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Solar Energy in Pueblo: PV System Owners' Perspective

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Abstract

This project explored the motivation, challenges, benefits, and overall experiences of PV system owners and how ownership influenced and changed their lives concerning energy use, conservation and efficiency. The pilot phase of this program which was conducted in Pueblo, Colorado helped in understanding the experiences of PV system owners in this area, and will enable future policy designers to incorporate solutions that could improve the experiences with PV systems for future owners. Part of the result of this study is intended to contribute to the discussion of future government programs aiming at increasing the uptake of PV system installations, as well as its influence over the potential to reduce energy consumption at the household level.

Keywords: *PV, System Owners, Efficiency, Energy, Conservation, Installations.*

1. Introduction

The world's attention has largely shifted regarding climate change and global warming emissions. These phenomena, which are caused by human activities, result in an increased earth temperature with its attendant effects on human health, environment, and climate. Scientists believe that this dangerous trend will continue as long as the effects of human activities on the environment are not mitigated. Over the years, in a bid to check this trend, alternative energy sources such as the solar, wind, hydro, geothermal, and biomass have been explored and increasingly promoted among the populace, hence reducing the health, environmental and climate hazards associated with the use of fossil fuels.With solar energy gaining momentum as a viable source of renewable energy, there is a need to consistently increase focus and investment in solar PV as an integral part of alternative clean energy source. The purpose of this research is to understand the motivation, challenges, benefits, and overall experiences of PV system owners and how ownership influenced and changed their lives concerning energy use, and efficiency. The pilot phase of this program was conducted in Pueblo, Colorado, and it helps in understanding the experiences of PV system owners in this area. Apart from the potential of this research in enabling policy designers to incorporate solutions that could improve the experiences with PV systems for current and future owners, it is also intended to contribute to the discussion of future government programs aiming at increasing the uptake of PV system installations, as well as reducing energy consumption at the household level.

Data from the US Energy Information Administration (2016) show that in 2015, 60% of the electricity generated in Colorado came from coal, 22% from natural gas, and 18% from renewable energy resources. Pueblo County, with an estimated population of 161,519 (U.S. Census Bureau, 2015), is one of the 64 counties in the state of Colorado. Sunshine is abundant throughout the year, with an annual total of nearly 3470 sunshine hours, or 78% of the possible total which makes the city a desirable location for solar energy investments (Wikipedia, 2017). Pueblo is an ideal spot for solar investors to build because substations and transmission lines are easily accessible (Pulp, 2014).

The costs of solar energy systems have decreased greatly during the last 15 years due to the eligibility of solar systems for a number of federal, state, local, and utility financial incentives made possible through the legislation of the Emergency Economic Stabilization Act of 2008. The Act establishes a 30% tax credit for all residential solar electric installations for 8 years (for property placed in service after December 31, 2008). It allows utilities to benefit from the credit. Colorado's main utility providers offer excellent solar rebates to offset the upfront cost of solar in Pueblo and make solar power more affordable for all homeowners. Xcel Energy, the state's largest utility, offers an incentive of up to $1.75 per watt (for example, $8,000 for a 4 kilowatt system) plus a $0.04 per kWh Renewable Energy Credit (paid monthly) for systems up to 10 kilowatts in size, while Black Hills Energy, the second largest state utility, offers an incentive of up to $2.00 per watt (for example, $8,000 for a 4 kilowatt system) plus a onetime $0.50 per watt REC for systems up to 10 kilowatts in size (Solar Colorado, n.d.)

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2. Methodology

This section highlights the method used in collecting and assessing the solar owner's opinion, satisfaction and motivation in the use of solar. For the purposes of the study, an advisory board was setup which comprised the Colorado State University – Pueblo engineering faculty, Thomas Corlett of The South East Colorado Renewable Energy Society, Mike Colucci of the Pueblo Regional Building Department, and Chris Markuson, the Pueblo County Director of Economic Development and Geographical Information System suggested possible questions. These questions and similar questions from previous solar studies in California and Australia were put together and comprehensively reviewed by the SECRES board and the advisory board. In drafting questions, we considered what information solar PV owners and policy makers are most curious about getting answers to. The questions were basically tailored to provide insight into the solar PV performance and to assess the positive and negative perception of solar home owners. The survey has a total of 45 questions divided into 8 segments with questions of similar interest in one segment. The segments are as follows:

1) Building and Ownership Information….6 questions
2) Finding Solar…3 questions
3) Investment/Incentives….12 questions
4) Solar PV Detail and Operation…9 questions
5) Solar PV Problems…3 questions
6) Satisfaction and Feedback…7 questions
7) Improvement Suggestions…2 questions
8) Follow Up…3 questions

The survey was conducted online and Survey Monkey was chosen as a medium to administer the questions to residential solar PV owners in Pueblo, encompassing 45 predominantly multiple choice, ranking questions and questions enabling further expansion. The survey was expected to take around 20 minutes to complete and was purely anonymous with no name, personal identifiers or IP address collected. Participation was voluntary and participants could exit the survey at any time without any penalty. The Colorado State University Pueblo Institutional Review Board (IRB), which protects the rights of volunteers/participants, qualified and approved the questionnaire and online survey for onward dissemination. The Pueblo Regional Department helped in supplying the solar installation database for Pueblo County. The data, which covered solar installations in Pueblo and its environs from 2009 to December of 2015, had a total of 572 solar PV units installed. The data was further trimmed down to only reflect the residential solar PV installations which is the area this study covers. The trimmed data reduced to 453 residential solar PV units and contained information such as the permit number, address, owner name, phone number, contractor code, work class, and unit number.

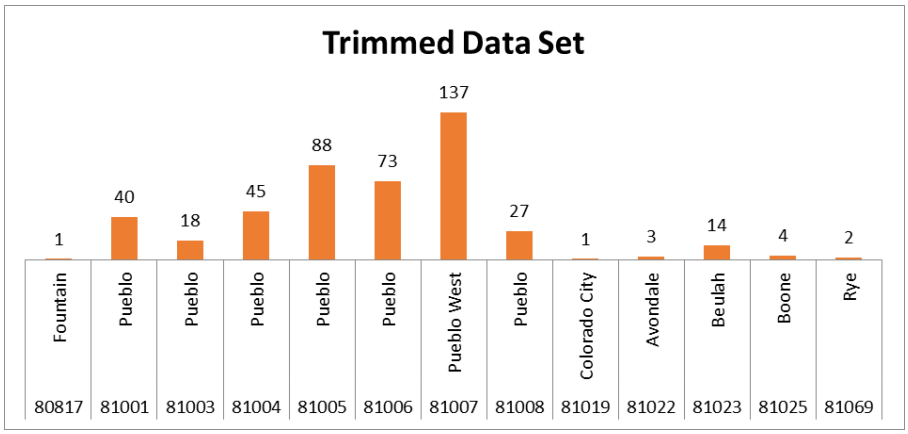

Figure 1: The Trimmed Data Set

The database contained limited information such as the full names and addresses of solar PV owners. Because ownership of some of the houses has since changed over the years, we used the Pueblo County Online Property Search tool to update the current owner's full names and addresses. Respondents were invited to complete the survey through postcards sent in two trenches to their addresses sourced from the trimmed solar PV database. The first trench was an invitation to respond to the survey and the second was a reminder to complete the survey sent two weeks after the first trench was sent. Incentives in the form of five $40 debit gift cards were offered to the respondents to motivate participation.

3. Results

The survey was open from the 21st of April 2016 till the 30th of June. During this period there was 23% response level (102 responses from 453 invites). The result was carefully sorted to remove duplicate responses, which brought down the effective responses to 93 (21% of total invites). Duplicates arose because some individuals started the survey, didn't finish and then did it completely at a later time. Figure 2 shows the total installations by zip code according to the 2015 solar installation data for Pueblo. It also shows the number of respondents compared to the total installations for each zip code. It could be observed that the number of respondents varies almost directly with the total installation per zip code. Response level (percentage) per zip code was highest at the zip code 81069 with 50% and had one response out of 2 total installations. This is followed by zip code 81023 with 5 (36%) response level. The least response level (14%) was observed at the zip code 81006 with 10 respondents out of 73 installations.

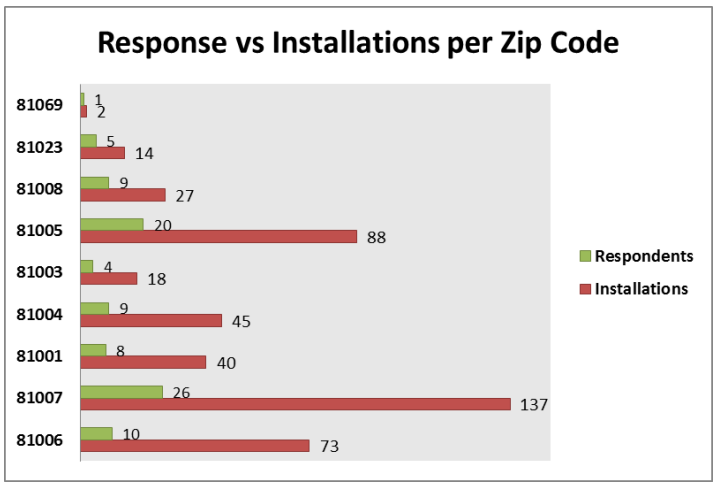

Figure 2: Respondents vs. Installation by Zip Code (Residential Solar)

3.1 Satisfaction by Zip

Digging further to correlate their satisfaction with the location of their houses through zip code, the graph in figure 3 below shows that:

Zip	81004	81069	80111	81003	81008	81005	81001	81006	81023	81007
Number of Installations	9	1	1	4	9	20	8	10	5	26

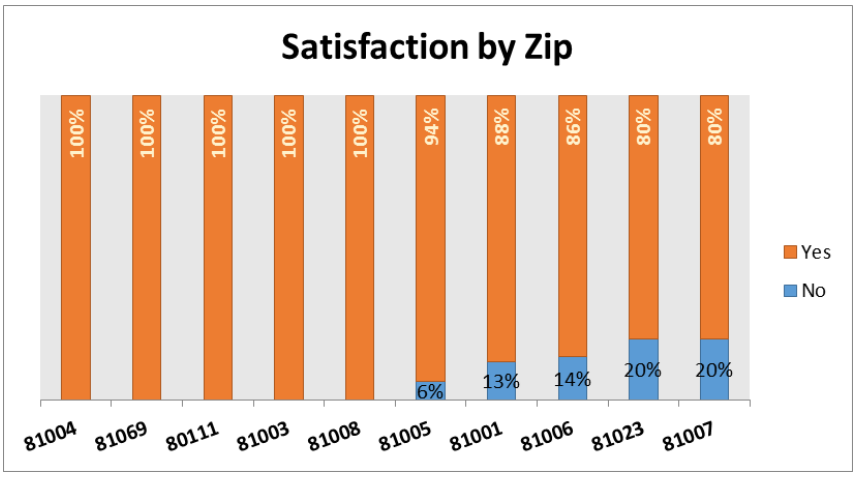

Figure 3: Satisfaction by Zip

Among all solar owners, 23% of respondents reside in the zip code 81007 (Pueblo West) and are 80% satisfied. Other locations that showed high satisfaction with solar installation include zip codes 81005 with 19%, 81004 and 81008 with 10% respectively all in Pueblo. Among the unsatisfied, the highest presence was also in the zip code 81007 (Pueblo West) as shown in figure 3. The response pattern might not be unconnected with the fact that zip code 81007 has the highest number of solar installations in Pueblo with 137 units. Again, the area could be

regarded as middle-class with the average median household income at $65,384 and median home value at $176,900. Figure 3 shows the percentages of satisfaction for each zip code.

3.2 Satisfaction by Age

People who installed their solar systems when they were between the ages of 50 and 70 years old tend to be more satisfied with their installation than every other age group as showed in figure 4 57% of total respondents fall under this age bracket. Figure 4 shows that satisfaction increased with age.

Age	30-39	40-49	50-59	60-69	70-79
Count	14	15	26	26	1

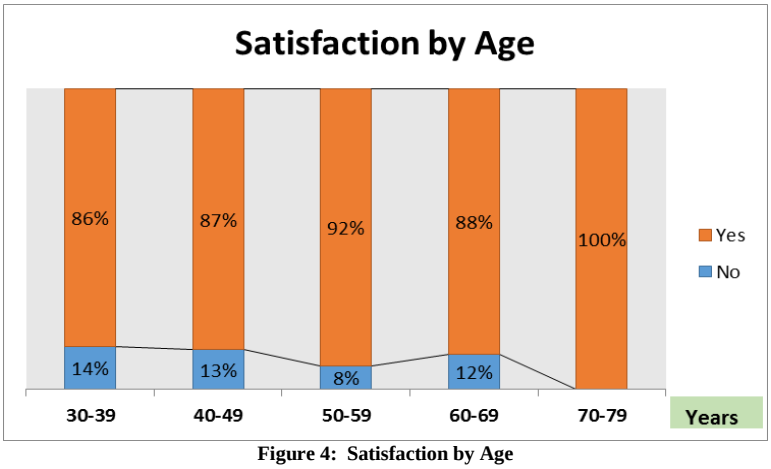

Figure 4: Satisfaction by Age

3.3 Satisfaction by Years of Usage

Figure 5 shows that those who installed their systems 7 to 8 years ago (2009-2010) were more satisfied with 33% of respondents indicating so. It is worthy of note that these were the years Pueblo witnessed the highest installation rate. The behavior of the graph could also be attributed to the availability of incentives at the time of installation and being able to have offset their payments on the installation. Satisfaction marginally dipped a little among those who installed their system between the years 2011 and 2012. From the graph, it would be safe to infer that those who installed their systems between 2009 and 2015 are the most satisfied.

Year	2007	2008	2009	2010	2011	2012	2013	2014-2015
Count	2	6	12	16	12	10	6	22

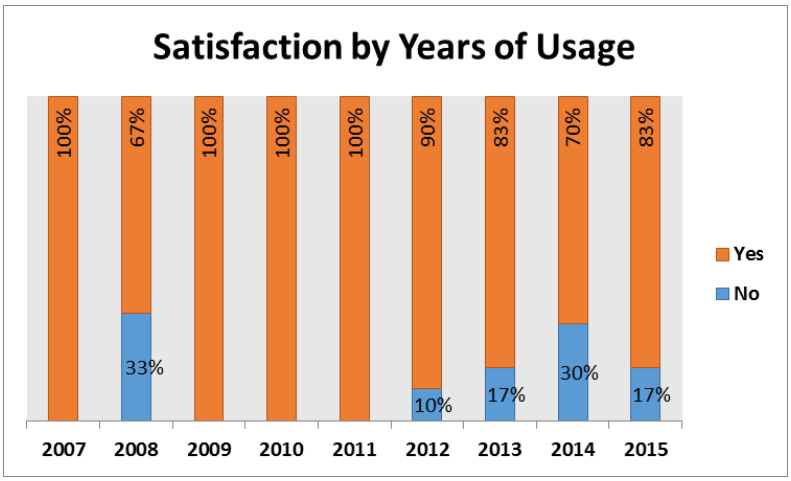

Figure 5: Satisfaction by Years of Usage

Year 2008 could have witnessed more dissatisfaction because of the relatively new technology and less efficient inverters. Dissatisfaction started to rise from the year 2012 to 2015 probably because of the frustration with the time to payback, and reduced incentives.

3.4 Installations by Zip

When considering population by zip, Pueblo North (81001) is the most populated with 30,498 people and closely followed by South Pueblo (81005) with 29,975. Pueblo West (81007) is the third highest in population with 29,709 people. A sharp contrast to the population spread is the pattern of solar installation. Pueblo West despite being the third most populous area in Pueblo is actually where we have the most installations of residential solar with 137 units. Most responses to this survey no doubt came from Pueblo West where we have the most installations; 28% of the responses came from here whereas South Pueblo, being the second most populous area and the second in installations, follows with 22%.

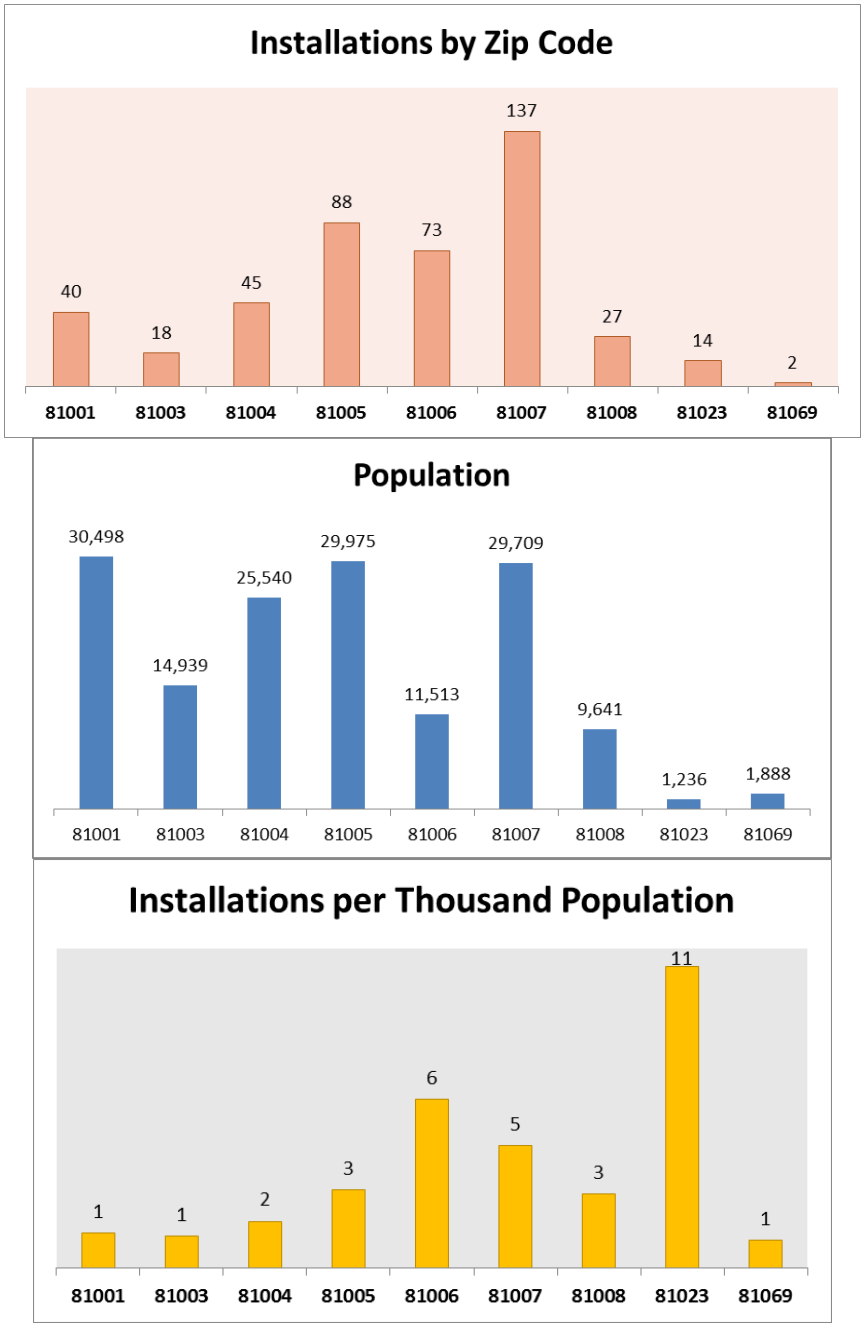

Figure 6: Installations per Thousand Population

When considering residential solar installation density, figure 6c, which tracked the number of solar PV installations per 1,000 population, measures the breadth with which solar energy has been adopted in a community relative to its size. A key observation was made in the zip code – 81023 (Beulah). This area has 11 installations per a thousand population making it the most concentrated in Solar PV usage. The isolated nature of this area could be a reason for this pattern.

Most respondents have occupied their property between 1 month and 5 years followed by those have occupied theirs for between 5 and 20 years. A vast majority had their systems installed themselves and mostly between

2009 and 2011; and at the ages between 50 and 60. A notable observation is that most owners installed their systems between the ages 50 and 70.

3.5 Installation by Year

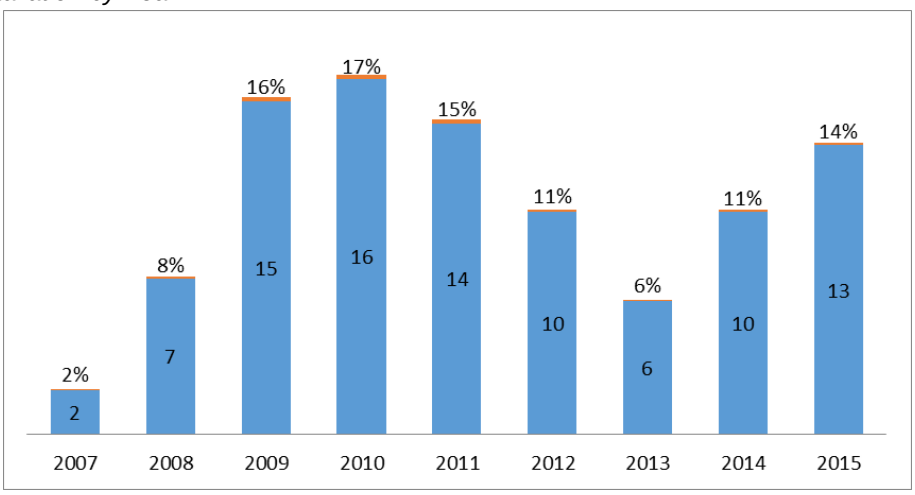

Figure 7: Installation by Year

Results show that the year 2010 witnessed the highest residential solar system installation in Pueblo followed closely by the preceding year – 2009. Year – 2011 had 15% whereas, 2007 had the least number of installations; 2%. The graph also shows that the years 2009, 2010, and 2011 witnessed the highest solar uptake in Pueblo. The decline in installation from the year 2010 to 2013 (17% to 6%) was the result of Black Hills Energy going into a deficit with their RES balance in 2011 after a regime of undue high incentives of $4.50 per watt which saw installation peak in 2010. Black Hills Energy attempted to completely stop any incentive, but a group of installers and advocates developed a 2011 plan to save the industry locally by reducing the monetary incentive over time while allowing some installations. The plan included rate design and structure in agreement with Black Hills Energy. The plan, which was suspended in 2012, almost killed the local solar business, although the business is cautiously on a recovery phase now.

3.6 Finding Solar

Newspaper/Radio, Internet, and Family/Friend were the chief sources of solar knowledge by respondents. Among other factors, reducing energy bill and the desire to live green were the driving factors that influence their eventual solar purchase. It is not enough to develop the interest in solar, sometimes executing the plan could be a herculean task. Most owners found their system installers through yellow pages and internet search which is not very different compared to the San Diego study where respondents indicated that personal reference and internet were their major sources. Others found theirs through fair/home show and professional reference. It is pertinent to note that many respondents sourced installer information through family, friends, energy company salesman, Angie's list and builder.

3.7 Investment/Incentives

Whereas a majority attested to their financial investment in solar as being a good value for their money, 10% thinks there's too much time to pay off. Although 91% of solar owners claimed a rebate or tax credit on their system, 9% did not, citing reasons such as unavailability of rebates at the time, and not knowing how to go about it. It was more like a consensus answer when 95% of respondents admitted that their electricity bills diminished after the acquisition of the solar system. Even with most respondents (96%) expecting their solar installation to increase the value of their homes by 5 to 10%, it is surprising that many (68%) would not have installed solar without a rebate offer. This again is similar to the response from the San Diego study, and it may not be unconnected with the initial cost of installation. Results show that owners considered the actual payback period (6 to 10 years) forecasted for their systems as reasonable. Similar to the San Diego study, it is encouraging to know the interest being generated by solar installation as most owners (87%) attested to the positive reactions from neighbors about their installations. Neighbors had particularly asked questions about the cost of installation, savings, and satisfaction with 22% of respondents indicating that at least one neighbor has/may buy a system.

3.8 Solar PV Detail and Operation

Whereas a vast majority (86%) of the respondents indicated that the sizes of their systems were 10Kw or less, sizes of houses in square feet were mainly between 1000 and 3000 sq ft as shown by the data (figure 8).

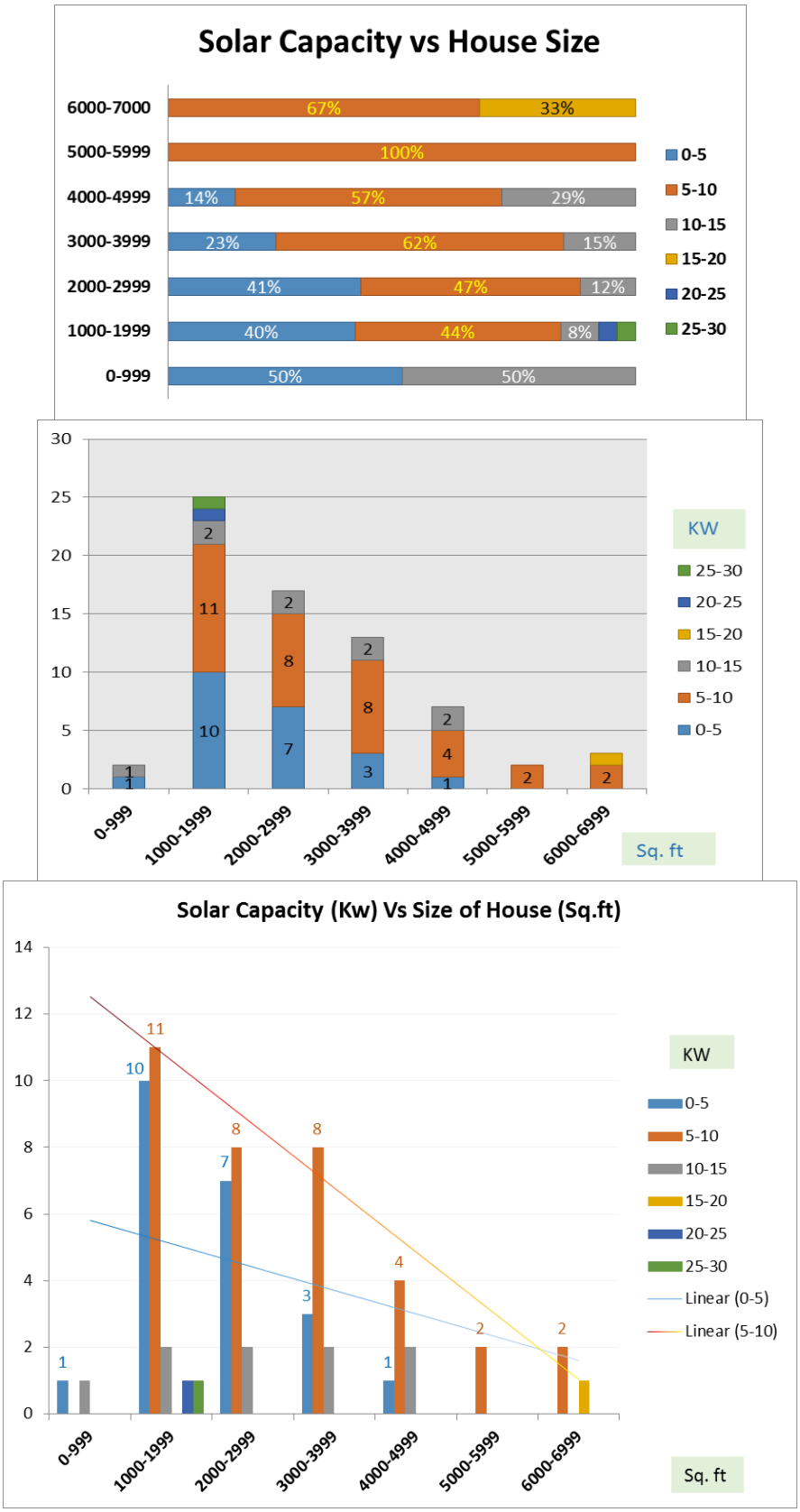

Figure 8: Solar Capacity and Size of House

Large house sizes did not directly represent higher solar installation capacity as most homes maintained 10Kw or less capacity as shown in the graph. A notable feature is that the use of 5KW and 10KW solar capacity decreased with increased house sizes as shown in 8b. The decrease does not show a choice of an alternative higher installation capacity, but that not very many solar owners have large house sizes. On the average, the data shows that the monthly electricity consumption of residential solar owners in Pueblo County is 586 KWh which is far

less than the amount of electricity the average American home uses. The US Energy Information System suggested that the average electricity consumption per month per American home is 901KWh.

3.9 Consumption vs. House Size

No correlation could be established between consumption and house sizes. It would be ordinarily expected that the bigger the house, the higher the energy consumption. Figure 9 shows that this is not the case; rather, owners had an average consumption level of 586KWh.

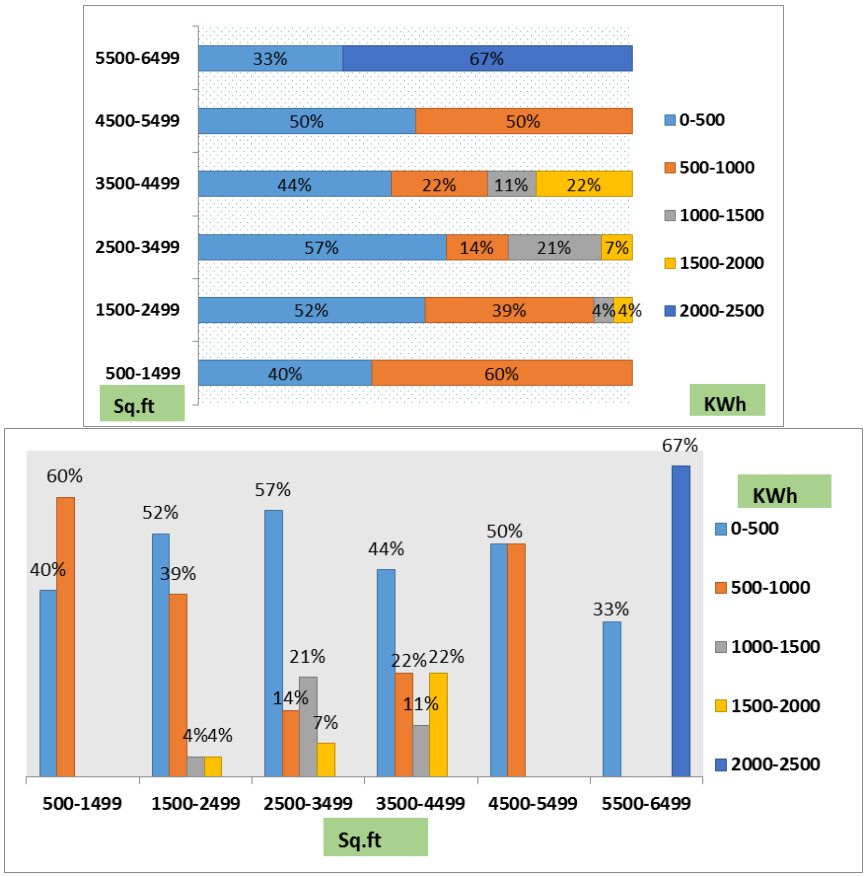

Figure 9: Consumption and House Size

Whereas almost all the respondents (99%) have their houses connected to the grid, 73% of them export an average monthly electricity of 600KWh or less to the grid largely due to the sizes of their systems and consumption. Connection to the grid did not seem to be a major problem as 96% of owners got connected within the initial 3 months of installation. On acquaintance with electricity at home, majority of owners have not only become more conscious of their energy use since after system installation, they, among other things, know the total electricity generated by their PV system and the total electricity consumed by their household. There seem to be energy contentment among owners as they expressed no clear interest in further expanding their systems.

3.10 Solar PV Problems

Whereas many owners (33%) did not encounter any barrier during system installation compared to the case with San Diego study (56%), chief among the barriers encountered is cost. Others include barriers with electricity utility provider, permitting and inspections. In terms of operation, majority of users have not encountered any problems. The few problems usually were fixed by the original installer and mainly came from inverter failure. Other remote problems are:

- Confusing billing.
- Animal interruptions such as squirrels and pigeons.
- Technical issues on panel and system operation.
- Reduced efficiency of system over time.
- Still paying high electric bill plus solar bill.
- Lack of knowledgeable support.
- Cleaning of panels.
- Issues with installer and utility.

3.11 Owners' Feedback

Assessing owners' opinion on what they will do with their system if they move, the majority (64%) would invest in a new PV system in their new houses. However, some do not intend to invest again in PV systems due to age. Results show that the average age of owners at the time of installation was 53; and 66% were 50 years or more at the time. This result suggests that most owners were either retired or close to their retirement age and would not want to move in the first place. Another reason they would not want to invest again depends on rebate availability. When asked what they thought could help solar PV uptake increase, respondents were almost unanimous in ranking the factors. They include:

1. Higher economic incentives (64%)
2. Active approach by electricity companies (44%)
3. Community based demonstration programs (43%)
4. More information and media campaigns (37%)

Owners, when given the opportunity to suggest best ways to stimulate solar energy uptake, advocated a much more affordable system, low initial cost and easier access to finance. Some advocated for a higher tax credit, and others think that the tax credits should be replaced with tax rebates. On an active approach by electricity companies, they were more direct that Black Hills Energy or others should lead the campaign and pay more per KWh when they buy back from the consumer; the company should not to be buying power at wholesale and be selling back at retail prices. Some believe that a unified code system for the US will help lower installation cost. Increasing the efficiency and improving the aesthetics of the PV system were also strongly supported. A lower payback period and less regulation were reechoed. Whereas some suggested that solar PV should be made mandatory just like the auto insurance, others think that the system should be made in such a way that you do not have to pay for electricity bills. Paramount among the suggestions is the need for more comprehensible information, advertisements, seminars, and media blitz in order to sell the long term financial/savings benefits, the ease of installation, and environmental benefits to the public. There was a call for demonstration projects or the establishment of a solar home tour similar to the Xeriscape tour, and to publicize same in the local media.

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