Canada. He placed the various barriers into monetary, social, institutional, and technological categories but noted that the classification of the barriers was not rigid and some barriers crossed over into two or more categories. His research focused on a financial incentive, specifically a feed-in tariff, called the Renewable Energy Standard Offer Program (RESOP) that had been introduced by the Ontario Power Authority (OPA) in 2006. Under the terms of the RESOP, the OPA would pay $0.42 (Canadian) per kWh generated by a PV system to the owner of the system for a period of 20 years. In his relatively small group of survey respondents, all of which were within the group of the earliest adopters of the RESOP, he found that 75% were strongly motivated by environmental factors and would have implemented a PV system even without the added financial incentive.

An analysis of policy instruments used to incentivize the faster diffusion of RETs by Valentina Dinica utilized an investor-oriented perspective and compared feed-in tariffs with quota systems. She found that policies designed to overcome the economic and financial barriers to adopting RETs could be analyzed by utilizing a risk-profitability profile and translating policy language into investment-focused terminology but found the approach did not adequately incorporate the non-financial risk factors (e.g. reliability risks for homeowners, political risks for policy makers, technological risks for utilities) common to many RETs. She argues that the often complex and diverse payment streams that are characteristic of feed-in tariff programs are less desirable to potential investors in RET systems and that more straightforward support schemes such as investment subsidies and direct financial incentives would be preferable as policy instruments.

In 2001, Painuly described a framework with which to identify the barriers to RE projects in a given country or region and methods which might overcome them. His process for characterizing the potential barriers to a project include first performing a literature review, looking in particular for case studies which describe similar projects, then site visits and interaction with stakeholders. He provides an extensive list of barrier elements and possible strategies one could employ to surmount them. Using the framework described above as a guide, Reddy and Painuly surveyed various stakeholders, including households, industrial and commercial establishments, RET system developers and policy experts to develop a systematic classification of the barriers to RET adoption in Maharashtra State, India. The results indicated that the economic, financial and market barriers ranked as most important, as would be expected, but that lack of awareness and information was ranked higher by respondents than the technical, behavioral and other categories of barriers (Reddy and Painuly 1439).

Faiers and Neame studied consumer attitudes regarding residential solar power systems in England. They conducted a survey designed to characterize the chasm (described above in Section 2.1.1) between the existing, idealistic early adopters of solar thermal and PV systems and the potential "early majority" adopters, who were perceived as more pragmatic, in Northamptonshire. A Kelly's Repertory grid methodology (see Van Kleef et al.) was used, and 100 owners of solar energy systems and 1,000 others who had previously adopted "other types of energy efficiency measures, who, for the purposes of this survey were classified as 'early majority'; i.e. pragmatic enough to purchase energy efficiency measures, but not so innovative as to purchase solar power" (Faiers and Neame, 1801) were sent survey forms. The survey instrument contained 23 sets of bi-polar description pairs such as reduces pollution/increases pollution, generates savings/does not generate savings and affordable technology/unaffordable technology. Respondents marked spots on lines between each pair of descriptors to indicate their attitudes regarding solar energy in terms of each pair. Responses were received from 43 solar adopters and 350 early majority candidates for solar power. The results indicated that the early majority respondents were generally positive about the environmental aspects of solar power, but not enough to overcome the negative economic attitudes and be convinced of the overall benefits of solar energy technologies and thus "jump the chasm." Although the magnitudes of many of the levels of perception for the 23 characteristics differed significantly between the early and majority adopters, there were no characteristics for which the perceptions contrasted, i.e. the average for the early adopters was on the positive side and that for the majority adopters was negative. In terms of identifying the chasm, key non-financial elements for the early majority respondents include the perception that solar systems are unattractive and visually intrusive and that installation and maintenance may be issues. Among the possible marketing strategies Faiers and Neame recommend are that suppliers of RETs work closely with early adopters to improve the operational and aesthetic aspects of the products they market, and seek to understand the perceptions and needs of their potential customers.

Finally, a 2006 DOE report described a review of 19 documents published since 2000. It listed the most frequently identified nontechnical barriers to the diffusion of solar energy, as they fit within the broader category of energy efficiency and renewable energy (EE/RE) technologies. The list of barriers included the following, with the numbers of documents the barrier appeared in shown in parenthesis:

- Lack of government policy supporting EE/RE (13)
- Lack of information dissemination and consumer awareness about energy and EE/RE (12)
- High cost of solar and other EE/RE technologies compared with conventional energy (10)
- Difficulty overcoming established energy systems (10)
- Inadequate financing options for EE/RE projects (10)
- Failure to account for all costs & benefits of energy choices (8)
- Inadequate workforce skills and training (7)
- Lack of adequate codes, standards, and interconnection and net-metering guidelines (5)
- Poor perception by public of renewable energy system aesthetics (4)
- Lack of stakeholder/community participation in energy choices and EE/RE projects (4) (Margolis and Zuboy 6)

2.2 Definition and common uses of consumer profiles

The development of consumer profiles is one of the processes used by companies who wish to focus their marketing efforts on specific segments of heterogeneous markets. Since the word market has several meanings, a textbook definition of how it is being used in this context is in order here:

> [A] market is an aggregate of people who, as individuals or as organizations, have needs for products in a product class and have the ability, willingness, and authority to purchase such products. (Pride and Ferrell 177)

A heterogeneous market is composed of a variety of individuals or organizations with diverse product needs, and marketing to this group is referred to as mass marketing. Consumer profiles are elements within the process of market segmentation, which is used to define or characterize specific target market segments within a larger heterogeneous market. Using consumer profiles to more efficiently reach the members of these target markets is called niche marketing. A market segment is defined by a set of segmentation variables which are used to characterize its members in terms of their demographics and a number of psychographic, geographic and behavioristic characteristics. Table 2 categorizes and lists some of the characteristics that might be included in a consumer profile.

As was mentioned in the Introduction, consumer profiles will be described for two sets of residents of Cochise and Santa Cruz Counties. The profiles will contain several demographic characteristics along with some personal values and indicators of attitudes that fall into the psychographic and behavioristic categories. No geographic

Table 2.

Categories of Characteristics Commonly Used in Consumer Profiles

Demographic	Psychographic	Behavioristic	Geographic
Age	Personality attributes	Benefit expectations	Urban/suburban or rural
Gender	Motives	Volume usage	Region
Race	Lifestyles	End use	City/county size
Ethnicity		Price sensitivity	Market density
Income		Brand loyalty	Climate
Education			Terrain
Occupation			
Family size			
Religion			

Source: Pride and Ferrell Figure 8.5.

variables, however, will be included. Although some of the survey respondents live in Nogales and Sierra Vista, which are small cities with populations of 20,837 and 43,888 (U.S. Census Bureau 2010 data) respectively, no distinction was made in the analysis herein about their choices to live in a city, a small town/village or on a large ranch far from any other residents or populated areas.

As was the case for the review of the academic literature for the adoption of RETs in rural areas, there is only a small body of books, articles and theses which have focused on the use of consumer profiles with respect to diffusion of RETs. An article published in 1983, when consumers in the U.S. were still highly conscious of the 1973 and 1980 oil price hikes, surveyed opinion leadership and other psychographic characteristics of 817 Florida residents, 488 of which had adopted some type of solar energy device. The results indicated

> that the lifestyle characteristic of energy consciousness within an individual is associated with a number of other salient lifestyle characteristics…. This finding implies that the policy of either the public or private sectors to mass market the idea of energy conservation, and the subsequent purchase of some particular energy saving devices, would be largely ineffective. Instead, selectively targeted appeals to specific markets … would be the more effective alternative. (Davis and Rubin 185).

It seems that little has changed in terms of marketing solar energy technologies since 1983. Although concerns about global climate change have at times replaced distress about rising gasoline prices in the national consciousness, researchers are still having no problem finding differences in the demographic and psychographic profiles of innovators/adopters of RETs and the more pragmatic early majority adopters. A survey of innovators, who had previously purchased residential solar energy systems, and pragmatists, who "had previously purchased conventional energy efficiency products such as cavity wall or loft insulation, but had not enquired about purchasing solar thermal systems" (Faiers et al. 3419) found several statistically significant differences in the responses from members of the two groups. Income levels were lower among the innovators, and observability, an indication of whether it is possible to see an innovation in popular use, was regarded as important to the pragmatists but not to the innovators.

Several recent studies have analyzed electricity ratepayers' propensity to pay a premium price for "green electricity," an option that is available from many electricity providers, including Sulphur Springs Valley Electric Cooperative (SSVEC) in southeastern Arizona, along with Salt River Project and Arizona Public Service Company, which provide electricity to residents of metropolitan Phoenix. Ritsuko Ozaki used a theoretical framework that included DOI theory along with theories of cognitive and normative behavior and measurements of energy consumption to develop a survey questionnaire and a list of interview questions. She then surveyed and conducted a series of semi-structured interviews with employees at a university in London, who had an admittedly green bias. She found that there was a high level of uncertainty about the green electricity service and that even green consumers would not adopt it

> without practical knowledge about how green electricity is generated, how the premium they pay is used, ease of changing contracts etc.... Positive green attitudes towards

> pro-environmental behaviours do not necessarily translate into the performance of the behaviours. People are capable of being contradictory or hypocritical. The challenge for those wishing to promote green electricity, therefore, is how to fill the gap between intentions and actual behavior (Ozaki 13).

A discussion concerning this "lack of practical knowledge," along with some ways to overcome it and fill the chasm between the early adopters and the majority of potential renewable energy technology adopters, will be presented below in Chapter 4.

It is hoped that this review of the theory of diffusion of innovations and some of the previous analyses of the adoption of RETs, along with the overview of consumer profiles, will provide a foundation for understanding the rationale for some of the choices of survey and analytical methodology that will be described in the next chapter.

3. RESEARCH DESIGN AND METHODOLOGY

After several discussions and lengthy and careful consideration of the possible techniques for analyzing how and why people decided to adopt renewable energy technology, the decision was made to use a market research tool, the consumer profile, as the primary unit of analysis. This choice allows the results of the research to be described and interpreted in two important ways. First, it allows for a rigorous statistical analysis of the data collected. It also provides the basis for a set of recommendations about how the profiles might be used by the marketers, designers and installers of solar and wind energy systems, as well as the governmental, non-profit and community stakeholders as they work together to achieve more widespread penetration of these and other RETs into rural markets.

In social science research that involves the use of a survey, both the specification of the hypotheses to be examined and the design of the survey instrument are vitally important tasks. The survey instrument went through a series of iterations before reaching its final form. It incorporated the survey design principles described in detail in Section 3.2 and it is replicated in Appendix C.

The following sections lay out the research questions and hypotheses to be explored, and the methods that were employed during that exploration.

3.1 Research questions and hypotheses

The most significant questions to be answered by in this thesis are these:

1. Is the consumer demographic profile for renewable energy system adopters distinguishable from the profile for those who chose to install other upgrades/additions to their homes?

2. Are the energy conservation habits for renewable energy adopters significantly different from those of non-adopters?

3. What were the sources of information consulted and the most important factors that motivated the decision to purchase a renewable energy system?

4. Which, if any, of the factors which influenced the decision to live in a rural area or small city or town in southeastern Arizona was related to the factors that informed and influenced the decision to purchase a renewable energy system?

The first two questions can be expressed as null hypotheses to be investigated and possibly rejected using the survey results. The null hypotheses can be stated as follows:

1. The demographic profile of the renewable energy technology adopters among residents of Cochise and Santa Cruz Counties is indistinguishable from that of other residents of the two counties who have installed non-energy-related additions or upgrades or have remodeled their homes.

2. The energy conservation habits of renewable energy technology adopters among residents of Cochise and Santa Cruz Counties, as described by numeric values calculated from ordinal survey responses, are the same as those of non-adopters.

It is important to note that even if one or both of the null hypotheses cannot be rejected by the data obtained from the survey results, this information will still be valuable to those who wish to promote and increase market penetration of RETs in southeastern Arizona.

3.2 Survey design and development

The basis for several of the questions included in the survey designed for this thesis was drawn from a survey that was used by the Santa Cruz County-based organization Practical Energy for Rural Communities, or PE4RC, for which I have served as a research fellow and project coordinator. PE4RC conducted a survey in the winter of 2009 to get a better understanding of the knowledge, priorities, actions and plans regarding energy conservation and renewable energy as expressed by the residents of the town of Patagonia and the unincorporated communities of Sonoita, Elgin and Canelo. The results of that survey, along with the survey instrument and other related material, which was mass-mailed to almost 2,000 addresses in those northeastern Santa Cruz County communities and achieved a 7.5% response rate, are available on the Survey page of the organization's web site (PE4RC). The tool used for collecting the data for this thesis, the Renewable Energy Decision Factors (REDF) Survey, relied primarily on phone and face-to-face interviews rather than a mass-mailing.

3.2.1 Initial survey design

The questions used for the PE4RC survey provided a good start for obtaining some of the information necessary to develop a consumer profile for the RET adopters that would be surveyed as part of this research. But that survey did not ask for any demographic information, nor about the respondents' personal values or reasons for living in southeastern Arizona. In order to more effectively incorporate the additional questions into a longer survey, the principles of survey design laid out by Dillman were followed. The addition of questions to elicit the demographic and values information led to the initial design for the REDF Survey instrument.

One of the chief considerations for the design of the instrument was to keep the number of demographic questions at a manageable level while gathering enough information to construct the demographic profiles. An early draft of the instrument included questions for the ages, genders and education levels of both the interviewee and his/her spouse/household partner. In subsequent drafts, the demographic questions for the partners were eliminated, and thus the final survey instrument included questions to elicit the demographic data for only the interviewee, who was to be pre-qualified as the primary decision-maker regarding implementation of energy systems or other household upgrades, additions or remodels. The result was a total of 22 questions included in the survey instrument, several of which had at least ten sub-questions or categories to check. Most of the responses required only checking a box, and there were three open-ended questions plus a handful of “Other:______” responses available to respondents.

Due to the relatively large number of questions, the survey was divided into three parts:

1. Energy use/conservation/renewable energy system actions and attitudes.

2. Overall (not energy-specific) personal priorities and characteristics.

3. Demographic information.

As is the case with all human subject research undertaken at Arizona State University, Institutional Review Board approval for the survey design and cover letter was required. A description of the survey protocol and a draft of the survey instrument were submitted to the ASU Office of Research Integrity and Assurance for approval. Due to the low-risk and non-controversial nature of the research, the protocol was considered exempt from further IRB review and was documented as such in a letter dated July 6, 2010. An image of the letter granting exemption is included herein as Appendix A.

3.2.2 Pilot interviews

In order to gain experience with administering the survey and to get feedback about the wording of some of the questions and possible responses as well as suggestions for additional categories to include as possible responses, the initial survey instrument was piloted using six RET adopters who live in Santa Cruz County. I had met the two individuals and two couples who were the pilot respondents during my work with PE4RC, and their feedback resulted in a more effective design for the final survey instrument. Having the opportunity to run through the survey questions with people I knew was also quite valuable for me personally. For me, making cold calls to, and eventually ringing the doorbells of, people I didn't know to ask them to spend 10-15 minutes speaking with me and being a part of my research was the most challenging aspect of this research. Thus my opportunity to get comfortable with asking the survey questions was very important to its successful completion.

3.2.3 Final survey instrument design

After incorporating the suggestions provided by the survey pilot respondents and another round of feedback from the thesis committee, the final versions of the cover letter and survey instrument were completed and are included as Appendices B and C.

The first section of Part 1 of the survey instrument contained questions to be answered by all of the respondents. The questions that asked about their energy conservation habits and energy efficiency measures they had already installed, or planned to install at some point in the future, were designed to provide conservation habit and efficiency measure scores that could later be used in the statistical analysis. The remaining questions in Part 1 were divided to acquire different pieces of information from the RET adopters and from those who were considering such a purchase had not yet done so. The responses to the questions about what motivated and informed the RET adopters' decisions to purchase an energy system and the reason[s] reported by those who have not yet made that decision, along with the responses to the questions in Part 2 were used for the psychographic and behavioristic components of the respective consumer profiles.

The primary information that was used in the development of the profiles, however, as well as in the statistical analysis, is the demographic information reported in Part 3 of the survey instrument.

3.3 Identification of potential survey respondents

During the early phase of my research fellowship in Santa Cruz County, I met John Maynard, the member of the SCC Board of Supervisors who represents the rural eastern area of the county. He was intent on implementing a voluntary green building standard for the county and through him I met the SCC Chief Building Inspector, Bob Banzhaf. I learned from him that the number of building permits issued for solar and wind energy systems was tracked as a subset of the total number of utility-related permits issued each month and that the permits were public information. I subsequently realized that these permits would allow me to identify the county's residents who had installed solar and wind energy systems. During a brainstorming session with my thesis committee chair, we developed the idea of comparing the demographic profiles of RET adopters with those of other county residents who had spent money to upgrade or remodel their homes or build some kind of addition.

A preliminary review of SCC building permits for solar and wind energy systems indicated that the number of installations in that county would be inadequate for the survey and data analysis we had been discussing. I then performed a preliminary review of Cochise County building permits and determined that a 2-year time frame would provide a reasonable number of potential survey respondents who lived in the two counties.

3.3.1 Permits for solar and wind energy systems

There were a total of 210 permits, 47 in Santa Cruz and 163 in Cochise, issued for residential wind and solar energy systems in the two counties between July 1, 2008 and June 30, 2010. The permit format for SCC provided a benefit for this research because it included separate spaces for the phone number of the resident/permittee and for the contractor, who was often the person who filed the permit application. The result was that valid phone numbers for most of the SCC RET adopters were available to me. In CC, however, with just one phone number field on the permit application, most of the phone numbers on the permits were for the contractors who submitted the applications. Online phone directories were able to provide good phone numbers for only about half of the solar and wind system permits for that county, so the response rate for CC residents was lower.

3.3.2 Permits for home renovations, remodels and upgrades

There were considerably more than 200 building permits issued for additions, remodels and other home upgrades in the two counties over the 2-year period under review. A set of criteria was established in order to produce a list of residents who had been issued permits for substantial projects which would be in many cases similar in cost and scope with the purchase of a renewable energy system. The estimated costs (many of these permits were filed by and the work done by the homeowner) or prices of the jobs were listed on the permits, and most of them were between $10,000 and $50,000. Contact information for potential survey respondents was logged for only those permits that were clearly for a remodeling job or an upgrade or addition to an existing home with a minimum cost/price of $1,000. Examples of the descriptions for these jobs included living room, bedroom and Arizona room additions, construction or covering of patios and decks, and building carports, sheds, fences or walls. It was necessary to review a one-year period to obtain a list of 266 names and addresses (41 in SCC and 225 in CC) of what will be referred to hereafter as non-RE permittees.

3.4 Data collection

An optimistic target of 100 responses for each of the RET adopters and the non-RE permittees was established. There was some skepticism among my committee members about achieving that high of a response rate (~50% for RET and 37.5% for non-RE permittees) which turned out to be justified by the time I suspended the often quite rigorous efforts to reach potential respondents. But I had developed an effective script and the perhaps naïve confidence of a rookie social scientist and I set out to reach as many people as I could.

My ongoing work with PE4RC in SCC gave me a nice head-start to the data collection effort there. I had met several of the RET adopters in addition to those who had piloted the survey instrument, and found that I had e-mail addresses for several others in the mailing list we had developed for sending out announcements. I had used Survey Monkey earlier in 2010 for the PE4RC survey and I again employed it for the Renewable Energy Decision Factors Survey.

3.4.1 By phone

The initial review of building permits resulted in long lists of the names and addresses of potential respondents, but less than half of them included a phone number to go with the name. I used two free online resources, DexKnows.com and WhitePages.com, as the first effort to find a phone number for each name and address on the lists. There were still over 50 names on the lists for which neither free directory service had provided a number, so I subscribed to a service called People Lookup and was able to locate another dozen or so phone numbers.

Before any calls were placed, I created a set of call sheets with which to log the date, time and result of each call. The first set of phone calls was to the SCC RET adopters. Almost every one that answered the phone agreed to complete the survey, which took about 15 minutes, although a few lasted for as long as an hour. If an answering machine or voice mail service answered, I did not leave a message but instead logged the result and called the number back at a later time. I ran through the entire list, making repeated calls at different times and days to the numbers for which there was no answer or a voice mail machine or service answered.

The sequence was repeated, first for the SCC non-RE permittees, and then for the CC RET adopters and finally for the CC non-RE permittees.

3.4.2 Online

The online versions of the survey instrument, one each for SCC and CC RET adopters and one for all non-RE permittees, were available before I started making phone calls to solicit survey responses. I had anticipated that many of the respondents would balk at doing the survey on the phone and ask if they could respond online, but in the end only 3 or 4 asked to do so. The online survey form for the SCC RET adopters was also used by 7 of the 8 people for which I had e-mail addresses and sent a link to the survey.

3.4.3 In person

After several months of phone calls I had reached a point of diminishing returns and had accumulated a total of just over 100 survey responses, about 50 in each category. This was well under half of my target of 100 responses in each, but probably close to having enough for a statistically significant result. I thus started mapping the locations of some of the remaining potential respondents who lived in Sierra Vista, a list of about 40 names of RET adopters for which I had no phone number or no answers to any of my repeated calls. There were two clusters of address markers on the map, so I decided to go out and "pound the pavement" and ring the doorbells at those addresses. The effort that day was relatively successful, resulting in a total of 6 completed surveys and only one refusal out of 11 doorbells rung. Thus I made two more pavement- (or dirt road-) pounding trips from Elgin to Sierra Vista (about an hour's drive each way) which resulted in another dozen or so completed surveys for RET adopters. I was not comfortable, however, with the idea of walking up to the doors of the non-RE permittees.

3.5 Developing consumer profiles

The consumer profiles developed from the survey data collected from the renewable energy adopters and the non-RE permittees who are residents of the two-county region are the key results derived from this research. Constructing consumer profiles, however, is not an exact science. Within the broad field of product marketing, these profiles represent a portion of the information that marketing strategists use to better understand consumer buying behavior. To gain that understanding, it is critical to include all of the relevant demographic variables that will compose that portion of the profile along with the more nuanced psychographic and behavioristic variables that can be used to design more effective marketing and sales strategies. The questions in the Renewable Energy Decision Factors Survey used for this research were designed to collect information about the respondents and their attitudes, values and behavior. Compiling and analyzing this information to construct consumer profiles of the RET adopters and non-adopters will provide tools to help guide the designers of solar and wind energy systems and the promoters, marketers and sellers of those technologies to achieve their more rapid diffusion into the rural areas of southeast Arizona and beyond.

The age, household size, education level attained and household income are the four components of the demographic profile that was used for the primary statistical analysis that is described in the next section. To this core profile, a representation of the respondents' energy conservation habits and energy efficiency improvements that have already been installed, along with their new technology adopter categorization, were added to provide information about the behavior of the respondents. Finally, the consumer profiles were completed by the addition of the psychographic information gleaned from the answers to the questions about the motivations for conserving energy and the respondents' personal values.

The responses to the questions in the survey that were included for only the RET adopters provide some additional insights into their buying behavior and motivations, along with information about the various sources of information they used while investigating RETs and making the decision to purchase them. Similarly, the responses to the question asking why the non-RE permittees had not yet purchased a solar or wind energy system may indicate whether any of the other possible reasons other than the high cost of RE technology were significant. Some of the perspectives gained from these responses will be incorporated into the consumer profiles, and they will be also be discussed in the recommendations section.

3.6 Statistical analyses

The survey responses used both to construct the demographic profiles and to calculate measures of the respondents' energy conservation habits did not directly provide numeric results that could be statistically analyzed in order to provide the evidence with which the null hypotheses could be rejected. The following sections describe the assumptions used to convert the check boxes used to gather the demographic data into numeric values and the process used to transform the ordinal responses that described respondents' energy conservation habits into numeric scores.

3.6.1 Analysis of demographic profile data

The elements of the demographic profile are the respondents' average age, household size, level of education attained and household income. Only the household sizes were calculated directly from the survey responses for the two sets of respondents. The mean ages were based on the midpoints of the 5-year wide age brackets, with an age of 68 assumed if the response was "Over 65". The responses to the question "Highest education level attained" were converted to the years of education assumed as shown in Table 3.

Table 3.

Education Levels and Corresponding Years of Education

Response to survey question "Highest education level attained"	Number of years of education assumed
High school	12
Some college/Associate's degree	14
College graduate/ Bachelor's degree	16
Post-graduate studies/ Master's or PhD	20

The possible responses to the survey question "Household income from all sources" were $20,000-wide ranges. For the purpose of calculating the mean income levels for the two groups of survey respondents, the midpoints of the income ranges were used as shown in Table 4.

The household income question was the only one in the survey for which there was a substantial number of respondents who declined to respond. One straightforward option for dealing with missing data values is to perform the analysis using only the surveys for which the data is complete, and another is to use a mathematical algorithm to estimate the missing values based on the existing data for each set of respondents. The decision about how to handle the missing values was

Table 4.

Household Income Ranges and Corresponding Income Levels

Response to survey question "Household income from all sources"	Income level assumed
Under $20,000	$10,000
$20,000-$40,000	$30,000
$40,000-$60,000	$50,000
$60,000-$80,000	$70,000
$80,000-$100,000	$90,000
Over $100,000	$110,000

not made prior to the collection of the survey responses and the subsequent data analysis, so both analytical techniques were applied.

There were a total of 76 responses from RET adopters and 57 from non-RE permittees, for which 17 and 8 respondents, respectively, declined to divulge their household income levels. Thus an initial data analysis was performed on the complete responses from 59 RET adopters and 49 non-RE permittees. Then, in order to estimate the values for the missing income levels the expectation-maximization (EM) algorithm was employed. The EM algorithm is an iterative procedure which first estimates expected values for the missing data based on the covariances among the existing data. Covariances are a measure of the collinearity of the data, the degree to which the variables are inter-related. For example, household incomes and education levels are related, with higher education levels being positively correlated with higher incomes, and thus exhibit a degree of collinearity. Using the initial estimates for the missing data, a new set of covariances is calculated and the process continues iteratively until the covariances for the current step are unchanged from those of the previous step (Dempster et al.). EM algorithm estimates for the missing values were generated using the PASW 18 (designated as Predictive Analytics SoftWare on ASU's application system, it was formerly known as SPSS) software application and subsequently analyzed using the method described below.

Under the assumptions described above to translate the age, education level and income range responses into numeric values, the 4-element vectors containing the mean age, household size, years of education and household income level can be calculated, along with the covariance matrices, for the two sets of survey responses. Using mean vectors $\bar{x}_1$ and $\bar{x}_2$ and covariance matrices $\sum_1$ and $\sum_2$ for two data sets of size n_1 and n_2, the squared statistical distance, designated as a T^2 statistic, can be calculated using Equation 1 (Johnson and Wichern).

$$T^2 = [\bar{x}_1 - \bar{x}_2]' \left[\frac{1}{n_1}\Sigma_1 + \frac{1}{n_2}\Sigma_2\right]^{-1} [\bar{x}_1 - \bar{x}_2] \qquad (1)$$

In order to evaluate the validity of the null hypothesis at a 99% level of confidence, the value of T^2 is compared to a X^2 (Chi-squared) statistic for 4 degrees of freedom and significance level $\alpha = 0.01$, or 13.28. Thus if the value of T^2 that is calculated for the mean vectors that represent the average age, household size, years of education and household income for the renewable energy technology adopters and the non-RE permittees surveyed in the two-county study area is greater than the critical X^2 value of 13.28, the null hypothesis will be rejected.

3.6.2 Analysis of energy conservation habits

Survey respondents' energy conservation habits were elicited using a 3-point ordinal scale in which they described how often they followed six specific household energy conservation practices such as "wash laundry with cold water" and "turn out the lights when leaving a room." Two additional "Other: __________" responses were available, and respondents specified whether they "always," "sometimes," or "rarely or never" follow the practices on the list.

In order to perform a statistical analysis based on the responses to the energy conservation habits question, numeric scores were calculated by assigning a value of 2 for "always", 1 for "sometimes" or 0 for a "rarely or never" response, then summing the values for each respondent. Next the mean conservation habit score $\bar{Y}_a$ and variance s_a^2 were calculated for the RET adopters and similarly $\bar{Y}_n$ and s_n^2 were calculated for the non-adopters. Given that the numbers of responses n_a for the RET adopters and n_n for the non-adopters were both over 30, a two-sample z-test was used. Null hypothesis #2 states that their energy conservation habits are the same, so a *z* statistic for $\bar{Y}_a - \bar{Y}_n$ was calculated using equation 2. Then a one-sided P-value based on *z* determines whether to reject null hypothesis #2 based on $\alpha = 0.01$.

$$z = \frac{\bar{Y}_a - \bar{Y}_n}{\sqrt{\frac{s_a{}^2}{n_a} + \frac{s_n{}^2}{n_n}}} \qquad (2)$$

The statistical analyses described above will provide answers to research questions 1 and 2. The other two questions do not have yes or no answers and fall within the province of market research. They will be answered in Section 4.2.

4. RESULTS AND OBSERVATIONS

The primary analytical results that will be reported here are the statistical analyses of the demographic profiles and conservation habits based on the data contained in the responses to the Renewable Energy Decision Factors (REDF) Survey. The first is a two-part statistical analysis that focuses on the demographic profiles, which are based on responses to these survey questions: What are your age, household size, education level and annual household income? Then the second analysis looks at survey respondents' energy conservation habits as described in research question and null hypothesis #2.

Although presenting the evidence that allows a researcher to reject a null hypotheses is a vitally important element in any thesis, what may be even more significant in this one is the information contained in "the rest of the story." The development of a detailed consumer profile for the southeastern Arizona adopter of solar or wind energy technology and the observations and discussion of his or her motivations and the information sources used while making the decision to purchase a renewable energy system represents the true potential for this work to become a substantial achievement.

4.1 Data analysis

As was first stated in Section 3.1, the first null hypothesis to be evaluated is "the demographic profile of the renewable energy technology adopters among residents of Cochise and Santa Cruz

Counties is indistinguishable from that of other residents of the two counties who have installed non-energy-related additions or upgrades or have remodeled their homes." The demographic profiles to be analyzed are composed of the mean values of the numerical representations of the responses to the age, household size, highest education level attained and household income questions from Part 3 of the REDF Survey. The analyses for the two methods for dealing with the missing household income responses will be presented separately in the following two sections.

4.1.1 Statistical analysis of complete demographic profiles

The problem of missing data points is a common problem in social science research and in many other fields. One method to deal with it is to simply reject any responses that do not contain complete data and base the results on the remaining data. This method works well when the number of missing values is relatively small.

In this analysis, 76 responses from RET adopters and 57 from non-RE permittees were collected. Of those, a total of 25 respondents (17 RET and 8 non-RE) preferred to not divulge their annual household income, a missing value rate of 18.8%. The remaining 59 RET adopter and 49 non-RE permittee (which will hereinafter be referred to as simply RET and non-RE) responses were deemed adequate for the calculation of a T^2 statistic with a 4-element vector of means based on the 12:1 and 14:1 ratios between the number of complete responses and the number of variables and the relatively small difference between the number of samples from the two data sets (Johnson and Wichern 245-6). The PASW 18 software application was used to calculate the 4x4 covariance matrices, which are shown in Appendix E and are designated $\sum_{C1}$ and $\sum_{C2}$ for the RET and non-RE responses, respectively. The vectors of means for the four variables are designated by $\bar{x}_{c1}$ and $\bar{x}_{c2}$ and are shown in Table 5. The column labeled $\Delta\bar{x}_C$ contains the differences between the four pairs of means. Note that it is not necessary to normalize the data values (e.g. using thousands for the household income levels so they would be on the same order of magnitude as the other variables) for the analysis because using the covariance matrices accomplishes the equivalent of normalizing of the data.

Table 5.

Vectors of Means used for the Analysis of Complete Responses

Variable	RET Adopters	Non-RE Permittees	$\Delta\bar{x}_c$
Vector:	$\bar{x}_{c1}$	$\bar{x}_{c2}$	
Age	60.627	54.735	5.892
Household Size	2.153	2.673	-0.520
Years of Education	17.424	15.388	2.036
Household Income	$77,458	$70,408	$7,050

When the mean vectors $\bar{x}_{C1}$ and $\bar{x}_{C2}$ and the covariance matrices $\sum_{C1}$ and $\sum_{C2}$ are plugged in to Equation 1, the result is T^2 = 22.58. Given the critical value of the test statistic, $X_4^2(0.01)$ = 13.28, null hypothesis #1 is rejected at a confidence level of 99%

4.1.2 Analysis of demographic profiles using EM algorithm estimates

The EM, or expectation-maximization, algorithm provides a method to calculate estimates for missing values in data sets such as those that were collected from the RET and non-RE respondents for the REDF Survey. The PASW 18 software application was used to calculate the estimates for the 17 missing household income values in the RET data set and the 8 missing values in the Non-RE data set. PASW 18 then calculated the 4x4 covariance matrices, which are shown in Appendix E and are designated $\sum_{E1}$ and

Table 6.

Vectors of Means using EM Algorithm Estimates for Missing Values

Variable	RET Adopters	Non-RE Permittees	$\Delta\bar{x}_E$
Vector:	$\bar{x}_{E1}$	$\bar{x}_{E2}$	
Age	61.092	54.670	6.422
Household Size	2.092	2.580	-0.488
Years of Education	17.368	15.68	1.688
Household Income	$76,084	$71,660	$4,424

$\sum_{E2}$ for the RET and non-RE responses, respectively. The vectors of means for the four variables are designated by $\bar{x}_{E1}$ and $\bar{x}_{E2}$, along with the differences $\Delta\bar{x}_{E}$ are shown in Table 6.

When the mean vectors $\bar{x}_{E1}$ and $\bar{x}_{E2}$ and the covariance matrices $\sum_{E1}$ and $\sum_{E2}$ are plugged in to Equation 1, the result is T^2 = 23.62 and again null hypothesis #1 is rejected at a confidence level of 99%.

The analytical result obtained after using the EM algorithm reinforces the earlier conclusion. Furthermore, given the slightly larger value for the T^2 statistic for the larger data sets that included the estimates for the missing household income values, the additional step required to calculate the estimates was worthwhile. It is interesting to note that despite smaller differences between the means for three of the four variables in the demographic profiles that contained the estimates for the missing values, the larger T^2 value indicates a greater squared statistical distance between the vectors $\bar{x}_{E1}$ and $\bar{x}_{E2}$ than the distance between $\bar{x}_{C1}$ and $\bar{x}_{C2}$.

4.1.3 Statistical analysis of energy conservation habits

Research question #2 can be answered using null hypothesis #2: "The energy conservation habits of renewable energy technology adopters among residents of Cochise and Santa Cruz Counties, as described by a numeric value calculated from ordinal survey responses, are the same as those of non-adopters." In order to analyze the responses to the REDF Survey's question about energy conservation habits, the “always”, “sometimes” and “rarely or never” answers were converted to numeric scores as described in Section 3.6.2. The results are a mean energy conservation score $\bar{Y}_a$ = 8.95 and variance s_a^2 = 6.29 for the n_a = 76 RET adopters and a mean score of $\bar{Y}_n$ = 8.28 and variance s_n^2 = 3.74 for the n_n = 57 non-adopters.

When these results are plugged in to Equation 2, the test statistic for $\bar{Y}_a - \bar{Y}_n$ is z = 1.73. Based on the assumption that RET adopters have better energy conservation habits than non-adopters, the one-sided P-value based on z is 0.0418, which is greater than α = 0.01. Therefore, null hypothesis #2 cannot be rejected at a confidence level of 99%.

4.2 Descriptions of the basic consumer profiles

In the sections that follow, consumer profiles will be described for the two groups of Cochise and Santa Cruz County residents who were surveyed as part of this research. The charts that provide visual representations of the data and the tables that summarize it are based on all 133 (76 RET and 57 Non-RE) survey responses. More detailed expositions of the survey responses are contained in Appendix D.

The demographic characteristics of the RET adopters and the non-RE permittees which were used in the data analysis above are also the cores of their consumer profiles. The distributions of the responses for age, household size, education levels attained and annual household income are shown in Figures 7-10.

Both age distributions appear to be bi-modal. The peak at 46-50 for the non-RE respondents is likely due to families with children in the house and parents with adequate income to build additions such as family rooms, decks and patios. The second non-RE peak is from retirees who have renovated or built an addition. For the RET adopters, the apparent bi-modal pattern may be misleading. 54 of the 76 RET adopters (71%; see Appendix D11) are retired, so most of the 62 respondents who are in the 56 and over age brackets represent a block of adopters who are already retired. The peak representing the respondents who are over age 65 may be an indication that non-financial considerations were among the more significant drivers

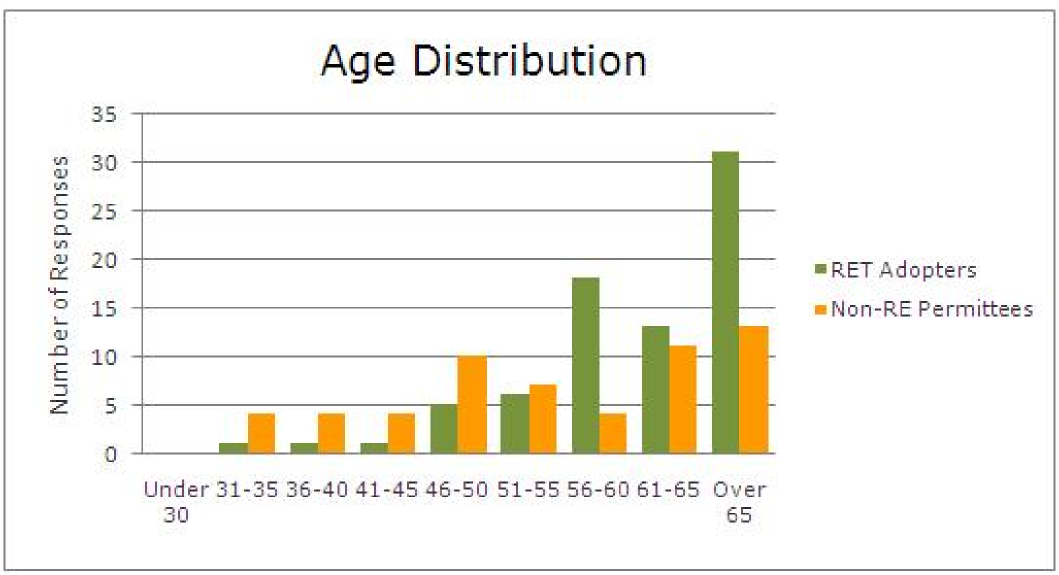


Figure 7. Distributions of survey respondent ages.

that motivated these older RET adopters' decisions to purchase solar and wind energy systems.

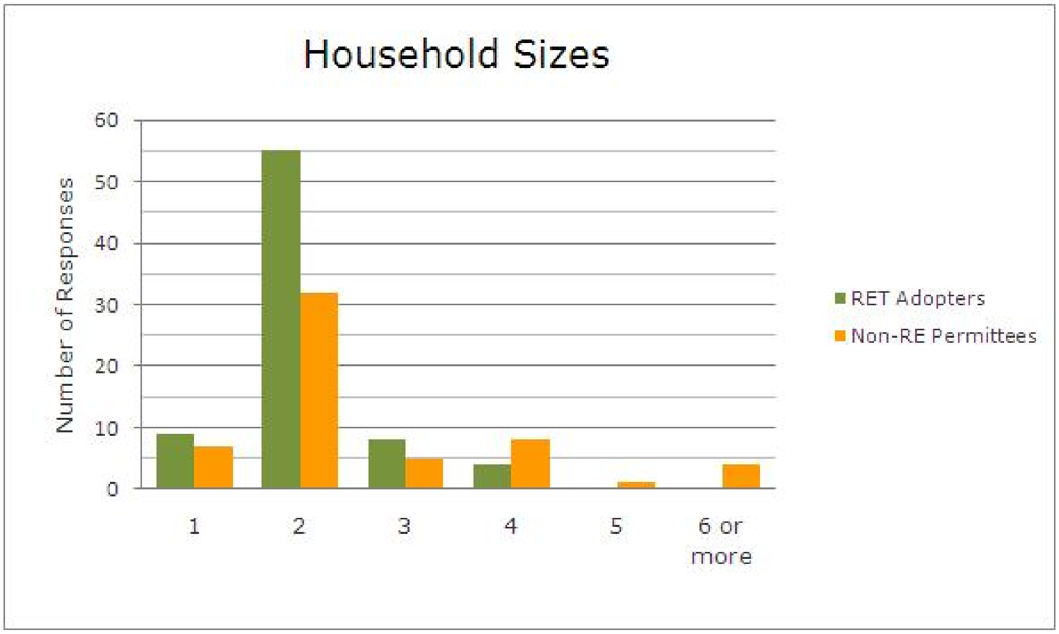


Figure 8. Survey respondent household sizes.

The majority of respondents, 72% of RET and 68% of non-RE, in both data sets live in 2-person households. This also reflects the fact that 88% of RET and 86% of Non-RE respondents are married (see Figure 8 and Appendix D17).

Figure 9 shows the respondents' education levels, the results of the responses to the survey question "highest education level attained." There is a dramatic difference in the profiles for the two sets of respondents, with almost half of the RET adopters having an advanced degree. This result is consistent with other analyses of renewable energy system purchasers going back as far as 1981 (cf. Labay and Kinnear; Sawyer).

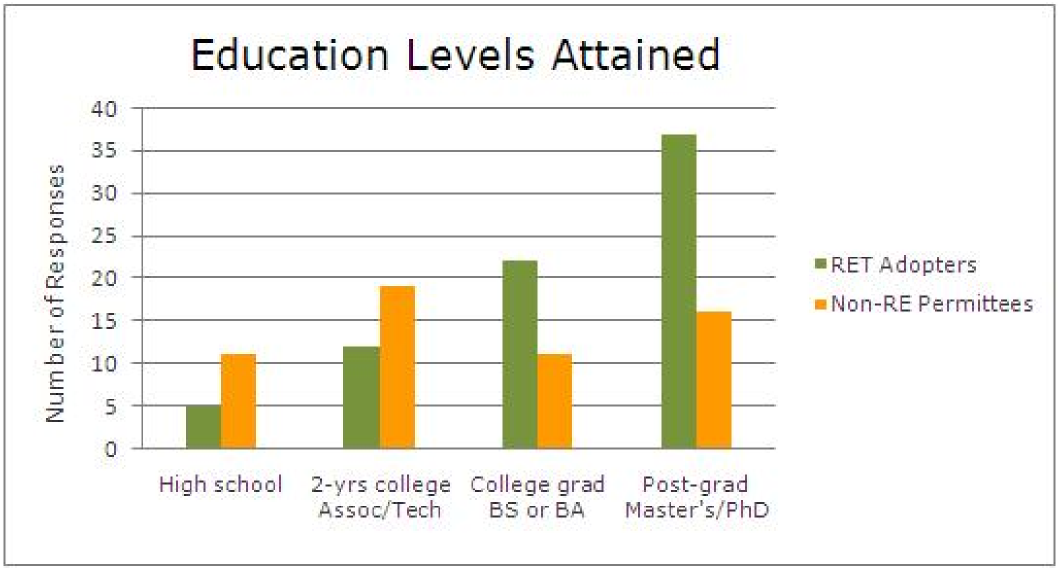


Figure 9. Responses to “highest education level attained”.

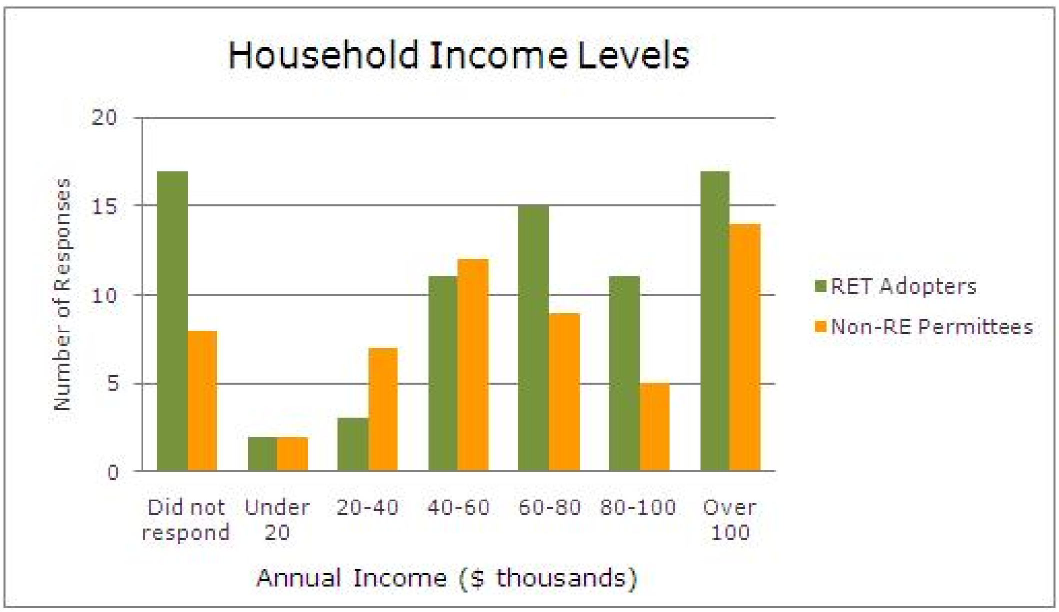


Figure 10. Respondents’ household income levels.

As was the case with the distributions of ages, there is also a bi-modal distribution of income levels for the available responses. Given the high initial cost of wind and PV systems, it is not surprising that the largest group of RET adopters had annual income levels of over

$100,000, and perhaps the same reasoning applies for the cost of adding a room or renovating a home, based on the responses from the non-RE permittees. The large numbers of responses for the highest household income category would seem to indicate that the actual average income levels for both data sets is somewhat higher than the mean values used in the data analysis and that perhaps a few more income categories should have been available as possible responses.

The survey included questions designed to measure a pair of behavioristic characteristics of the respondents regarding their energy conservation habits, as shown in Figure 11, and the steps they have taken to implement energy efficiency measures in and around their homes.

The percentages shown in the pie charts were calculated by first totaling the numbers of "Always," "Sometimes" and "Rarely or Never" responses to survey question 1, which listed six routine methods, such as "wash laundry with cold water" and "turn out the lights when

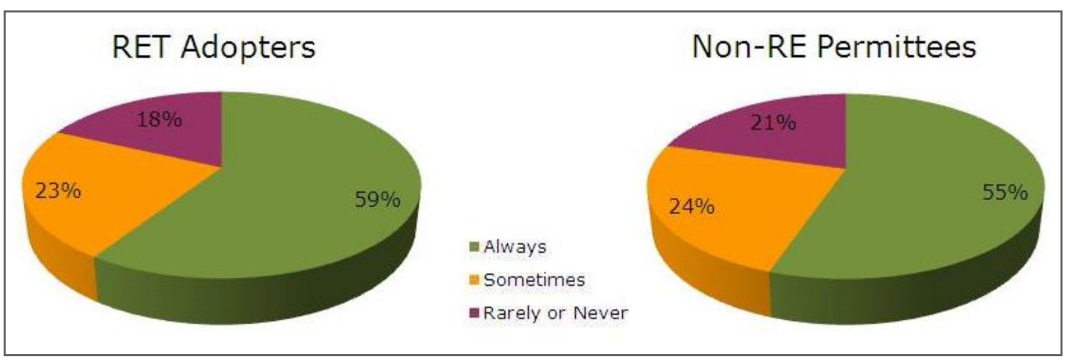


Figure 11. Respondents' conservation habits as measured by rates of use of six household methods to save energy.

leaving a room," for the two sets of respondents, then dividing by the respective total numbers of responses. There is obviously not a dramatic difference in their conservation habits, and there did seem to be an energy conservation ethic, even if motivated only by the opportunity to save on electricity costs, among both sets of respondents when I interviewed them.

Figures 12 and 13 provide representations of the energy efficiency measures the survey respondents have purchased or installed, including renewable energy systems. As was the case with the energy conservation measures, there were no substantial differences in the composite behaviors regarding energy efficiency between the two groups of respondents, except of course that the RET adopters have already purchased and installed their solar and wind energy systems. The findings regarding the respondents' behavioristic characteristics may appear to be counterintuitive, since it seems to make sense that homeowners who have installed renewable energy systems would have already implemented comprehensive energy efficiency measures and practice many conservation habits around the house. The results of many previously reported surveys, however, are consistent with the observations reported here (c.f. Labay and Kinnear; Guagnano et al.).

The final set of characteristics that will contribute to the consumer profiles of the southeastern Arizona RET adopters and

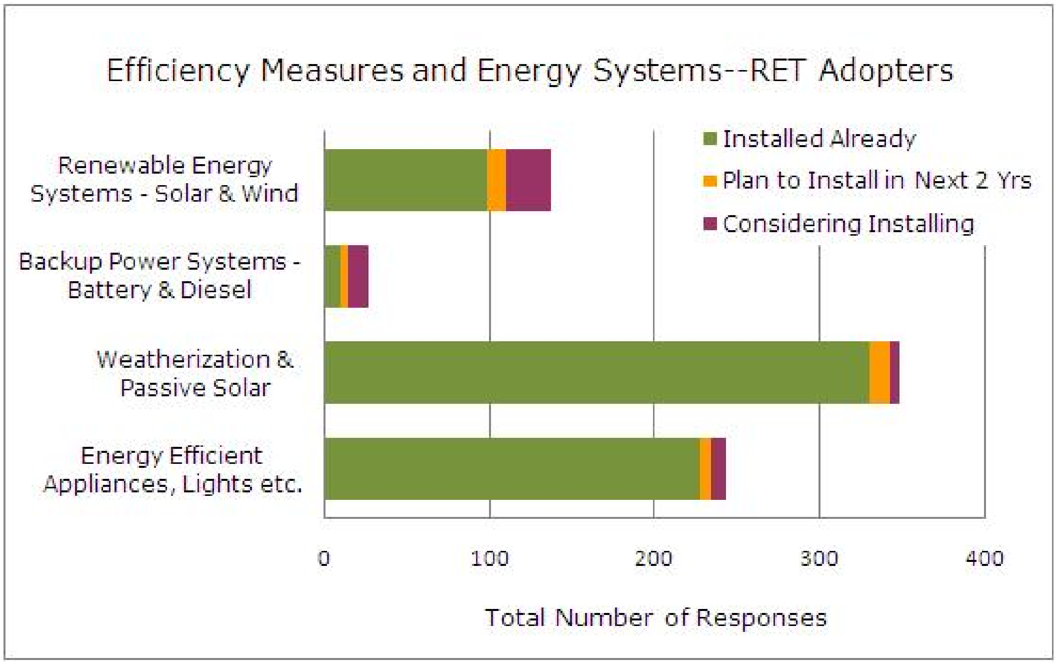


Figure 12. Energy systems and efficiency measures, RET adopters.

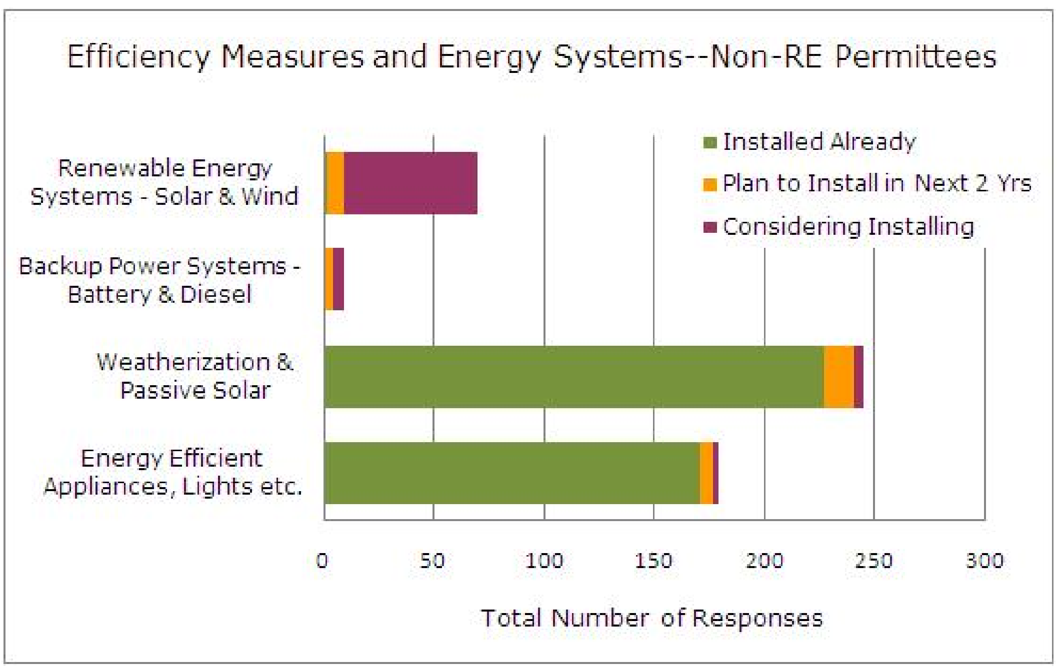


Figure 13. Energy systems and efficiency measures, non-RE permittees.

non-RE permittees is composed of psychographic data. A number of differences between the two sets of respondents will be described here and in Section 4.3, but no analyses will be performed to demonstrate their statistical significance. The primary reason for this approach is that the development of consumer profiles is part art and part science, and their potential subsequent use would be as a component of a marketing strategy rather than a more academic exercise.

Several survey questions were designed to measure respondents' motivations and values, starting with #2, which attempts to assess the motivations for the energy conserving behaviors reported by respondents under question 1. Figure 14 shows the results, with RET adopters indicating that they are more concerned

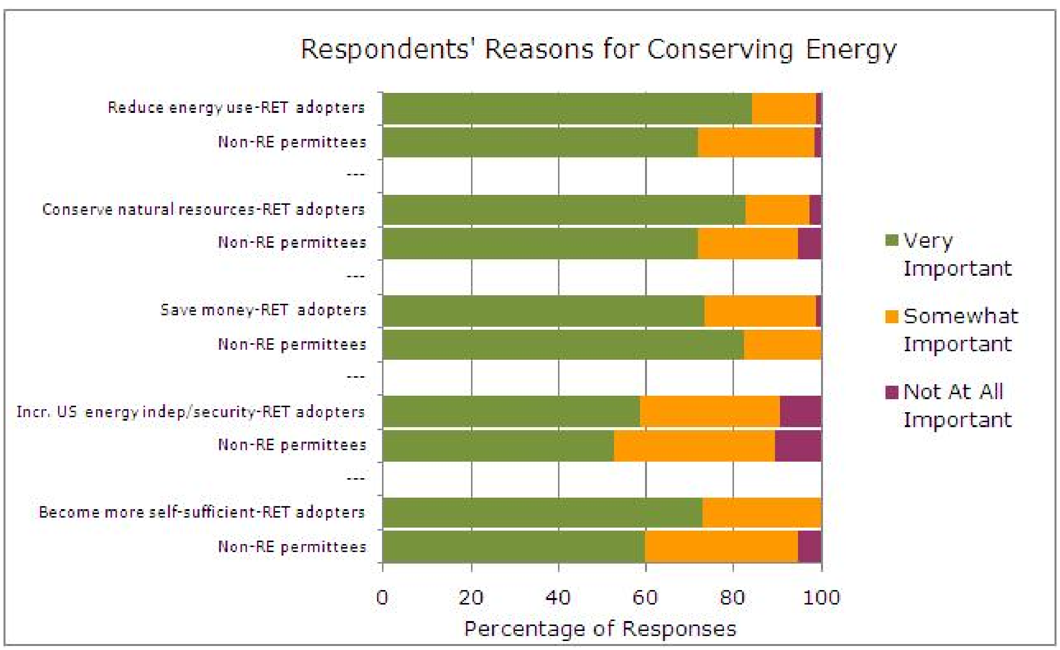


Figure 14. Rankings of survey respondents' reasons for their energy conservation behaviors.

with resource conservation, energy security and self-sufficiency, while the non-RE permittees rank saving money as being more important. Note that in Figure 14 the scale is based on the percentage of responses, as are most of the remaining charts in this section, from each data set in order to make the side-by-side comparisons of RET adopters and non-RE permittees more easily understandable.

The survey included one question meant to measure a characteristic that has elements that are both behavioristic and psychographic in nature: the self-assessment of respondents' early or late adopter purchasing habits. Although a higher proportion, 18%, of RET adopters selected "I am excited about new ideas or technology and usually one of the first people to try out something new", as compared to 10% of non-RE respondents, it was difficult to draw any conclusions in terms of the RET adopters' possible early adopter behavior because of the high number of "Other" responses. The breakdown of the rest of the responses is shown in Figure 15, and the descriptions of the other purchasing styles are included in Appendix D14.

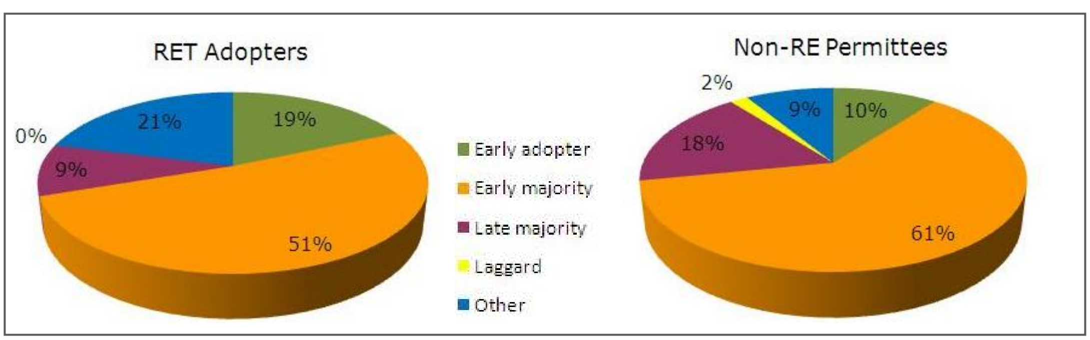


Figure 15. Respondents' self-described technology purchasing habits.

Survey question 10 was designed to develop personal value profiles for each set of respondents. It contains a list of 12 personal value traits that were ranked in terms of importance on a 3-point scale: very, somewhat or not at all important. The results are presented in Figure 16 and it includes several notable findings. First is the ranking for innovation, which was ranked very important by 60%

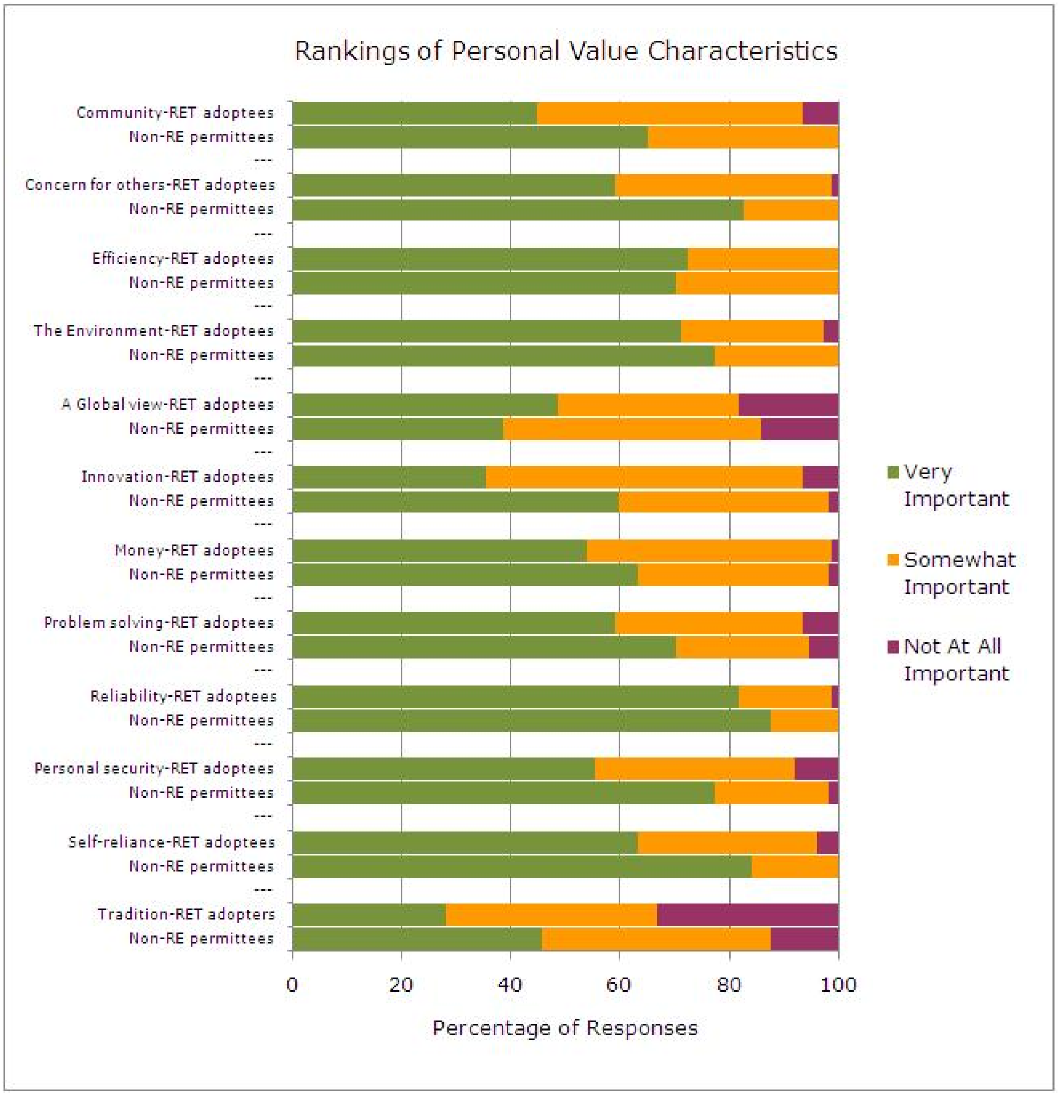
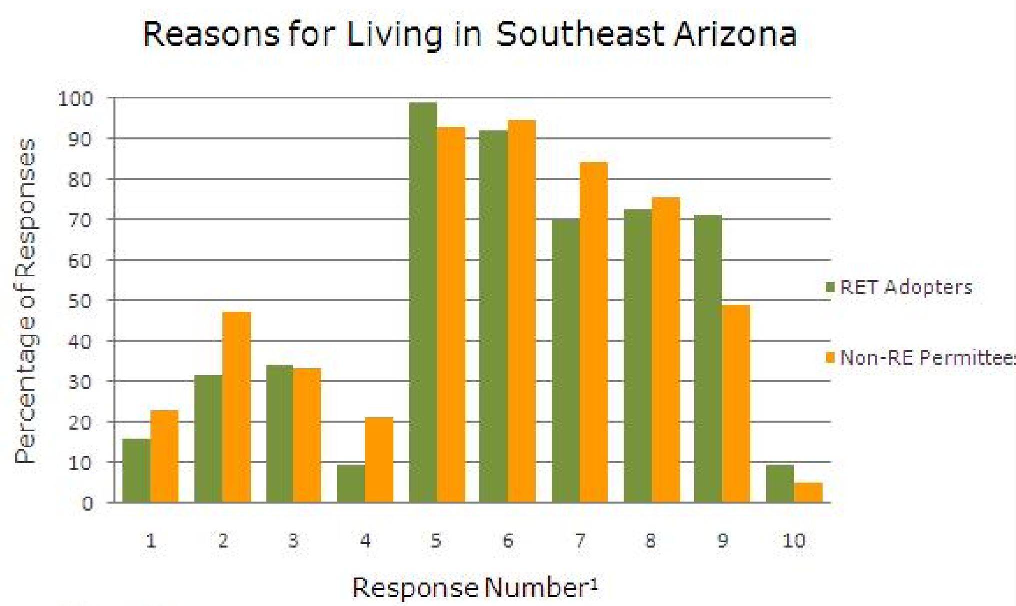


Figure 16. Rankings of respondents' personal value characteristics.

of non-RE respondents but only 35% of RET adopters. This is consistent with the 33% of RET adopters who consider tradition to be not at all important. Another interesting result is that more non-RE permittees ranked as very important 10 of the 12 personal value characteristics, while more RET adopters ranked only efficiency and "a global view" as very important. The only category for which all of the responses were either very or somewhat important was efficiency.

One final question was included in the portion of the survey that was designed for all respondents: a list of possible reasons to live in rural southeastern Arizona. It was thought that the responses may have provided some additional useful information for the profiles, but there were few substantial differences, as can be seen in Figure 17. It does appear, however, that spouses/partners and family members (response numbers 2 and 4) living in the area were more prevalent for non-RE permittees, and that the RET adopters are more likely to be retired (response number 9). Therefore the answer to research question 4 is perhaps, because there is not a enough evidence to indicate a solid yes or no.

The Renewable Energy Decision Factors Survey contained a few questions designed to be answered only by RET adopters or non-RE permittees. Descriptions of the responses to those questions, along with the exposition of the consumer profiles for each group of respondents are presented in the following sections.



[1]Response Number	Reason for living in southeastern Arizona
1	Born or raised in or close to this community
2	Have family in the area
3	Came for a job or to start a business/ranch/farm in the area
4	Spouse/significant other lives or previously lived here
5	Like the climate/scenery/environment
6	Prefer to live in a rural community
7	Social and/or recreational opportunities a good fit for your lifestyle
8	Feel more safe and secure in a rural rather than an urban setting
9	Chose to retire here
10	Other (describe below)

Figure 17. Respondents' reasons for living in southeastern Arizona.

4.2.1 Consumer profile: renewable energy technology adopters

The final elements to be included in the profile for the RET adopters were derived from the responses to three survey questions that were designed to be answered by only them. One was a simple yes or no question: Did you defer a major home remodeling or renovation project in order to purchase a renewable energy system? A total of 5 respondents, or 6.6% of the 76 RET adopter responses, answered yes.

One survey question was designed to gain a better understanding of the motivating factors that ultimately led to the purchase of a solar or wind energy system. RET adopters were asked to respond using the 3-option scale of importance: very, somewhat or not at all important. A summary of responses is shown in Figure 18, and it corroborates the earlier results that indicate a high level of concern for the environment. More importantly, it emphasizes the importance of both the long-term economic value RET purchasers perceive when they invest in a system and the financial incentives that helped to facilitate those investments.

The final components that will be included in the RET adopter profile are the responses to this question: What information sources did you use in making your decision to purchase a renewable energy

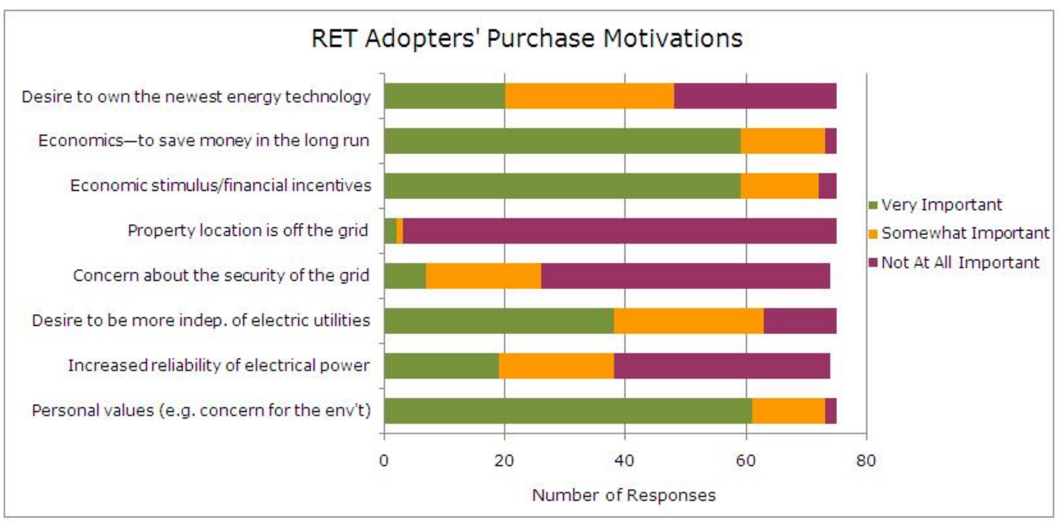


Figure 18. RET adopters' motivations to purchase an RE system.

system? The three possible responses were “used extensively”, “used somewhat” and “did not use at all”. The results in Figure 19 answer research question 3 and indicate that the dominant sources the RET adopters used to educate themselves prior to purchasing their systems were their contractors or RE company salespeople and the Internet.

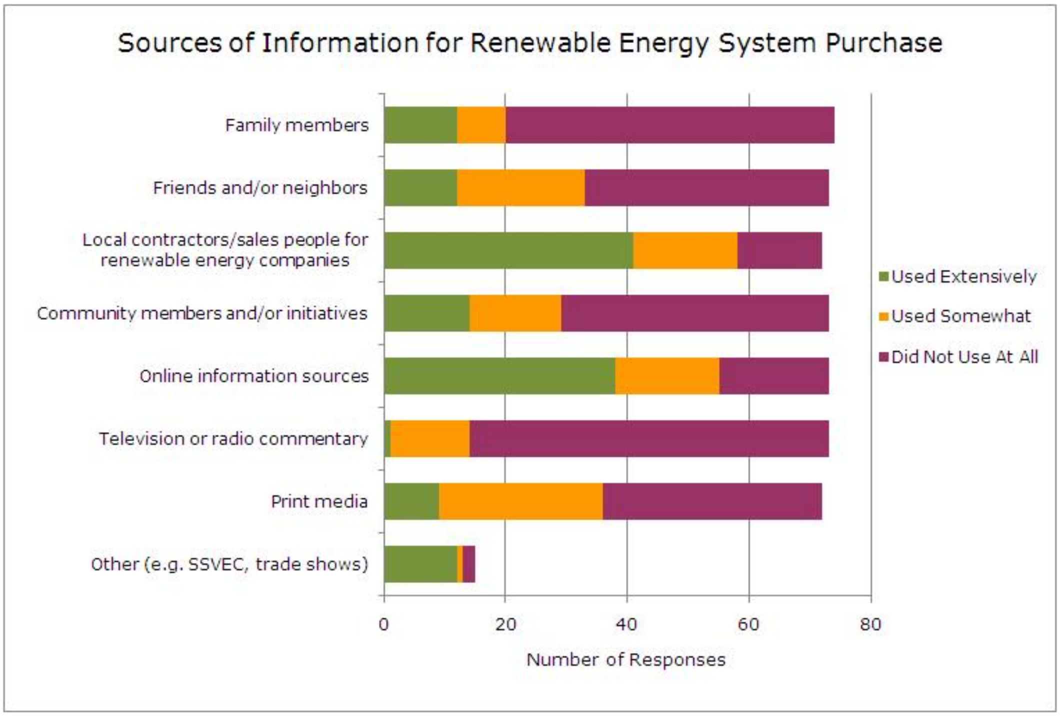
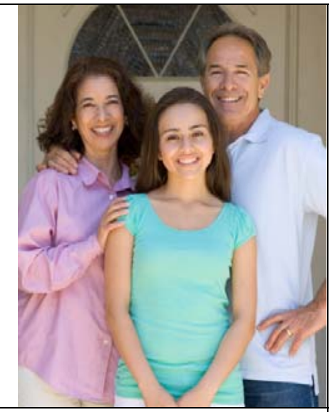


Figure 19. RET adopters’ motivations to purchase an RE system.

The consumer profile for the rural southeastern Arizona renewable energy technology adopter is shown in Table 7. For most of these couples, their children have finished with any schooling for which the parents were financially responsible. One or both could be a retired faculty member from a college or university in another part of the country. Their disposable income situation may have recently improved as their children have moved from being financially

Table 7.

Consumer Profiles for RET Adopters and Non-RE Permittees

Renewable Energy Technology Adopters 	Non-RET Permittees 
This empty-nest, retired couple has no children at home.	This middle-aged home-owning couple has likely one or possibly more children still living at home.
Well-educated: likely with a master's degree if not a PhD.	One or both spouses typically hold a bachelor's degree or at least some community college or technical school training.
Average annual household income of over $75,000.	Their annual household income averages about $70,000.
Living in the last home they plan to build or buy.	These people are probably not in their last home.
Seriously committed to conserving energy and willing to take some personal responsibility for their energy use.	The family displays fairly good energy conservation habits.
Extensively used online research and advice from contractors or company representatives when making the decision to purchase a renewable energy system.	One or both parents are likely to have previously lived in the area or have family members nearby.

dependent to independent. Choosing to add a renewable energy system to their homes was as much a personal commitment to global energy conservation as to saving themselves money over time. On the other hand, they are unwilling to spend money foolishly on methods that will not provide some sort of reasonable financial benefit.

4.2.2 Consumer profile: non-renewable energy permittees

The consumer profile for the rural southeastern Arizona resident who performed a renovation or addition to his or her house but did not purchase a renewable energy system is shown in Table 7. The average annual income of the non-RE adopting family is about $5,000 per year less than the RET adopters, which makes sense when you consider the differences in age and education levels. However, these consumers often also have the financial burden of one or more children at home or going through college, so their disposable income is more limited.

The home renovations they recently installed may have included adding space for older children, a deck, gazebo or patio cover, or simply improving their existing living space by upgrading their bathrooms or kitchens. Since they are likely to sell their house at some point in the future, any home modifications or additions would have resale value factored into their calculations.

Their energy conservation habits are good, but more likely to be motivated by the goal of saving money rather than reducing global energy use. The primary incentive these families would have for installing renewable energy technology would be financial. They are also concerned about whether the technology is reliable and would rather wait until the process is more established and the technology matures. For many of them, adopting renewable energy is simply not a priority at this point in their lives.

4.3 Recommendations for renewable energy technology promoters

Consumer profiles contain information that allows those who market and sell products to more efficiently target the approaches they use to both reach out to prospective customers and to close sales on the prospects they have identified. Profiling allows for optimal use of limited sales and marketing resources by defining the primary target market. Prospects who match the characteristics of current buyers are more likely to buy the product. Focused advertising, promotional and sales efforts, niche marketing rather than mass marketing, a rifle rather than a shotgun approach, allows the marketer to aim and then fire to hit the target. The 80-20 rule applies here: concentrate 80% of marketing and sales efforts on the 20% of the market that is most similar to the established customer profile of those who have purchased the product to increase the chances of success.

Many major consumer products companies use this technique to define and target their customer bases. Then the next step is to determine the motivations of current customers and overcome objections of those who are not currently customers. By identifying and understanding how to overcome the hidden objections, sales people can address them without ever hearing them. Table 8 contains a summary of the responses to the question "If you want to install and have investigated or are investigating/considering a solar or wind energy system but haven't implemented it yet, why not?" Although it is based on a relatively small sample, as only 51 of the 57 non-RE permittees responded to it, the results are instructive for understanding the reasoning used by southeastern Arizona residents who chose not to purchase a renewable energy system and instead performed an upgrade, renovation or addition to their homes. The responses to this question are also provided in Appendix D9 and all of the "Other" reasons are listed on the following page.

The obvious and most substantial reason for not buying a solar or wind energy system is the high initial cost. Prices for RETs, particularly PV panels, are in a downward trend, but at the same time the rebates offered by (in some cases, they are actually more like arm-twisted out of) electric utility companies are also shrinking. Demonstrating a short payback period as a counter to the cost objection can sometimes be effective, but explanations of how paybacks are calculated can be difficult to understand and the calculations depend on assumptions about future interest rates and how fast, if at all, electricity prices will rise.

Table 8.

Reasons for not Purchasing a Renewable Energy System

Reason	% of 51 Responses	Number of Responses
Cost	86.3%	44
Would prefer to wait until technology matures or becomes more widely adopted	41.2%	21
Not enough information to make a good decision	27.5%	14
Too busy	11.8%	6
No suitable location for installation	2.0%	1
My neighbors will complain	0.0%	0
Other (listed below)	19.6%	10

The 10 other reasons given for not purchasing an RE system:

- solar energy systems are too complex
- doing other remodeling projects first
- live alone; it would have too little impact
- children have moved out; less energy use now
- payback period is too long
- no interest whatsoever in renewable energy
- no interest in renewable energy
- don't like the look
- would go all solar if we were younger
- concerned about safety of the system-a possible lightning strike

With both prices and the financial incentives to purchase them falling, perhaps at different rates, it can be difficult to instill a sense of urgency in a prospective buyer of a solar or wind energy system. One way to counter a stalling tactic from a prospect is to present the purchase of the energy technology as an alternative to investing in the stock market, using traditional measurements of financial investments such as internal rate of return or return on investment as the highlight. This approach can be particularly effective for owners of apartment buildings and other landlords or retirees who already understand the financial terminology and can benefit from the accelerated depreciation and interest deductions.

For homeowners who say they may not own their homes long enough to realize a benefit from an energy system, marketers could point out the fact that residential real estate appraisers calculate the value added to a home by capitalizing the annual energy cost savings of solar and wind energy systems at 5%. For example, if a PV system generates enough electricity to reduce the annual amount paid for electricity by $1,000, the home's appraised value would be $20,000 more than an otherwise comparable home without the PV system. A recent[2] article by Adomatis describes four methods by which savings

[2]There are numerous direct and indirect online references, virtually all of them without a formal citation, to a 1998 article by Nevin and Watson in *The Appraisal Journal*. Some of them cite a 10-20x capitalization multiplier. Others use a multiplier of 20.73, equivalent to a capitalization rate of 4.824%, for each dollar of annual energy savings, which is actually from a 1983 article by Johnson and Kaserman.

due to a renewable energy system or other energy cost savings measures can be used to appraise the value a renewable energy system adds to a residence.

When considering the second-most prevalent reason survey respondents cited for not yet adopting renewable energy, the idea that the technology is immature, the challenge comes from the reality that the technology is already fairly mature. Most RETs are in fact far more mature than other technologies, such as television, were when they were adopted by even the late majority. The difference is not the actual maturity level, but the level of penetration of the technology into the large U.S. residential market. This relatively limited diffusion of residential renewable energy systems has created the perception of an immature industry, despite its three-decade plus commercial history.

One explanation for this perception has been expounded in the research on influence conducted by Robert Cialdini. He lists six "weapons of influence," and a number of them can be used to support the sales process. The one that applies specifically in this instance is what he calls "social proof," whereby people are shown to be more responsive to new ideas and purchases if they see evidence that some of their peers are making the same decision. Thus seeing a PV system on a neighbor's roof and discussing his or her experiences with it may reduce your uncertainty about the purchase of a similar system for your house. Then once a certain number of people have purchased the new product or committed to the new idea, a tipping point will be reached and many more will follow.

The third most significant concern, a lack of reliable information on renewable energy or a lack of understanding of the information, is one area that can and should be addressed by everyone involved in the renewable energy industry. From the technical descriptions of the efficiency and expected output from the systems to pro formas (projections) of financial costs, tax-based incentives, utility company rebates, and the long-term economic benefits, much of the available information has been confusing at best and at times contradictory. In spite of academic, government and industry efforts to simplify the presentations of the concepts and clarify misconceptions about the technologies, there are few sources of information that are accurate, understandable, and easily applicable to an individual household's specific requirements. When the challenge of explaining a complex system is combined with an industry with low market penetration, it is no surprise that confusion about the process leads to decisions to reject renewable energy. A significant opportunity is presented by the potential purchasers of systems who lack adequate information to make the decision to adopt RETs. It is the chance for the most effective renewable energy system marketers to present more readily understandable and accurate information to them and ultimately convert them from potential purchasers into actual RET adopters.

One final note in this section is the recommendation that everyone involved with the marketing and sales of solar and wind energy systems should always operate within the highest levels of ethical standards and technical excellence. Some solar and wind energy salespeople are renewable energy's version of used car salesmen, manipulating information any way they can to get a sale. A Google web search for the phrase "misleading sales tactics" and the word solar resulted in over 10,000 hits. With a sometimes uninformed marketplace that may be poised to take off toward widespread implementation of RETs, the local face of the industry doesn't need any black eyes, so maintaining the highest ethical and quality standards is of paramount importance.

4.3.1 Marketing RET systems in southeast Arizona

The clearly defined consumer profile of the solar and wind energy system purchaser in Santa Cruz and Cochise counties provides one way to begin to follow the 80-20 rule. By targeting retirees and other empty-nesters, and seeking ways to reach highly educated rural community members, marketers can maximize the impact of their efforts to continue reaching the early adopters until the larger wave of early majority purchasers takes over. One way to efficiently get in front of groups of potential RET adopters is to do presentations at clubhouses in existing or newly-developed retirement communities. I witnessed the application of this idea when I personally interviewed three residents of such a community in Sierra Vista. This development of about 150 tightly-packed homes had 5 homes with PV systems installed that were all the result of a single presentation at the community's clubhouse by a representative of a solar energy design and installation company.

An application of the social proof technique described above is to ask satisfied customers to provide testimonials and if possible even have them host open houses or speak directly with potential customers. Particularly for rural residents, this can be a very effective way to overcome both the immature technology argument and the lack of information objection.

A review of the profiles for both the RET adopters and the non-RE permittees can also provide an idea of what not to do. It seems apparent that families with children are much less interested in RETs, so it is probably not an effective use of scarce marketing resources to promote renewables at family-oriented events or in such publications.

4.3.2 Marketing RETs in other rural areas

Many of the recommendations for marketers that were laid out in the two previous sections will also apply to other rural areas in the U.S. A key strategy that should be particularly effective for ranchers and farmers who might be willing to invest in larger systems is to promote RETs as long-term income-producing investments they can use to diversify their income streams.

Reaching rural residents with higher discretionary incomes is also a good strategy, so networking with business people, particularly realtors and building contractors, in the target geographic markets can be a productive way to reach potential RET adopters.

4.4 Final observations and recommendations

From a technological viewpoint, neither wind nor solar energy conversion devices are innovations. And due to their intermittent nature, neither can be more than components, which are now small but growing rapidly, of the energy supply and delivery industry in the U.S. Viewed from a marketing perspective however, wind energy, solar thermal and photovoltaic technologies for residential applications are in the early stages of diffusion into a very large market which is composed of a large proportion of the homes and apartment buildings across the country. They are elements of an evolving system that depends more and more on the distributed generation of electricity, as contrasted with the present centralized generation model in which large coal-fired and nuclear facilities generate electricity which is then transmitted and distributed across a vast electrical grid. The growth of and increased reliance on distributed generation is a positive indicator for RETs because they work well at a variety of scales and have differing land requirements. Although PV systems in the southwest

U.S. require about the same amount of land as conventional power generation systems, wind energy systems require more land per unit of power generated than coal or nuclear technologies (Fthenakis and Kim).

The wide-open spaces that characterize most rural areas can provide an abundant resource that is suitable for both solar and wind energy systems. The rural residents in the U.S., along with the hundreds of small energy companies who design and install the power-producing nodes, which could be anything from rooftop PV systems on ranch houses to megawatt-scale arrays of PV panels or wind farms, in distributed generation networks are important stakeholders in the transition to a world that is dominated by widely-distributed power producers. Both sets of stakeholders need to establish and maintain good working relationships with the managers of the co-ops that serve them, and together focus on meeting the energy needs of the future rather than clinging to the status quo represented by today's unsustainable energy systems.

Efficient allocation of resources, on a variety of levels, will be the key to achieving the sustainability of our energy systems. The polluting and ultimately finite fossil fuel resources will remain as part of the electricity generation mix for many decades to come, but our reliance on them will gradually decline as the adoption of RETs becomes more and more widespread. The resources available for promoting renewables by marketers of RET systems, as well as the non-profits and governmental agencies that support their widespread diffusion, need to be effectively managed for their respective operations to be successful. The technical staff and managers at rural electric co-ops must continue to fulfill their primary function, the reliable delivery of electricity to their members, while adapting to the new realities of the two-way transmission of power generated by thousands of residential systems and perhaps a few independent power producers spread across their territories. The transition to a distributed generation paradigm represents a disruptive innovation that will be a challenge for all electric utilities. They will need to rely on NREL and manyl other information and technical resources so they can successfully adapt to the new energy era. The final set of resources that must be efficiently utilized are those of the rural residents themselves. The financial resources will become more realistically available for them as the prices of RETs continue to decline while fossil- and nuclear-generated electricity becomes more costly. The propensity for the early adopters of RETs to be highly educated, however, while the non-adopters report that the systems are too complex to understand, indicates an inefficient allocation of informational resources. It will require the combined efforts of all of the stakeholders, which actually includes all people, rural and urban residents alike, working together to develop the knowledge and understanding that will lead to a sustainable energy future.

5. CONCLUSIONS

At the start of this process, I anticipated that there would be some differences between the renewable energy technology adopters and the other permittees. What I had not anticipated was the distinctive differences between the demographic profiles for the adopters as compared to the non-adopters and the similarities in their energy conservation habits. I also did not anticipate how powerful this information could be to renewable energy promoters.

5.1 Summary

The survey responses provided a wealth of information about the demographics, motivations and decision processes of both the RET adopters and the non-adopters in the southeastern Arizona study area. The four characteristics which comprised the demographic profiles—age, household size, years of education and household income—provided a meaningful way to demonstrate the statistically significant difference between the two groups of respondents. The tendency for the RET adopters to be more diligent about conserving energy than the non-adopters, however, was not statistically significant. The survey data also provided additional insights that helped provide the answers to the other questions posed by this research: RET adopters are motivated by both economics and personal values, and their primary information resources were found via the Internet and provided by their contractors or renewable energy integrators. And finally, their reasons for living in southeastern Arizona are largely unrelated to their motivations and decision processes regarding RETs.

The detailed consumer profiles indicate that Cochise and Santa Cruz County RET adopters are older, have smaller households, higher levels of educational attainment and greater household incomes than the residents of the counties that built an addition, remodeled or otherwise upgraded their homes. The RET adopter profile provides a basis for developing a plan to market solar or wind energy systems to others who match the profile and live in this specific rural region, and that plan should also be useful in other rural areas throughout the U.S.

The knowledge gained by a modest understanding of diffusion of innovations theory and the barriers to implementing renewable energy systems serves to illuminate the challenges facing RET promoters who can envision the widespread penetration of those technologies into U.S. markets. Most of the recommendations for promoters and marketers of RETs were provided with the aim of achieving this larger objective, and they can be summarized as follows:

- Focus sales and marketing efforts on the market segment that is most similar to those who have already purchased RETs.
- Present solar and wind energy systems to businesses and landlords as superior financial investments
- Utilize weapons of influence such as social proof to help overcome false perceptions about RETs

- Develop effective presentations and hone communication skills to maximize effectiveness of information dissemination
- Maintain the highest levels of ethical behavior and technical excellence

This information would obviously be of use to RET designers and installers. It is just as useful, however, for other groups such as non-profits with a focus on reducing carbon in a community as well as its dependence on fossil fuels. Rural electric co-ops and other utilities that are facing renewable portfolio standards may also benefit from drawing on this information to encourage their members to adopt renewable energy systems as one of their strategies to achieve those standards. In addition, political and community leaders who want to see progress in these areas can use this information as a guideline to position limited resources for the most impact.

The widespread adoption of renewable energy technologies will lead to an increasing share of power produced by distributed generation of electricity in the U.S. and elsewhere around the world. All of the stakeholders in the electricity generation industry, including the large and small utility companies, the solar and wind energy system manufacturers, the designers and installers of those systems, and the residential, commercial and industrial users of electricity, as well as academic and government researchers and educators, must work together as the trend toward increasing distributed generation continues. Achieving effective levels of cooperation and better communication among those stakeholders is the only sure way to achieve a sustainable energy future.

5.2 Directions for further research

Several opportunities for continued research became evident as a result of this effort. Utilities currently think of themselves as centralized power producers or distributors of centrally-generated power, and they need to move toward becoming centralized electricity brokers and operators of energy storage systems. Policy-oriented studies by government agencies and academic researchers may help them begin to plan for assuming those roles.

Utilities are also the most trusted sources for information about all energy technologies. They can participate in developing more effective modes of information dissemination, and more easily understandable content along with those who are already working to achieve those goals.

This research has brought into view a lot of information about the RET adopters in a relatively small area in rural Arizona. Empirical research in other rural areas, perhaps even using an enhanced version of the Renewable Energy Decision Factors Survey, can be performed to determine if these patterns are unique to southeastern Arizona or whether they apply in other rural areas. It is also clear that geographic characteristics should be included in consumer profiles of RET adopters and there is the potential to apply them and also to perform a more thorough analysis of the behavioristic and psychographic data collected during this or similar research projects.

Moving beyond questionnaire-based surveys, focus groups can be used to get more in-depth information from a specific rural area, such as the buying habits, media-usage patterns, decision processes and specifics on why residents bought a particular system or purchased from a particular company. Learning the reasons that residents adopted a renewable system and the reasons why they almost said no can be valuable for understanding how to reach the next segments of the market, the early and then the late majority adopters, who will drive the widespread implementation of renewable energy technologies in the future.

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APPENDIX A

IRB EXEMPTION LETTER FOR SURVEY DESIGN

ASU Knowledge Enterprise Development

Office of Research Integrity and Assurance

To:	T Agami Reddy
From:	Mark Roosa, Chair SM Soc Beh IRB
Date:	07/06/2010
Committee Action:	**Exemption Granted**
IRB Action Date:	07/06/2010
IRB Protocol #:	1006005272
Study Title:	Renewable Energy Decision factors

The above-referenced protocol is considered exempt after review by the Institutional Review Board pursuant to Federal regulations, 45 CFR Part 46.101(b)(2) .

This part of the federal regulations requires that the information be recorded by investigators in such a manner that subjects cannot be identified, directly or through identifiers linked to the subjects. It is necessary that the information obtained not be such that if disclosed outside the research, it could reasonably place the subjects at risk of criminal or civil liability, or be damaging to the subjects' financial standing, employability, or reputation.

You should retain a copy of this letter for your records.

APPENDIX B

SURVEY COVER LETTER

COVER LETTER
for
Renewable Energy Decision Factors Survey Participants

September 24, 2010

Dear Participant:

I am a graduate student under the direction of Professor T. Agami Reddy in the School of Sustainability at Arizona State University.

I am conducting a research study to better understand the decision processes used by southeastern Arizona residents when they decided to purchase renewable energy systems. I am inviting your participation, which will involve completing a survey form that will take no more than 10-20 minutes of your time.

Your participation in this study is voluntary. You can skip questions if you wish. If you choose not to participate or to withdraw from the study at any time, there will be no penalty.

Although it is unlikely that you will realize any direct benefit from participating in the study, it is hoped that the knowledge gained by this research will help to increase the rate of installation of renewable energy technology in southeast Arizona and in other rural areas in the U.S. There are no foreseeable risks or discomforts anticipated for you as a result of your participation.

Your responses will be anonymous. The results of this study may be used in reports, presentations, or publications but your name will not be known. Results will be shared only in the aggregate form.

If you have any questions concerning this study, please contact the research team, either me at the number listed below or Dr. T. Agami Reddy, the Principal Investigator, at (480) 965-4460. If you have any questions about your rights as a participant in this research, or if you feel you have been placed at risk, you can contact the Chair of the Human Subjects Institutional Review Board, through the ASU Office of Research Integrity and Assurance, at (480) 965-6788.

Return of the questionnaire or completion of the phone or online version of the survey will be considered your consent to participate.

Sincerely,

Wayne E. Porter
(602) 513-9415 (cell)
Co-Investigator, Renewable Energy Decision Factors Study
MS Candidate, School of Sustainability
Arizona State University

APPENDIX C

SURVEY INSTRUMENT

Renewable Energy Decision Factors Survey

Part 1. Energy use/conservation/renewable energy system actions and attitudes.

1. ***How often does your household use the following methods to save energy or reduce your energy usage?***

Always	Sometimes	Rarely or Never	
___	___	___	Lower the thermostat setting in the winter and raise it in the summer
___	___	___	Wash laundry with cold water
___	___	___	Dry laundry on a line or a rack instead of using the dryer
___	___	___	Turn out the lights when leaving a room
___	___	___	Use automatic standby or shutdown option on computer systems
___	___	___	Take short showers and/or use water-saving shower heads
___	___	___	Other: ______________________________
___	___	___	Other: ______________________________

2. ***How important to you are the following reasons for why you use the conservation methods you checked above?***

Very Important	Somewhat Important	Not At All Important	
___	___	___	Reduce energy use
___	___	___	Conserve natural resources
___	___	___	Save money
___	___	___	Increase energy independence or security of the U.S.
___	___	___	Become more self-sufficient; rely less on the electric grid & natural gas/propane
___	___	___	Other: ______________________________

3. ***Which of the following have you installed or plan to in the next two years? (Check all that apply)***

Installed already	Plan to install in next 2 years	Considering installing	Don't Know or Not Applicable	
___	___	___	___	Solar-thermal system for hot water (number of panels: __)
___	___	___	___	Photovoltaic (PV) panels for electricity (system rating: ____kW)
___	___	___	___	Wind turbine for electricity (system rating: ____kW)
___	___	___	___	Diesel or propane generator for backup power (unit rating: ____kW)
___	___	___	___	Batteries to provide household power for off-grid energy storage or reliability
___	___	___	___	Weatherstripping or caulking to better seal doors and/or windows
___	___	___	___	Wall or ceiling/attic/roof insulation
___	___	___	___	Dual-pane and/or low-E windows
___	___	___	___	Skylights or other natural lighting features
___	___	___	___	Passive solar methods such as trees to shade house, window awnings/shutters etc.
___	___	___	___	One or more energy-efficient major appliances (e.g. A/C, refrigerator, dishwasher)
___	___	___	___	Put TV/video system on a power strip and turn it off when not using
___	___	___	___	Replace light bulbs with fluorescent bulbs or LEDs
___	___	___	___	Put outside lights on a timer/motion detector or turn them off at night

4. In your own words, please briefly describe either why you chose to implement a solar or wind energy system or why you instead installed a more conventional upgrade, renovation or addition to your home and not an energy system.

____

____

____

If you have purchased a solar or wind energy system, please answer questions 5-8, otherwise skip to question 9.

5. How important were the following factors that motivated your decision to purchase a renewable energy system?

Very Important	Somewhat Important	Not At All Important	
___	___	___	Desire to own the newest energy technology available
___	___	___	Economics—to save money in the long run
___	___	___	Economic stimulus or renewable energy financial incentives
___	___	___	Property location is off the grid
___	___	___	Concern about the security of the grid
___	___	___	Desire to be more independent of electric utilities
___	___	___	Increased reliability of electrical power
___	___	___	Personal values (e.g. concern for the environment or sustainability principles)
___	___	___	Other: ______________________________

6. What information sources did you use in making your decision to purchase a renewable energy system?

Used Extensively	Used Somewhat	Did Not Use At All	
___	___	___	Family members
___	___	___	Friends and/or neighbors
___	___	___	Local contractors/sales people for renewable energy companies
___	___	___	Community members and/or initiatives
___	___	___	Online information sources
___	___	___	Television or radio commentary
___	___	___	Print media
___	___	___	Other: ______________________________

7. Did you defer a major home remodeling or renovation project in order to purchase a renewable energy system?

___Yes ___No ___Not Applicable; new home or renovations already completed

8. Comments about decision factors, information sources you used regarding your renewable energy purchase or your reasons for deferring other remodeling or renovation projects to buy an energy system:

____

____

____

____

Please proceed to Part 2.

9. If you want to install and have investigated or are investigating/considering a solar or wind energy system but haven't implemented it yet, why not? (Check all that apply; please answer only if you did NOT purchase a renewable energy system.)

__ Cost
__ No suitable location for installation
__ Not enough information to make a good decision
__ Too busy
__ My neighbors will complain
__ Would prefer to wait until technology matures or becomes more widely adopted
__ Other: ______________________________

Part 2. Overall (not energy-specific) personal priorities and characteristics.

10. Rate the following personal values in terms of how important each is for you.

Very Important	Somewhat Important	Not At All Important	
___	___	___	Community
___	___	___	Concern for others
___	___	___	Efficiency
___	___	___	The Environment
___	___	___	A Global view
___	___	___	Innovation
___	___	___	Money
___	___	___	Problem-solving
___	___	___	Reliability
___	___	___	Personal security
___	___	___	Self-reliance
___	___	___	Tradition

11. Why do you live in this part of Arizona? (Check all that apply)

__ Born or raised in or close to this community
__ Have family in the area
__ Came for a job or to start a business/ranch/farm in the area
__ Spouse/significant other lives or previously lived here
__ Like the climate/scenery/environment
__ Prefer to live in a rural community
__ Social and/or recreational opportunities a good fit for your lifestyle
__ Feel more safe and secure in a rural rather than an urban setting
__ Chose to retire here
__ Other: ______________________________
__ Other: ______________________________

12. If you lived elsewhere, would you have put in a renewable energy system?

___ Yes ___ No ___ Not Sure or Not Applicable

13. Why or why not?

____

____

14. *When it comes to making purchases for your home or personal use: (Please check one)*
__ I am excited about new ideas or technology and usually one of the first people to try out something new.
__ I am willing to try new products, but generally wait to see how others like them first.
__ I tend to hold off on new products until a majority of the people I know have purchased and are using them.
__ I am generally one of the last people to buy new products or try something new.
__ Other: ____

Part 3. The following demographic questions are for academic purposes only and individual answers will be kept confidential.

15. *Age*
___ Under 30
___ 31-35
___ 36-40
___ 41-45
___ 46-50
___ 51-55
___ 55-60
___ 61-65
___ Over 65

16. *Are you?*
___ Male
___ Female

17. *Marital Status*
___ Married or live with long-term partner
___ Single, Widowed or Divorced

18. *Number of children under 18 in household*
___ None
___ 1
___ 2
___ 3
___ 4 or more

19. *Household size*
___ 1
___ 2
___ 3
___ 4
___ 5
___ 6 or more

20. *Highest education level attained*
___ High school
___ Some college /Associate's degree
___ College graduate/Bachelor's degree
___ Post-graduate studies/Master's or PhD

21. *Household income from all sources*
___ Under $20,000
___ $20,000-$40,000
___ $40,000-$60,000
___ $60,000-$80,000
___ $80,000-$100,000
___ Over $100,000
___ Prefer not to divulge

22. *Race/Ethnicity (Check all that apply)*
___ White
___ Hispanic or Latino
___ Black or African American
___ Native American
___ Asian
___ Other
___ Prefer not to divulge

Thank you very much for your participation.

If you would like your name (or a nickname) to be included in the thesis acknowledgements, please write it here or e-mail it to me:

____

If you would like a .pdf of the thesis, please email me at weporter@asu.edu and write "send me a copy of your thesis" in the Subject line.

Wayne Porter

APPENDIX D

SUMMARIES OF SURVEY RESPONSES

The sub-appendices which follow contain summaries of the responses to the Renewable Energy Decision Factors survey. They are designated APPENDIX D1 through D22, with the numerical suffixes representing the question numbers from the survey instrument shown above in APPENDIX C.

Questions 1-4 and 10-22 were designed to be answered by all of the respondents, and each corresponding sub-appendix will contain breakdowns of the responses from renewable energy technology (RET) adopters and non-renewable energy permittees. Some of the sub-appendices containing these sets of responses will be designated by –A for RET Adopters and –N for Non-RE permittees. Questions 5-8 were for RET adopters only and #9 was specifically for non-adopters.

Questions 4, 8 and 13 were open-ended and in most cases I paraphrased the responses to them in my notes as I was conducting the phone or in-person interviews. There were about a dozen online responses by RET adopters, and in those cases the responses are reproduced exactly as they were entered by the respondent. Several questions had "Other: _____________" as a possible response and the other energy conservation measures, motivations and reasons are listed below the summaries of the corresponding responses in each sub-appendix.

APPENDIX D1-A

RET Adopters' responses to survey question 1:

How often does your household use the following methods to save energy or reduce your energy usage?

Response:	Always	Sometimes	Rarely or Never
Lower the thermostat setting in winter and raise it in the summer	53	13	10
Wash laundry with cold water	34	31	11
Dry laundry on a line or a rack instead of using the dryer	17	20	39
Turn out the lights when leaving a room	62	11	3
Use automatic standby or shutdown option on computer systems	49	11	12
Take short showers and/or use water-saving shower heads	48	17	10
Other: ____________________	16	4	0

Other conservation measures reported:

use windows for natural ventilation and fans in all rooms

cook outside to keep house cool in summer

manually control hot water heater

Compost, mulch, eat low on the food chain, cancel unwanted catalogs, use greywater

you need an "almost always" choice

Try to use washer and dryer, dishwasher at off peak times. Use rolldown shutters, summer and winter, to conserve. Use small appliances rather than oven. Use deciduous tree to save. Use gray water from laundry to water landscapping. Have a composting toilet in detached bedroom and bath off garage. Switched to low water use clothes washer. to shade

use cross-ventilation for cooling in summer

RET Adopters' other conservation mesures reported (continued):

use cross ventilation in summer for cooling; minimize oven use and usually cook outside in summer

use high-efficiency fireplace for space heating

minimize opening of refrigerator door

on-demand tankless gas HW

use thermal curtains and don't use oven in summer, instead I grill outside

Maximize our electricity usage during the day while our solar is making power.

cook with solar oven on occaision; do battery recharging during daylight hours to use solar benefit

unplug electrical items when not in use ie coffee maker, cell phone chargers etc.

cpmpact flouresants

Use a solar oven occasionally; open window coverings at appropriate times during winter and close them at appropriate times in summer; replace incandescent bulbs with CFLs

use evap cooler

unplug appliances when away

open windows for natural ventilation

radiant heating & cooling system works in summer and winter and is supplemented by wood and propane

APPENDIX D1-N

Non-RE Permittees' responses to survey question 1:

How often does your household use the following methods to save energy or reduce your energy usage?

Response:	Always	Sometimes	Rarely or Never
Lower the thermostat setting in winter and raise it in the summer	43	8	6
Wash laundry with cold water	32	15	10
Dry laundry on a line or a rack instead of using the dryer	6	19	32
Turn out the lights when leaving a room	43	14	0
Use automatic standby or shutdown option on computer systems	32	9	14
Take short showers and/or use water-saving shower heads	29	18	9
Other: ________________	5	0	0

Other conservation measures reported:

use fireplace to heat house in winter

use ceiling fans

use wood pellet stove for heating in winter

set hot water temperature to a low setting

water heater is on a timer system

APPENDIX D2-A

RET Adopters' responses to survey question 2:

How important to you are the following reasons for why you use the conservation methods you checked above?

Response:	Very Important	Somewhat Important	Not At All Important
Reduce energy use	63	11	1
Conserve natural resources	62	11	2
Save money	55	19	1
Increase energy independence or security of the U.S.	44	24	7
Become more self-sufficient; rely less on the electric grid & natural gas/propane	54	20	0
Other: ______	1	0	0

Other reasons reported:

important for all of us to conserve energy and other natural resources

APPENDIX D2-N

Non-RE Permittees' responses to survey question 2:

Response:	Very Important	Somewhat Important	Not At All Important
Reduce energy use	41	15	1
Conserve natural resources	41	13	3
Save money	47	10	0
Increase energy independence or security of the U.S.	30	21	6
Become more self-sufficient; rely less on the electric grid & natural gas/propane	34	20	3
Other: ______	0	0	0

No other reasons reported.

APPENDIX D3-A

RET Adopters' responses to survey question 3:

Which of the following have you installed or plan to in the next two years? (Check all that apply)

Response:	Installed already	Plan to install in next 2 years	Considering installing	Don't Know or Not Applicable
Solar-thermal system for hot water (number of panels: ___)	30	8	12	7
Photovoltaic (PV) panels for electricity (system rating: _____kW)	64	2	6	1
Wind turbine for electricity (system rating: _____kW)	5	1	10	10
Diesel or propane generator for backup power (rating: _____kW)	7	2	7	10
Batteries to provide household power for off-grid energy storage or reliability	3	3	5	10
Weatherstripping or caulking to better seal doors and/or windows	68	3	0	2
Wall or ceiling/attic/roof insulation	65	3	0	3
Dual-pane and/or low-E windows	73	2	0	1
Skylights or other natural lighting features	60	3	3	3
Passive solar methods such as trees to shade house, window awnings/shutters etc.	64	1	3	4
One or more energy-efficient major appliances (e.g. A/C, refrigerator, dishwasher)	65	2	4	2
Put TV/video system on a power strip and turn it off when not using	33	0	6	6
Replace light bulbs with fluorescent bulbs or LEDs	63	5	0	3
Put outside lights on a timer/motion detector or turn them off at night	66	0	0	5

APPENDIX D3-N

Non-RE Permittees' responses to survey question 3:

Which of the following have you installed or plan to in the next two years? (Check all that apply)

Response:	Installed already	Plan to install in next 2 years	Considering installing	Don't Know or Not Applicable
Solar-thermal system for hot water (number of panels: ___)	1	3	24	2
Photovoltaic (PV) panels for electricity (system rating: _____kW)	1	3	29	3
Wind turbine for electricity (system rating: _____kW)	0	1	8	4
Diesel or propane generator for backup power (rating: _____kW)	1	3	3	3
Batteries to provide household power for off-grid energy storage or reliability	0	0	2	4
Weatherstripping or caulking to better seal doors and/or windows	51	4	1	0
Wall or ceiling/attic/roof insulation	47	1	2	0
Dual-pane and/or low-E windows	51	3	0	0
Skylights or other natural lighting features	35	2	1	0
Passive solar methods such as trees to shade house, window awnings/shutters etc.	43	4	0	0
One or more energy-efficient major appliances (e.g. A/C, refrigerator, dishwasher)	49	2	1	0
Put TV/video system on a power strip and turn it off when not using	23	2	0	4
Replace light bulbs with fluorescent bulbs or LEDs	47	2	0	0
Put outside lights on a timer/motion detector or turn them off at night	52	0	1	0

APPENDIX D4-A

RET Adopters' responses to survey question 4:

In your own words, please briefly describe either why you chose to implement a solar or wind energy system or why you instead installed a more conventional upgrade, renovation or addition to your home and not an energy system.

It would have been more expensive to bring the grid to the house so it remains off-the-grid.

The future. Reduce energy bills and reliance on coal-based energy. We live in Arizona--thus we need to utilize the abundant sunlight.

Did wind generator, doors and windows to both conserve energy and resources, also resulting in dollar savings.

Financial - it made long-term economic sense.

Desire to conserve energy and the environment

"Two reasons for installing a solar-thermal system:
First, it was the most viable and economically sensible option
Second, it works well and is composed of simple technology"

Like the idea of using the sun instead of the grid. It is more conservative--saves money and is good for the environment.

Reduce dependence on coal, put more back into the grid than we use. It is the right thing to do.

It seemed cost effective, with the rebates given at the time, to install and make some of the power we use.

For my wife and I it was the right thing to do and we could afford it with the rebates.

We installed solar panels to save money and to conserve energy.

Use flooring to gain heat in winter.

I recently installed a larger PV system.

To save energy, resources and money.

RET Adopters' responses to survey question 4 (continued):

The right thing to do economically--makes good business sense.

Distance from nearest neighbor and grid.

Important to do something--few realize there are big problems with our current energy generation, transmission and distribution systems.

It was the right thing to do and the incentives made it possible.

It made sense.

It makes sense but not necessarily economically. It is very important, however, and others in my neighborhood are involved.

It was a good thing to do, a win-win.

With the sunshine in Arizona, it would be silly not to.

Discussions with kids on impacts on environment, e.g. global warming, and about becoming more self-sufficient. We made alternative energy generation a priority for our family.

Went with PV system to save money. The added benefits regarding the environment were a secondary consideration.

The rebates offered for our PV system made it to good to pass, after rebates from SSVEC and tax credits we paid only a fraction of what the system would have cost. We are also able to make clean power to help the enviroment and save money at the same time. Our house is completely electric so the system just made sense.

Mainly to conserve resources and take advantage of renewable energy. Economic benefits and incentives were a secondary motivator.

Purely for the money savings. Our PV system cost was $62,000.00. After Federal, state, and local tax rebates and credits are exausted we will have spent about $12,000.00 out of our pocket. Other than that, any alternative energy is not cost effective. At todays rates our PV system will produce about $42,000.00 dollars worth of electricity over a 20 year span. Alternative energy does not save money unless someone else pays for it.

To reduce energy personal dependence and reduce polution

RET Adopters' responses to survey question 4 (continued):

Economic benefit is reducing propane gas use. More efficient to reduce energy use and implement renewable energy technology.

A. Upon moving to Arizona three years ago from Kentucky, my husband and I expected that EVERYONE would be using solar power out here. We were aghast that most people leave this obvious power source UNUSED!!! It just makes sense to use the sun around here. I've been an environmentalist all my life and it was a no-brainer to install a solar energy system as soon as the funds were available. Actually, I wish I hadn't had to bear all that expense. I would've gladly paid our utility company more for electricity each month, in order for THEM to deal with the solar energy technology instead of me having to do it myself. But, of course, the company won't do it. So, my husband and I had to do it ourselves.
B. We originally considered installing only a solar water heating system, and waiting until later to incur the expense of a full array of solar panels. But, that ended up not making sense to us, because the panels would eventually provide solar energy for water heating, thereby making a separate solar water heating system unnecessary.
C. Would love to have a battery for storing the energy produced by our solar panels, but our contractor says the current generation of such batteries is not cost-effective. Sigh.

To make as much energy as we're using--to become net zero. We also want to buy a plug-in hybrid car.

The utility and federal tax breaks were key factors. And it's good to be green.

Long-term cost savings were the primary driver.

To conserve resources and reduce pollution. Also to save money in the long run.

High electric bills; recently retired. Renewable energy is environmentally effective and financially beneficial.

Cost of electricity was becoming too high.

To help save the planet.

More economical

RET Adopters' responses to survey question 4 (continued):

To be more self-sufficient. Not very comfortable with the electric grid/infrastructure. Have a dual meter and want to go off-grid. Also the rising cost of electricity and it's better for the environment.

To lower the electric bill.

Solar HW was installed by our home's previous owner. We installed the PV system to reduce our electricity purchases. We got a large rebate from SSVEC and tax benefits.

1) Reduce oil dependency and help clean the environment
2) 43-acre spread--too costly to bring in the grid.

To save money and go green.

It was the right thing to do. Concerned about energy use and carbon footprint so doing my part to reduce both of them. Will have lower cost of energy over time. Increased my property value and will eventually receive a rebate from SSVEC.

Replaced old water heater with solar HW system. Will save money with the new system.

I live in an area with a good wind resource.

Solar HW was a good investment for our property

To reduce our energy purchases.

3 reasons: good for the environment, cuts our electricity cost and is the right thing to do.

Desired to take advantage of the sun. Started with solar HW then added the PV system. Plan to add a natural gas-fired generator for blackouts.

1) long-term investment
2) utility rebates are available now--take advantage
3) Use sunlight--abundant in AZ

Save money and energy.

Rebate opportunities. Annual true-up will reduce electricity bills to the minimum possible.

RET Adopters' responses to survey question 4 (continued):

To save money and become more energy independent.

We installed a solar energy system to save money and to take advantage of available tax credits and rebates and also to lower our high energy costs.

Main motivations were the tax incentives and utility company rebate.

I was the first customer for my son's new solar energy business.

solar-thermal is cost-effective but PV is not

With the incentives, the short payback period made a PV system a good investment.

Elegant idea; saves energy and money. Also added circulation pump to save water.

Desire to decrease the U.S. dependence on foreign oil and use the sun--we're in AZ!

Always interested in energy efficiency. Followed my neighbor's lead by installing a PV system.

Primarily to save energy and reduce electricity bills. Wanted to become more green for many years.

Because it made so much sense--technologically, economically and aesthetically.

To be free from utility companies.

Wanted to eliminate electric bills.

Want to be comprehensively energy efficient

To save money. The co-op paid for half of the PV system and tax credits also cut my total cost.

I work in the PV industry. Familiarity with the technology led to comfort and with the incentives available now PV systems are much more cost-effective.

APPENDIX D4-N

Non-RE Permittees' responses to survey question 4:

In your own words, please briefly describe either why you chose to implement a solar or wind energy system or why you instead installed a more conventional upgrade, renovation or addition to your home and not an energy system.

A total of 12 responses stated simply "cost" or the equivalent of "solar is too expensive."

Save money. I haven't heard enough research on the benefits to the environment.

We have not installed any energy system because the current system does not yet need to be replaced.

Investigated ground-source heat exchange unit and plan to install when financially feasible.

Installed a ramada to cover the patio. It blocks the sun on the south & west sides of the house and provides passive solar cooling.

wanted a garage now

Have horses and needed a barn. Could be a platform for a PV array.

wanted shade--less expensive than solar panels

patio was easier to install than solar

needed more living space

the cost, particularly of battery systems

cost and waiting for the technology to improve

no interest in solar or wind

waiting for better and cheaper options

Needed more space so built a courtyard. It will also provide passive solar cooling.

Cost of solar; needed an apartment for our son.

cars needed protection from the sun

Non-RE Permittees' responses to survey question 4: (continued)

needed to build wall around pool

High cost and waiting for more efficient technology

needed to renovate the back porch

Contractor was not experienced with solar technology and would not install it.

Net cost is affordable when all incentives are applied but utility rebates are slow to arrive.

high cost--payback period is too long

Not quite ready. Need more time and experience with PV systems.

On fixed income. Could not afford a renewable energy system.

Looking to install solar later. Needed an Arizona room now.

lightning strike on old solar collector burned the house down

remodeling kitchen before installing solar water heating system

too old to attain the full benefit

waiting for improvements in technology and price

wanted to determine the energy needed by the Arizona room before installing solar

APPENDIX D5

RET Adopters' responses to survey question 5:

How important were the following factors that motivated your decision to purchase a renewable energy system?

Response:	Very Important	Somewhat Important	Not At All Important
Desire to own the newest energy technology available	20	28	27
Economics—to save money in the long run	59	14	2
Economic stimulus or renewable energy financial incentives	59	13	3
Property location is off the grid	2	1	72
Concern about the security of the grid	7	19	48
Desire to be more independent of electric utilities	38	25	12
Increased reliability of electrical power	19	19	36
Personal values (e.g. concern for the environment or sustainability principles)	61	12	2
Other: ______________________________	2	0	0

Other factors reported:

keep $ in USA not send it overseas.

utility incentives impt., federal tax incentive, not impt.

APPENDIX D6

RET Adopters' responses to survey question 6:

What information sources did you use in making your decision to purchase a renewable energy system?

Response:	Used Extensively	Used Somewhat	Did Not Use At All
Family members	12	8	54
Friends and/or neighbors	12	21	40
Local contractors/sales people for renewable energy companies	41	17	14
Community members and/or initiatives	14	15	44
Online information sources	38	17	18
Television or radio commentary	1	13	59
Print media	9	27	36
Other: ____________________	12	1	2

Other information sources reported:

A total of 5 responses reported SSVEC or the power company/co-op.

Alternative energy expo in Tucson

contractor directly involved with renewables

We are educated! Husband has master's in biology and AS in solar technology (1980) We had the first solar installation (domestic hot water in Denver in1978). We also had passive solar heating on a 1918 house.

subcontractors

Talked with builder of our house

Info in publications from Sulphur Springs Valley Electric Cooperative

Other information sources reported: (continued)

solar energy design tools

presentation by Salt River Solar at community clubhouse

trade shows.

APPENDIX D7

RET Adopters' responses to survey question 7:

Did you defer a major home remodeling or renovation project in order to purchase a renewable energy system?

Response:	Count
Yes	5
No	67
Not applicable; new home or renovations already completed	3

APPENDIX D8

RET Adopters' responses to survey question 8:

Comments about decision factors, information sources you used regarding your renewable energy purchase or your reasons for deferring other remodeling or renovation projects to buy an energy system:

Had an energy audit performed prior to purchasing the solar energy systems.

Installing the PV system was the first major upgrade for the house.

We built a new house and that is the best time to design for and install solar PV panels.

I wanted to time the market to achieve maximum benefit.

Remodeling will come later anyway.

Some other projects were modestly deferred.

Re: "concern about the security of the grid" -- I am extremely concerned about the security of the grid. I would like very, very much to go off the grid. However, this concern was a decision factor only in the sense that, in deciding to install solar panels, we had in the back of our minds that eventually, when battery technology improves, we'll be in a position to go off the grid to some extent. (Hope this makes sense.)

We built our home to maximum energy efficiency standards in '95-'96 and included passive solar design features.

Government propaganda on global warming is over-played and some pols are capitalizing for their own benefit.

APPENDIX D9

Non-RE Permittees' responses to survey question 9:

If you want to install and have investigated or are investigating/ considering a solar or wind energy system but haven't implemented it yet, why not? (Check all that apply; please answer only if you did NOT purchase a renewable energy system.)

Response:	Count
Cost	44
No suitable location for installation	1
Not enough information to make a good decision	14
Too busy	6
My neighbors will complain	0
Would prefer to wait until technology matures or becomes more widely adopted	21
Other: ______________________	10

Other reasons for non-adoption of renewable energy systems:

solar energy systems are too complex

doing other remodeling projects first

lives alone

children have moved out--less energy use now

payback period is too long

no interest whatsoever in renewable energy

no interest in renewable energy

don't like the look

concerned about safety of the system--possible lightning strike

would go all solar if we were younger

APPENDIX D10

All responses to survey question 10:

Rate the following personal values in terms of how important each is for you.

	RET Adopters			Non-RE Permittees		
Response:	Very Important	Somewhat Important	Not At All Important	Very Important	Somewhat Important	Not At All Important
Community	34	37	5	37	20	0
Concern for others	45	30	1	47	10	0
Efficiency	55	21	0	40	17	0
The Environment	54	20	2	44	13	0
A Global view	37	25	14	22	27	8
Innovation	27	44	5	34	22	1
Money	41	34	1	36	20	1
Problem-solving	45	26	5	40	14	3
Reliability	62	13	1	50	7	0
Personal security	42	28	6	44	12	1
Self-reliance	48	25	3	48	9	0
Tradition	21	29	25	26	24	7

APPENDIX D11

All responses to survey question 11:

Why do you live in this part of Arizona? (Check all that apply)

Response:	RET Adopters	Non-RE Permittees
Born or raised in or close to this community	12	13
Have family in the area	24	27
Came for a job or to start a business/ranch/farm in the area	26	19
Spouse/significant other lives or previously lived here	7	12
Like the climate/scenery/environment	75	53
Prefer to live in a rural community	70	54
Social/recreational opportunities a good fit for your lifestyle	53	48
Feel more safe and secure in a rural rather than an urban setting	55	43
Chose to retire here	54	28
Other: ______________________________	7	3

Other reasons to live in Arizona for RET adopters:

slower lifestyle, cost of living is less than in CA, proximity to medical care is a concern

Land is available in the wide-open spaces here.

minimal snow

wanted to move to a more unspoiled area

Like rural nature of Tubac with easy access to city amenities, airport, restuarants, etc.

like the people and to purchase beef, vegetables and wine that's grown or made locally

wife does athletic training in the mountains near here.

childhood dream about building a home in the desert.

Other reasons to live in Arizona for non-RE permittees:

daughter competes in rodeos

husband chose to live in Sonoita

health

APPENDIX D12

All responses to survey question 12:

If you lived elsewhere, would you have put in a renewable energy system? (Note that this question was initially designed for RET adopters but a handful of non-RE permittees also responded.)

Response:	RET Adopters	Non-RE Permittees
Yes	42	3
No	4	0
Not Sure or Not Applicable	30	3

APPENDIX D13-A

RET Adopters' responses to survey question 13:

Why or why not? [follow-up to question 12]

A total of 4 responses were "probably".

But only if it made economic sense.

For environmental benefits and energy savings

Depends on space available

Waited until after retirement because purchasing a solar energy system was a long-term investment.

If it made both economic and technical sense.

It is the right thing to do

climate

For us, it's the right thing to do and the right time to do it.

Hard to know. Depends on where.

Makes economic and environmental sense

There is a very good chance I would install a solar energy system elsewhere.

Definitely

Even if I lived in PA.

If still in Tucson, probably so but the activist community here in Sonoita was important.

To save money on electrical bill

I believe in using renewable energy, instead of using up non-renewable sources of energy

depends upon the location. For example, solair is really only viable in extremely sunny areas and even then it's still not up to snuff. I would chose an energy sourse more suited to the area, such as hydro for an area out east near a stream or creek. And I would do geothermal if I built a new home anywhere.

It would depend upon where I lived. For example, if I lived where it's dark much of the year, (or where thick woods would block out the sun), and where there's not much wind, then I'd have to investigate whether there any form of renewable energy system would make sense. Geothermal, maybe?

Probably would but would first need to analyze the geography.

Would need to see if it made sense.

If the geographic location is favorable and there were sufficient incentives available.

Depending on the climate--use the best available resources.

Would depend on where I live.

depends on the available resources. In the NE U.S., not so much.

If there was a good solar resource.

formerly lived on a sailboat

If the incentives and resources were there. In some locations, geothermal has good potential.

It would depend on the solar resource where you live.

clouds?

insufficient ROI

Depends on many factors--number of sunny days, length of winters, cost, etc.

If the resources are there.

Would install solar if financially able. (Non-RE permittee response)

APPENDIX D14

All responses to survey question 14:

When it comes to making purchases for your home or personal use: (Please check one)

Response:	RET Adopters	Non-RE Permittees
I am excited about new ideas or technology and usually one of the first people to try out something new.	14	6
I am willing to try new products, but generally wait to see how others like them first.	39	35
I tend to hold off on new products until a majority of the people I know have purchased and are using them.	7	10
I am generally one of the last people to buy new products or try something new.	0	1
Other (please describe below)	16	5

Other descriptions of RET adopters' purchasing habits:

Prefer to thoroughly research new products to make the most informed decision.

I do a lot of research then decide.

I purchase things when needed, research and then purchase what appears to be best product for need

We look at our personal needs--not the latest technology--have old TVs and new ones, for example. Use cell phones for necessity and convenience, on occasion, not because we have to have the latest communications technology.

Excited to learn about new technology but slower to adopt than most people.

Read about products and make purchases that make sense.

Generally averse to purchasing technology.

Only purchase something when absolutely necessary--don't make a lot of purchases.

I trust brand names.

I like Technology but wait for bugs to get worked out and price to come down

I tend to hold off on new products until I've had a chance to learn enough about them that I feel comfortable they would be useful to me and they would be worth the price

see how new products work--do research first.

My decision to purchase depends on how well a product works for me.

Prefer to research new technology.

Prefer to do my own research before making a decision.

prefer to do own research before making a decision to purchase technology.

Other descriptions of non-RE permittees' purchasing habits:

Research new items, then try to do it myself or wait until the price comes down.

Wait until the technology is mature. Develop my own understanding of the product. Don't buy on trends.

I'm generally an early adopter but I insist on reliability--can't tolerate the bugs.

Don't need new technology. Don't care what others use. I buy it when I need it.

Do research and make decisions independently of others.

APPENDIX D15

All responses to survey question 15:

Age

Response:	RET Adopters	Non-RE Permittees
Under 30	0	0
31-35	1	4
36-40	1	4
41-45	1	4
46-50	5	10
51-55	6	7
56-60	18	4
61-65	13	11
Over 65	31	13

APPENDIX D16

All responses to survey question 16:

Are you?

Response:	RET Adopters	Non-RE Permittees
Ma,le	51	35
Female	25	22

APPENDIX D17

All responses to survey question 17:

Marital status

Response:	RET Adopters	Non-RE Permittees
Married or live with long-term partner	67	49
Single, Widowed or Divorced	9	8

APPENDIX D18

All responses to survey question 18:

Number of children under 18 in household

Response:	RET Adopters	Non-RE Permittees
None	68	41
1	5	3
2	3	9
3	0	1
4 or more	0	3

APPENDIX D19

All responses to survey question 19:

Household size

Response:	RET Adopters	Non-RE Permittees
1	9	7
2	55	32
3	8	5
4	4	8
5	0	1
6 or more	0	4

APPENDIX D20

All responses to survey question 20:

Highest education level attained

Response:	RET Adopters	Non-RE Permittees
High school	5	11
Some college/Associate’s degree	12	19
College graduate/Bachelor’s degree	22	11
Post-graduate studies/Master’s or PhD	37	16

APPENDIX D21

All responses to survey question 21:

Highest education level attained

Response:	RET Adopters	Non-RE Permittees
Under $20,000	2	2
$20,000-$40,000	3	7
$40,000-$60,000	11	12
$60,000-$80,000	15	9
$80,000-$100,000	11	5
Over $100,000	17	14
Prefer not to divulge	17	8

APPENDIX D22

All responses to survey question 22:

Race/Ethnicity (Check all that apply)

Response:	RET Adopters	Non-RE Permittees
White	73	53
Hispanic or Latino	3	7
Black or African American	1	1
Native American	1	2
Asian	2	0
Other	2	0
Prefer not to divulge	0	2

APPENDIX E

COVARIANCE MATRICES USED IN STATISTICAL ANALYSES

Σ_{C1}—RET Adopters with Complete Responses

	Age	HshldSize	YrsEducn	Income$K
Age	70.134	-3.080	4.299	-111.309
HshldSize	-3.080	.511	-.669	4.360
YrsEducn	4.299	-.669	8.007	20.923
Income$K	-111.309	4.360	20.923	771.011

Σ_{C2}—Non-RE Permittees with Complete Responses

	Age	HshldSize	YrsEducn	Income$K
Age	127.657	-9.005	1.501	-90.306
HshldSize	-9.005	1.849	.088	10.136
YrsEducn	1.501	.088	8.534	35.255
Income$K	-90.306	10.136	35.255	991.497

Σ_{E1}—RET Adopters with EM Estimates for Missing Values

	Age	HshldSize	YrsEducn	Income$K
Age	61.311	-2.622	1.979	-105.695
HshldSize	-2.622	.431	-.448	4.362
YrsEducn	1.979	-.448	7.702	25.465
Income$K	-105.695	4.362	25.465	680.524

Σ_{E2}—Non-RE Permittees with EM Estimates for Missing Values

	Age	HshldSize	YrsEducn	Income$K
Age	127.083	-8.393	3.393	-74.199
HshldSize	-8.393	1.748	-.171	7.520
YrsEducn	3.393	-.171	8.970	36.245
Income$K	-74.199	7.520	36.245	884.172