THE POTENTIAL OF SOLAR ENERGY TO MEET RENEWABLE ENERGY NEEDS IN IDAHO, USA

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ABSTRACT

The purpose of this paper is to evaluate public attitudes about the potential of solar energy generation in Idaho. Currently, hydropower is the largest source of electricity in Idaho. However, this resource is already being used at close to 100% capacity. Idaho is one of the three fastest growing states in the United States – a situation that will require additional energy resources to meet growing electricity needs. The three renewable energy resources that have the potential to meet this additional electricity demand are solar, wind, and geothermal energy. On an annual basis, the Boise area, the fastest growing area of the state, with its desert climate, averages 2,993 total hours of sunshine, making it the 47th sunniest city in the United States. There are 120 completely sunny days and more than 210 days with some sun. This fastest growing area of the state has plenty of sunshine. Consequently, individual homeowners have the incentive to install efficient solar systems thanks to both abundant sunshine and government incentives. The potential and future of solar energy are evaluated in this paper by (1) public surveys about the acceptance of solar energy in urban cities in southwestern Idaho, (2) the trends in individual solar installations by homeowners, and (3) the costs of individual solar installations compared to the cost of purchasing electricity from the local power grid. Solar energy has become cost-effective compared to the cost of other renewable energy resources in the region thanks to improvements in solar cell technology in the last 10 years. It is estimated that home rooftops in Idaho have the potential to be covered with 4,800 MW of solar panels. This could generate 28% of all the electricity demand in Idaho. As of 2021, 573 MW worth of panels had been installed. More than 81% of homeowners in the Boise area have been approached by companies selling solar systems in the last 4 years. Approximately 35% of the homeowners who have received solar information view this renewable energy resource as viable, while more than 30% of the homeowners have either seriously considered solar energy systems or installed these systems since 2016. Solar systems are now found on the rooftops of approximately 4,000 homes in Ada and Canyon counties in southwestern Idaho. As long as federal tax incentives are offered for the installation of individual solar systems, this renewable energy source will expand at a fast pace in southwestern Idaho in the foreseeable future.

Keywords: public opinion, renewable energy, solar energy, sustainable energy.

1 BACKGROUND

The state of Idaho has a tradition of having renewable energy sources providing most of its electricity needs. The majority of electricity is produced by hydropower. However, in the last 15 years, Idaho has become one of the five fastest growing states in the United States resulting in the need to import and use more nonrenewable energy sources to meet this electricity need. There is widespread interest by individuals to generate their own sustainable and renewable electricity by using their own solar systems and windmills.

2 INTRODUCTION

The worldwide demand for energy continues to increase because of both population growth and the intensified use of energy by each person on Earth. The world's current population is growing at the rate of 81,000,000 per year, while people, particularly in middle-developed countries, are intensifying their energy use [1, 2]. Approximately 200 years ago, firewood was the major energy source exploited by humans. Even though, by definition, firewood is considered renewable, the large human population would deforest planet Earth

ISSN: 2056-3272 (paper format), ISSN: 2056-3280 (online), http://www.witpress.com/journals
DOI: 10.2495/EQ-V7-N2-140-150

to meet the energy demands of more than 7,900,000,000 people if this was our primary energy source.

Since the early 1900s, humans have relied on fossil fuels, including oil, coal, and natural gas, to meet the majority of energy needs in the developed world. Unfortunately, fossil fuels are finite in supply and their use results in carbon dioxide evolution, which in turn contributes to climate change. At this point in time, renewable and sustainable energy sources are needed to supply the human race and protect planet Earth for future generations [3]. The alternative renewables that are commonly included in scientific discussions include hydropower, geothermal energy, wind power, and solar energy.

Hydropower is renewable, produces a clean source of energy, and is widely used; however, there are limited sites on Earth that can produce large additional amounts of hydropower. Geothermal energy is also renewable, but with current technologies, sites are limited in their ability to exploit this resource. As a result, solar and wind as the most likely renewable and sustainable energy sources to replace fossil fuels and meet the energy needs of a future human population of 9,000,000,000. There are many sites on this planet where the potential for the generation of energy from wind is substantial; however, wind by itself cannot meet all energy needs. Conversely, there are many places where the production of energy from solar cells has the potential to meet a significant portion of future energy needs [4].

There has been widespread interest in solar energy since the 1980s; however, solar cells were simply too expensive to compete with natural gas and wind energy. Since the cost of solar cells started to decrease due to improved technologies in 2016, interest has greatly increased [4]. Renewable energy sources are dominating the new power installations of the last five years. In 2019, renewables (solar and wind) accounted for more than 70% of new power plants [5, 6]. Solar power has not only become cost-competitive, but it is cheaper than many other renewables. Solar photovoltaic (PV) systems are currently used on commercial utility farms and on individual home rooftops to generate electricity.

Idaho is a western state with a small population. Traditionally, more than 80% of its electricity needs have been met through the use of renewable energy sources. Although hydropower is the major renewable energy source in the state, wind and solar also contribute to meet the overall electricity demand [7]. Two non-renewables – natural gas and coal – make up the rest of the state's electricity needs. Idaho's population has grown rapidly in the last 15 years, outstripping the ability of hydropower to generate the electricity demanded in this growing state. Consequently, electricity produced from coal in an adjacent state and the use of natural gas to produce electricity has increased. To meet the increased energy demand, there has been a renewed interest in both wind and solar power. Today wind farms generate almost 16% of the electricity demand in Idaho. This occurs primarily in the southeastern part of Idaho, where the prevailing winds are strong. The southwestern part of Idaho has a desert climate that receives large amounts of sunshine. Most of the population growth is also in this part of the state. The major utility in southwestern Idaho currently purchases some electricity from a solar farm in the southern part of the state, and there is individual homeowner interest about installing solar systems in urban areas of Ada and Canyon counties in southwestern Idaho. The purpose of this paper is to evaluate interest by individual homeowners in this part of the state to install rooftop solar systems that are capable of meeting all the electricity needs of those homeowners.

3 METHODS

The following three methodologies are used in this paper:

3.1 Public surveys about the acceptance of solar energy in two urban counties in southwestern Idaho

A survey instrument was developed to determine public views of the value, potential, and sustainability of solar energy within Ada and Canyon counties in Idaho. The five survey questions were as follows:

> Q-1. Which of the following energy sources are renewable (sustainable)? Check all that are renewable: Burning firewood, Coal, Hydroelectricity, Natural gas, Oil, Solar, Wind.
> Q-2. What is your opinion of solar energy? Choose one of the following: Very favorable, Favorable, Neutral, Unfavorable, Very unfavorable.
> Q-3. Have you ever been contacted by a representative of a company selling solar equipment for your home? Choose one of the following: YES – I have been contacted, NO – I have not been contacted, NOT SURE.
> Q-4. How likely are you to install solar equipment on the roof of your home sometime in the next 5 years? Choose one of the following: Already installed, Very likely, Somewhat likely, Not likely, Absolutely not, No opinion.
> Q-5. If you were to install a solar system on your roof, would it be cost-effective within 10 years? Choose one of the following: YES – it would be cost effective, UNSURE, NO – it would not be cost-effective.

The survey target audience was a representative sample of the 650,000 adult residents of single-family homes in Ada and Canyon counties, Idaho. In addition, demographic information including gender, age, and educational level were also collected.

Both the 2016 and 2021 surveys were identical and developed using the Dillman methodology. The survey was delivered to clientele via the US Postal Service [8, 9]. The sufficient number of completed surveys was the goal to result in a sampling error of 5%–6% [10]. The survey process was also designed to receive a completed survey return rate of more than 50%. Addresses were obtained from a professional social sciences survey company (SSI, Norwich, CT). More than 1,000 surveys were sent out in each of 2016 and 2021. Four mailings were planned to achieve the 50% return rate. The mailing strategy used was identical to other surveys that had been routinely conducted in the region [11–14]. It only took three mailings to achieve the target return rate of 50% in 2016 and 2021.

Survey answers were coded and entered into Microsoft Excel. Missing data were excluded from the analysis. The data were analyzed at two levels using SAS [10]. The first level of analysis generated frequencies, while the second level evaluated the impacts of demographic factors. The significance ($P < 0.05$) of demographic factors was tested using a chi-square distribution [9, 10]. Since similar response rates were observed in all survey years, data analysis procedures were identical for each sampling.

3.2 Trends in individual solar installations by homeowners

The above surveys, information obtained from the local utility, Idaho Power, and discussions with several of the companies that had installed solar systems within the two-county area were used to collect this data.

3.3 Evaluating the costs of home-installed solar systems compared to long-term electricity purchases from the power grid

Again, the homeowner surveys, information from the local utility, and discussions with solar installation companies were used to collect this data.

4 RESULTS AND DISCUSSION

The survey methodology was designed to be able to compare resident responses over time so that useful information about solar energy attitudes and the willingness to convert to solar energy could be evaluated. Using the mail-based Dillman survey methodology, response rates of 52.5% and 53.4% were achieved for the surveys conducted in 2016 and 2021, respectively. The goal of a greater than 50% response rate was achieved for both surveys, resulting in a sampling error of less than 6%.

When this survey was first initiated in 2016, the population of combined Ada and Canyon counties was 655,867 [15]. However, by 2021, the two-county population had grown to more than 750,000 [16]. This 14.4% population increase resulted in the study area becoming more urban and more concentrated in communities with more than 100,000 people.

There were several instances in this survey study where the demographic factors of gender, age, and education level impacted respondent answers. These instances will be discussed in the following sections.

4.1 What is renewable energy?

A large majority of the surveyed public considered hydropower, wind, and solar energy as renewable energy sources in 2016 and 2021 (Table 1). Over two-thirds of surveyed respondents also considered the burning of firewood as a renewable energy source. Conversely, natural gas, oil, and coal were considered renewable by less than half of the public. Consequently, the public correctly identified renewable and non-renewable energy resources. In

Table 1: Urban southwestern Idaho homeowners' response to the question: "Which of the following are renewable sources of energy?"

Response	**2016**	**2021**	**Significance**
	---------- % ----------		
Hydropower	90.6	87.7	NS
Wind energy	92.1	94.3	NS
Solar energy	86.8	90.1	NS
Burning firewood	74.1	68.2	**
Natural gas	47.6	40.1	**
Oil	33.4	29.1	**
Coal	14.5	4.9	***
Significance	****	****	

NS = not significant; **, ***, and **** = significant at the 95%, 99%, and 99.9% level of probability, respectively.

2021, a larger percentage of survey respondents were able to correctly identify the nonrenewable energy sources compared to 2016 observations.

The demographic factors of gender, age, and education level impacted survey respondent choices (Table 2). Women were more likely to correctly distinguish renewable from nonrenewable energy resources than men. Respondents less than 30 years of age were more likely to correctly identify renewable energy sources than residents older than 75 years. In addition, respondents with a college degree were much more likely to correctly identify renewable and nonrenewable energy sources than those with 12 or fewer years of education.

4.2 Familiarity with solar energy

In 2016, only 35.4% of survey respondents had a favorable opinion (very favorable or favorable) about solar power (Table 3). However, by 2021, more than 57% of the public viewed solar power favorably. Conversely, the percentage of people with an unfavorable (unfavorable or very unfavorable) opinion about solar energy declined from 32.5% in 2016 to 25.6% in 2021. This change in opinion over time was likely attributed to increased public education about solar energy and the neighborhood presence of solar system sellers. Gender, age, and education level impacted the opinions of survey residents (Table 2). Women were more likely to have a favorable opinion of solar energy than men. Respondents that graduated from college view solar energy more favorably than the public with fewer than 14 years of formal education. Also, younger respondents viewed solar energy more favorably than people older than 75 years.

Table 2: The impact of demographic factors on the survey answers of the public in southwestern Idaho in 2016 and 2021.

Data table	Demographic factor	Significance	Most	Least
1	Gender	***	Female	Male
	Age	**	<30 years old	>75 years old
	Education	**	College	<12 years
3	Gender	***	Female	Male
	Age	****	<30 years old	>75 years old
	Education	**	College	<12 years
5	Gender	**	Female	Male
	Age	***	40–55 years	>75 years old
	Education	**	College	<12 years
6	Gender	**	Female	Male
	Age	***	40–55 years	>75 years old
	Education	**	College	<12 years

, *, and **** = significant at the 95%, 99%, and 99.9% levels of probability, respectively.

Table 3: Urban southwestern Idaho homeowners' response to the question: "What is your opinion of solar energy?"

Response	2016	2021	Significance
	---------- % ----------		
Very favorable	11.2	16.9	**
Favorable	24.2	40.6	****
Neutral	32.1	16.9	***
Unfavorable	15.4	10.7	**
Very unfavorable	17.1	14.9	NS
Significance	****	****	

NS = not significant; **, ***, and **** = significant at the 95%, 99%, and 99.9% level of probability, respectively.

Table 4: Urban southwestern Idaho homeowners' response to the question: "Have you ever been contacted by a representative of a company selling solar equipment for your home?"

Response	2016	2021	Significance
	---------- % ----------		
Yes, I have been contacted	12.7	81.4	****
No, I have not been contacted	77.1	13.9	****
Not sure or no answer	10.2	5.6	**
Significance	****	****	

** and **** = significant at the 95% and 99.9% level of probability, respectively.

Over the last 6 years, many Canyon and Ada county residents were exposed to entrepreneurs that sold or installed solar systems on individual homes (Table 4). The number of residents who were contacted by a representative of a solar company increased from 12.7% in 2016 to 81.4% in 2021 (Table 4). It is estimated that at least 35 different companies were peddling solar systems in the Boise area during this 6-year time period. These solar companies increased the familiarity of solar science to homeowners. Conversely, people living in rental housing had much less information and familiarity with solar systems.

4.3 Solar system installations and benefits

By 2021, more than 6% of surveyed homeowners had installed solar systems on their roofs (Table 5). In addition, another 23.7% of the survey respondents indicated that they were very likely to install solar systems on their homes in the next 5 years. When comparing the 2016 and 2021 survey values, it is obvious that the momentum has been building to greatly

Table 5: Urban southwestern Idaho homeowners' response to the question: "How likely are you to install solar equipment on the roof of your home sometime in the next five years?"

Response	2016	2021	Significance
	---------- % ----------		
Already installed	1.3	6.5	**
Very likely	10.4	23.7	**
Somewhat likely	12.0	15.9	NS
Not likely	30.6	22.9	***
Absolutely not	28.7	24.7	NS
No opinion	4.0	6.3	NS
Significance	****	****	

NS = not significant; **, ***, and **** = significant at the 95%, 99%, and 99.9% level of probability, respectively.

Table 6: Urban southwestern Idaho homeowners' response to the question: "If you were to install a solar system on your home roof it would be cost effective within 10 years."

Response	2016	2021	Significance
	---------- % ----------		
Yes, it would be cost-effective	20.4	39.2	***
Unsure	50.1	47.2	NS
No, it would not be cost-effective	29.5	13.6	***
Significance	****	****	

NS = not significant; *** and **** = significant at the 99% and 99.9% level of probability, respectively.

increase the use of solar energy in this two-county area of southwestern Idaho. A significant portion of the survey respondents indicated that they were not likely to buy into solar systems in 2016 (30.6%) but that they were somewhat likely and very likely (39.6%) to install solar systems in 2021. The demographic factors of gender, age, and education level also impacted the likelihood of installing solar systems (Table 2). Here, young residents, women, and college-educated residents were more likely to install solar systems over the next 5-year period.

The final question on the survey dealt with homeowners' understanding of the costs associated with a solar system installation. Almost 40% of the respondents in 2021 thought that installing a solar system would be cost-effective within a 10-year period (Table 6). This is close to double the percentage of people who thought that the installation would be cost-effective within a 10-year period in the 2016 survey. It is interesting that the percentage of

people who were skeptical about the cost effectiveness of a solar system decreased by more than 50% from 2016 to 2021. Again, age, gender, and education level impacted how respondents of Ada and Canyon counties answered this survey question (Table 2). Respondents between the ages of 40 and 55 years were most likely to view the solar system as cost-effective. Conversely, respondents older than 75 years were least likely to see the cost effectiveness in an installed solar system. As with the other survey questions, college graduates were most likely to see the cost effectiveness of installed solar systems. Women were also more likely to see the cost effectiveness of such installed systems than men.

4.4 Homeowner installation trends

Because the Boise area is the 47th sunniest in the United States, homeowners have come to realize that renewable, sustainable solar energy is a good fit for this fast-growing area. Many homeowners have become highly invested in these rooftop solar systems. The 2,993 total hours of annual sunshine in this two-county area makes solar energy an attractive alternative renewable energy source. To date, more than 573 MW of solar panels have been installed in Idaho – with at least half of the capacity in Ada and Canyon counties.

The results from the survey questions indicated that there is substantial enthusiasm for rooftop solar systems by individual homeowners. It is estimated that approximately 4,000 homes have installed solar systems (personnel communications with Idaho Power and several solar system providers). Approximately 100 systems are installed each in the months of May, June, July, August, September, and October. Installation rates are much lower in colder months but probably average between 10 and 20 systems in each of November, December, January, February, March, and April. The annual conversion rate to solar energy in Ada and Canyon counties exceeds 800 residences per year. Examples of solar panel installations are shown in Figs. 1, 2, and 3.

Figure 1: View of recently installed solar panels on the roof of a Boise, Idaho, area home. Photo courtesy of Blue Raven Solar Systems, Salt Lake City, Utah.

Figure 2: View of entire solar panel on the roof of a Boise, Idaho, area home. Photo courtesy of Blue Raven Solar Systems, Salt Lake City, Utah.

Figure 3: Completed solar system installation on the rooftop of a Boise area home. Photo courtesy of Blue Raven Solar Systems, Salt Lake City, Utah.

4.5 Cost comparison: solar vs. power grid

There are many variables to consider when trying to compare electricity costs over the long term between individual solar systems and relying on purchasing electricity from the power

grid. The installation of an entire rooftop solar system on an average single-family home ranges from $16,000 to $40,000. The estimated payback period to break even on a solar system designed to last 30 years ranges from 8 to 26 years. There are many variables that determine the economy and the actual payback. Some of these important considerations include the following:

- How is the initial system paid for cash or financing?
- If the system is initially financed, what is the financing rate?
- How much money goes to the local power company for managing the solar credits produced by the installed system?
- Federal government and/or state tax credit incentives.
- Average annual electricity rate increase charged by the local utility.

It is apparent that the initial monetary outlay to install a solar system is high; however, more than 4,000 residents in southwestern Idaho thought that the cost/benefit of solar was worth it. Positive trade-offs of solar installation include (1) tax credits, (2) low-cost loans that are substantially less than the costs of other loans, (3) the length of time the homeowner plans on staying in the home and/or increased home value incorporated into the home's resale price, and (4) benefits to the environment. Another important consideration is the potential annual rate of energy cost escalation from the utility company. Many experts expect the cost of energy to escalate by at least 6% per year. A homeowner paying $1,600 per year for electricity in 2021 would see their annual bill escalate to $3,330 in just 12 years. The solar system is immune to increases in energy prices.

5 CONCLUSIONS AND RECOMMENDATIONS

The major findings of this study were:

- A large majority of homeowners in southwestern Idaho were able to distinguish renewable from nonrenewable energy resources.
- More than 85% of the surveyed public considered hydropower, solar power, and wind energy as renewable energy resources.
- By 2021, more than 57% of the surveyed public viewed solar power favorably.
- More than 12% of the residents of the surveyed two-county area were contacted by a representative of a solar company in 2016; however, by 2021, 81.4% of the residents had been reached by solar representatives.
- By 2021, more than 6% of homeowners had installed solar systems on their roofs. In addition, another 23.7% indicated that they were very likely to install solar systems in the next 5 years.
- Based on the 2021 survey, almost 40% of the survey respondents thought that installing a solar system would be cost effective within a 10-year period.
- Solar systems are now found on the rooftops of approximately 4,000 homes in Ada and Canyon counties in southwestern Idaho.
- There appears to be significant momentum for the adoption of solar systems in the geographic area. Over the past 3 years, there have been approximately 100 installations in each of the summer months, while the number of new solar systems has been substantially lower (8–15) in the cooler months of the year.
- Coupled with federal tax incentives, the payback period for solar systems ranges from 7 to 26 years. Conversely, the solar panels should last for at least 30 years.

The demographic factors of gender, age, and education level affected the responses of residents to survey questions. Women were more likely to support the movement to other solar systems than men. College graduates were more likely with less formal education to support and install solar systems than respondents. Younger residents (less than 40 years old) were more supportive of renewables than older residents.

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