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SUSTAINABLE BUILT ENVIRONMENTS

CAPSTONE RESEARCH REPORT

Title: What Can Better Solar Education in Pima County, Arizona Do?

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ABSTRACT

While Arizona has abundant solar resources, policy decisions, regulatory changes, and the absence of state level incentive programs has limited the states solar adoption rate. This study examines if better solar education can change the way people in Pima County, Arizona purchase, manage, or make decisions about solar energy technologies. With the counties high solar irradiance of almost 300 days of sunshine (80%) a year, solar power has serious potential, but adoption remains limited due to knowledge gaps, economic barriers, and policy challenges. This longitudinal survey was conducted across two semesters of Fall 2024 and Spring 2025, and there were 68 participants in the first survey and 74 participants in the second survey. Results show that better solar education is supported by over half (56%) of the participants surveyed, because they believe better solar education improves solar purchasing/management decisions. The interviews confirm the survey results, with cost savings as the main consumer driver, distrust in some solar companies, and the affordable option of Power Purchasing Agreement's for people who cannot afford the cost of solar installation. The study further finds that solar education plays an important role in boosting solar adoption, addressing misinformation, and improving policy. The public's support for solar education, incentives/rebates, and energy conservation programs, says that Pima County could greatly expand its clean energy sector, providing jobs, and clean energy for the future generations of this region.

Key words: solar, education, incentives, and energy conservation

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Introduction:

Humanity has been using solar energy, radiant light and heat from the sun since ancient times. Technologies include solar heating, solar photovoltaic, solar thermal electricity and solar architecture, all these things have been contributing, to solve the world's energy crisis (Energy Vol. 53). The problem is, it is hard to say, from what we know, what people's attitudes are about solar energy management, since there is no real policy or education program, that teaches individuals or groups how to use and manage the sun to solve our energy problems. Because, we have such an abundance of Sun in Pima County, Arizona, and we do not know why people do not use the Sun more. So, we should provide solar education and policy, so that people can better manage the sun to solve their energy problems. Making the research question, can better solar education change the way people purchase/manage or make decisions about the sun?

Study Area:

The study area is Tucson, Arizona, Pima County in the Southwest U.S.A. Pima County has a total population of 1,043,433(U.S. Census) with a total number of households to be 445,475(U.S. Census). I am studying people's knowledge about solar around here because it receives 80%(NREL) of the time or 296 days of sunshine (Pima.gov). So, you would think there would be interest in some application of solar. Solar energy could give you energy for over 75% of the year here. Some education for the people in PV panels, solar energy, and solar thermal might have positive effects for people. So, that they could use these incentives/purchase and manage or make decisions(voting) about solar power. Pima County could be a place where solar power (PV panels, solar thermal) could be adopted due to education. There are more than 447,000 customers that TEP (Tucson Electric Power) serves (TEP) but an estimated 300,000 total solar installs in Arizona and 39,000 total solar installs in Arizona in 2023 (aztechcouncil.org). The University of Arizona and Pima Community College reside in this county with a median income of $69,758(U.S. Census) and 36% of the population in this county are bachelor's or higher (U.S. Census). So, maybe

solar energy technology education about the benefits could change the way people purchase/manage or make decisions about solar energy technologies in this dry/arid unique sunny region of the world.(Figure 3)(Figure 4)

Literature Review:

Science of Solar Panels:

When sunlight shines on the solar cell, electrons and holes are photogenerated, and are separated by the internal electrical field of the depletion zone, creating current flow through a external circuit. This process absorbs light energy, generating electron-hole pairs in the semiconductor, and separating their charge carriers. The p-type layer that has electrons called holes, and the n-type layer has electrons. When combined, a depletion zone forms at the junction where electrons move from the n-type side to the p-type side. It creates a internal electric field that prevents further electron-hole recombination. When sunlight shines on the cell, electrons are released, creating a flow of electricity through a external wire facilitated by the movement of electrons and holes across the formed depletion zone. This technology consists of numerous components, including PV panels that collect and convert sunlight into electrical energy (Renewable and Sustainable Energy Reviews Vol. 207)(Figure 1).

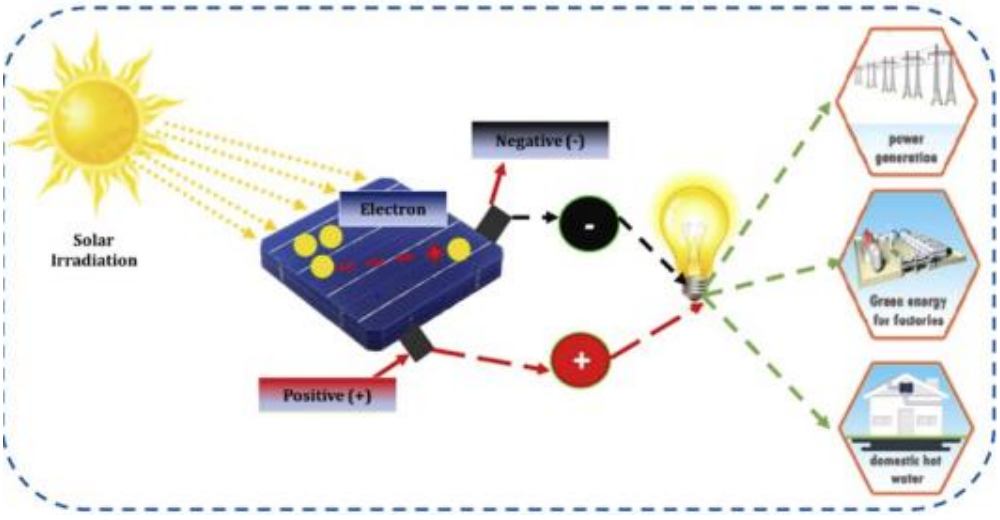

Figure 1: Science of Solar: Renewable and Sustainable Energy Reviews Vol. 207

Solar Panel Efficiency and Temperature:

Solar photovoltaic energy production is directly proportional to the amount of solar irradiance falling on the panel surface. Some portion of this irradiance is converted into electric energy and the rest of the solar energy heats up the solar panel. This energy must be removed from the solar panel which can be used for water heating or other useful purposes. The solar irradiance varies with time due to the change in sun movement and cloud cover [8]. High solar irradiance causes overheating of the photovoltaic cells which in turn reduces the conversion efficiency and can lead to the thermal stress of solar panels. As a result, solar irradiance has a highly significant effect on long-term electricity generation (Case Studies in Thermal Engineering Vol. 30).

PV performance can be evaluated through different criteria, including electrical, thermal output, exergy efficiency, cell conversion efficiency and net energy ratio. Such performance can be strongly influenced by several factors, such as PV module conversion efficiency, geographic positions, weather pattern, soiling, partial shading, PV tilt angle, PV cell temperature, atmospheric pressure and relative humidity (Renewable and Sustainable Energy Reviews Vol. 207).

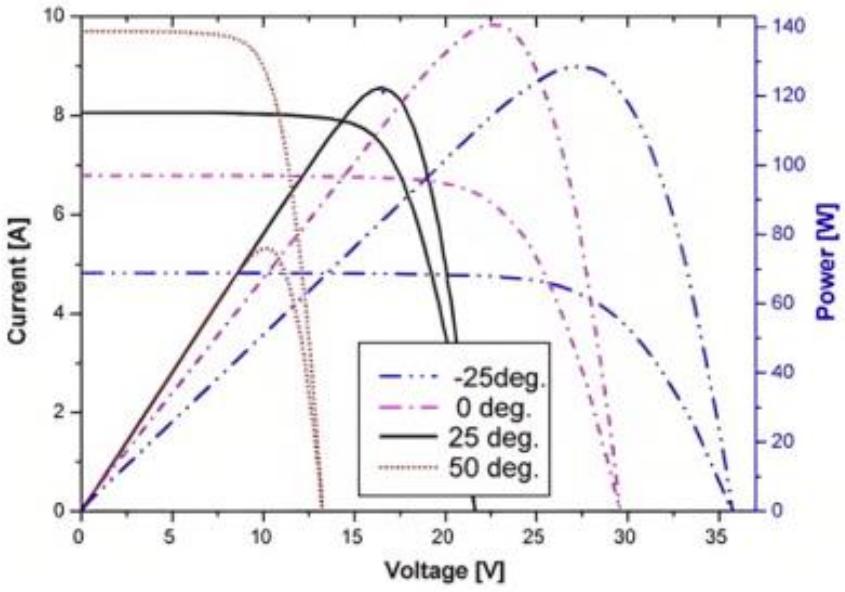

Figure 2:The Efficiency of Solar: Renewable and Sustainable Energy Reviews Vol. 207

PV panels convert 20 % of solar energy into electricity. The rest is converted to heat. According to previous studies, the PV panel's surface temperature is proportional to its electrical

output. The bandgap of the PV reduces as the temperature of the solar cell rises, increasing short-circuit current and a drop in open-circuit voltage explaining the voltage drop when temperature rises. The performance of a photovoltaic module is mainly influenced by the cell's semiconductor material, irradiation intensity, operating temperature, and wind velocity. The electrical efficiency of a crystalline silicon solar module drops by 0.5 % with a temperature increase of 1 °C, whereas the efficiency of an amorphous silicon solar cell drops by only 0.25 %(Figure 2)(Renewable and Sustainable Energy Reviews Vol. 207).

The efficiency and power of the solar photovoltaic module were measured with and without filters, and their performance was compared. From the study, it has been concluded that among all the color filters used, magenta color in the visible spectrum of solar radiation gave the maximum efficiency. The results also show that blue and magenta have maximum scope for producing more change in temperature when compared to other filters (Case Studies in Thermal Engineering Vol. 21)(Table 1)(Table 2)

Table 1: Peak Temperature: Case Studies in Thermal Engineering Vol. 21

Table 4. Peak temperature and average temperature of all filters.

S.No.	Condition	Peak Temperature(^{0}C)	Average Temperature(^{0}C)
1.	Without color filter	73.6	61
2.	blue color filter	78.9	59.4
3.	yellow color filter	72.3	58.2
4.	green color filter	74.9	61.5
5.	red color filter	74.5	57.4
6.	magenta color filter	75.9	57.3

Table 2:Peak Voltage, Current, Power: Case Studies in Thermal Engineering Vol. 21

Table 6. Comparison of peak voltage, current, and power for various conditions.

S.No.	Condition	Peak Voltage (V)	Peak Current (I)	Peak Power(W)
1.	Without color filter	19.04	2.4	45.32
2.	blue color filter	18.7	1.86	32.64
3.	yellow color filter	18.4	2.45	43.35
4.	green color filter	17.49	1.57	27.07
5.	red color filter	18.2	2.01	35.94
6.	magenta color filter	18.6	2.45	45.31

Lifespan of Solar Panels:

Determining the energy output of solar PV over its lifetime depends on the assumed degradation rate of the panels. Module encapsulation protects against weather factors, moisture and oxidation and can withstand mechanical loads (e.g. wind and hail). PV systems are often financed based on an assumed 0.5–1.0% per year degradation rate although 1% per year is used based on warranties. This rate is faster than some historical data given for silicon PV. In a study on c-Si modules, it was found that faster degradation occurs earlier and then it stabilizes indefinitely. In the study, more than 70% of 19–23-year-old c-Si modules had an annual degradation rate of 0.75%, still less than the 1% year assumed. The failure sources are summarized In another study, c-Si PVs installed in 1982 (much older technology) and tested in 2003 had an annual power degradation rate of 0.2%, although this rate was faster in the latter 4 years. Thus, the earlier degradation must have been slower than 0.2% per year. Furthermore, accelerated aging tests indicated that the panels had at least 15 years more of acceptable performance beyond the 21 years. Finally, another study indicated that the degradation of actual in-field c-Si cells is 0.2–0.5% per year. It can thus be concluded that in general, a degradation rate of 0.2–0.5% per year is considered reasonable given technological advances (Renewable and Sustainable Energy Reviews Vol. 15 Issue 9).

Education and solar adoption:

The study establishes that more specific attitudes affect behavioral intentions to adopt SETs than general pro-technology attitudes. Results reveal that both pro-environment and application-specific attitudes matter for behavior intentions to adopt SETs amongst households. However, the general pro-technology attitudes are not significantly associated with behavioral intentions to adopt SETs (Do all forms of public attitudes matter for behavioral intentions to adopt solar energy technologies (SET) amongst households?). The results show that attitude towards solar energy solutions, subjective norms, perceived benefits, perceived trust, knowledge about solar energy solutions, and social norms, influence the intention to adopt solar energy solutions.

Perceived behavioral control, perceived risk and perceived cost did not influence the intention to adopt solar energy solutions (Perceptions and beliefs influencing intention to use solar energy solutions in Zambian households).

Because, if we talk about geothermal or wind, all these other sources of renewable energy are limited compared to solar power from the sun. The discontent we identified, particularly among those with little knowledge of the solar project details, represents incipient resistance (Energy Policy Vol. 191). The rejection of solar was not because of self-interested NIMBY-type emotions. Rather, we believe that many of these respondents, most of whom had little previous knowledge of the solar project or of the place it is to be constructed (Public views about the world's largest proposed solar farm in remote Australia).

Overall, the greater strength of emotional response to the project than was apparent for other respondents, and the high proportion of Indigenous respondents expressing fear or helplessness, make it clear that a high level of consultation with the traditional owners of the site will be essential to ensure that benefits are not just adequate but also that they are in a form that is consistent with the wishes of the community (Energy Policy Vol. 191). Public support and acceptance for large, remote projects cannot be assumed. While large solar projects are easy to portray as visionary with global benefits, and currently enjoy majority support, the fact that a third of respondents were not strongly in favor makes projects vulnerable to disinformation campaigns (Energy Policy Vol. 191).

So, knowledge plays a big part in if solar is to be adopted in certain regions, and how accepted the project is with the public. Maybe Pima County, Arizona is one of those counties that will adopt solar after education, and growth of knowledge on the subject. Because, it is important to find out if we can get more people educated about the science, and efficiency of solar, to maybe recruit more engineers to make the technology, and science, more efficient, and cheaper. The problem is, it is hard to say, from what we know, what people’s attitudes are about solar energy technologies, since there is no real policy or education programs, that teaches us how to use and manage the sun to solve our energy problems in Pima County, because in Pima County we get a lot of Sun and people could take advantage of it. So, it will be best to perform a longitudinal survey that

will cover the fall 2024 and spring 2025, the survey is for people in Pima County, Arizona, and it is educational to the people that take it, and provides us with some information. Then in the spring we will re-evaluate ourselves to see if we have any changes in our beliefs about solar where our focus will be on energy conservation. There will also be interviews a few door-to-door salesman, so we can find out what it is like to be in the industry of solar, where they really get people's attitudes about solar energy technologies. So, my research question will be, can better solar education change the way people purchase/manage or make decisions about solar policy in Pima County, Arizona?

Methodology:

Research Design:

The research design that was developed is a longitudinal survey using Qualtrics that tested people's knowledge about solar energy technologies. The survey begins this fall semester of 2024 and finishes up asking more questions about the fall in spring 2025 SBE 498 where it will check and see how you feel about solar energy. By re-evaluating ourselves in the spring about what we learned in the fall we can detect changes in how we purchase/manage or make decisions about solar energy technologies. This re-evaluation in the spring makes it longitudinal because it will cover both semesters.

Research Question/Hypothesis:

Can better solar education change how people purchase/manage or make decisions about solar energy technologies in Pima County, Arizona? Yes, better solar education in Pima County will change the way people purchase/manage or make decisions about solar energy technologies.

The target population was anybody interested in solar energy technologies and education in Pima County, Arizona. As I said before Pima County has a total population of 1,043,433(U.S. Census) with a total number of households to be 445,475(U.S. Census). I

sent out emails to people and I posted QR codes around the county. Then I could get people to take the survey this fall 2024 in SBE 480, we think the QR code will be most useful. Then next semester in SBE 498 we will survey again to detect changes in the way we purchase/manage or make decisions about solar, that's why it's a longitudinal survey, it takes the fall and the spring. The survey starts with - can better solar education change the way people purchase/manage or make decisions about solar energy technologies? We think the target population surveyed will be interested in the topics listed in the survey and we will see positive results about adopting solar. I developed two surveys of 10 questions each in Qualtrics that were yes/no. When a person does not know the answer they get directed to some educational information about the topic. The survey tests knowledge of the participant about solar energy technologies to understand their interest in the subject of solar energy technologies.

First, we wrote down all 10 of the questions that I was going to ask for each of the two surveys. Then in Qualtrics we created a survey of those 10 questions and if you said "no" linked the answers to the questions. But if you said yes, it linked you to the next question. It linked the questions if answered yes or no using the "skip logic" function to their destinations of the information if answered no or to the next question if they answered yes. All the questions are created with the "multiple choice" function with 2 answers "yes" or "no" and for the information following the questions we used the "graphic/text" function to insert the information. And, after each question or answer make sure you do a "page break" so you see only one question or answer at a time. It took a couple drafts or "previews" before we got the bugs worked out, but I think I have it running smoothly now.

Here is the link to the two survey's that was developed:

1st - https://uarizona.co1.qualtrics.com/jfe/form/SV_cLOltg8IYO0cXtk

2nd- https://uarizona.co1.qualtrics.com/jfe/form/SV_b47raLlZmQbz4lU

The Questions –

Fall 2024 Solar Energy Technologies Survey:

1.) Are you happy with how much solar costs people today? Yes/no
-If yes is answered go to question #2
-If no is answered: The rising costs of fossil fuels solar is an attractive option for energy users.
2.) Did you know that in places of constant irradiance solar is "inefficient"? Yes/No
-If answered yes go to question 3
-if answered no you get - Irradiance - "Shining Brightly"
" The voltage and output power of solar cells decrease as the temperature increases for constant solar irradiance" (Figure 5)

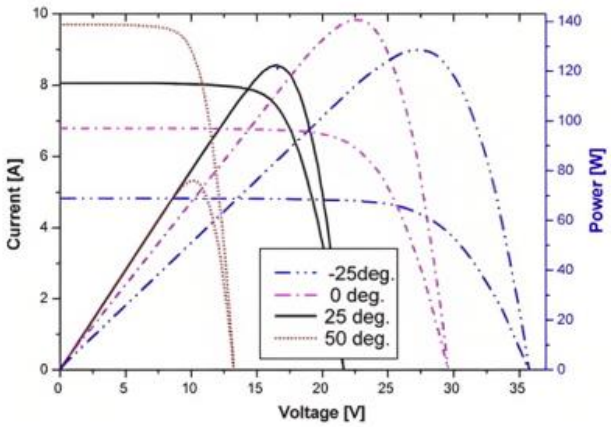

Figure 3: The Efficiency of Solar: Renewable and Sustainable Energy Reviews Vol. 207

3.) Did you know that the quality of silicon affects the "efficiency" of the solar panel? Yes/No – If answered Yes go to question 4

-if answered no - Crystal defects like dislocations and of course the grain boundaries determine the material quality and thus the solar cell conversion efficiency (Borchert, D., Rinio, M. Interaction between process technology and material quality during the processing of multicrystalline silicon solar cells).

4.) Did you know the PV panels solar cell is sensitive to temperature? Yes/No

-If answered Yes go to Question 6

- if answered no - Solar photovoltaic energy production is directly proportional to the amount of solar irradiance falling on the panel surface. Some portion of this irradiance is converted into electric energy and the rest of the solar energy heats up the solar panel. This energy must be removed from the solar panel which can be used for water heating or other useful purposes. The solar irradiance varies over time due to the change in sun movement and cloud cover. High solar irradiance causes overheating of the photovoltaic cells which in turn reduces the conversion efficiency and can lead to the thermal stress of solar panels. As a result, solar irradiance has a highly significant effect on long-term electricity generation.

5.) Did you know the solar cell makes more energy out of blue magenta than green light? Yes/No – If answered Yes go to question 6

-if answered no –

Table 3: Peak Voltage, Current, Power

Table 6. Comparison of peak voltage, current, and power for various conditions.

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5.	red color filter	18.2	2.01	35.94
6.	magenta color filter	18.6	2.45	45.31

According to peak power the magenta was just behind the filterless in peak power output green had the least peak power. There have been positive studies done to find which color light is best for a PV panel and its lifespan and performance output using colored filters over the PV panel. (Table 3)

6.) Shouldn't more sunshine equal more solar power? Yes/No

7.) Have you heard of solar thermal? Yes/No

-If yes is answered go to question 8

- if no is answered - Solar collectors and thermal energy storage components are used in the collection of the sun's heat and rays. Solar collectors need to have good optical performance, whilst the thermal storage subsystems require high thermal storage density, excellent heat transfer rate and good long-term durability.

8.) Can we use the sun to solve the world energy problems? Yes/no

-If yes is answered go to question 9

- if no is answered - Humanity has been using solar energy, radiant light and heat from the sun since ancient times and technologies. Technologies include solar heating, solar photovoltaic, solar thermal electricity and solar architecture, all these things have been contributing to solve the world's energy crisis

9.) We should be interested in educating people about making energy from the sun because it does not cost anything like fossil fuels or pollute? Yes/no

-If yes is answered go to question 10

- if no is answered - The results show that attitude towards solar energy solutions, subjective norms, perceived benefits, perceived trust, knowledge about solar energy solutions, load-shedding and social norms, in that order of magnitude, influence the intention to adopt solar energy solutions

10.) Do you think the government should give more money for solar research so we can produce better, cheaper, more efficient solar panels for places of constant irradiance so more people can have a cheap reliable form of energy that doesn't pollute? Yes/no

Spring 2025 Energy Conservation Survey:

1.) Should we care about energy conservation?
   - If “yes” is answered go to question 2.
   - If “no” is answered - Average energy conservation treatment effects are clustered around -2.7% and -2.3% savings for monthly and quarterly treatments and -6.4% savings for high energy users.
2.) Can I save money with energy conservation?
   - If “yes” is answered go to question 3.
   - If “no” is answered - We found positive attention to monetary motivations in all conditions, revealing positive attention to monetary and environmental motives.
3.) Would you drive an electric car?
   - If “yes” is answered go to question 4.
   - If “no” is answered - In general, people in segments that are less likely to use an electric car are more driving by emotions towards the electric car and more by reflective emotions towards car driving.
4.) Can you conserve energy with LED lights?
   - If “yes” is answered go to question 5.
   - If “no” is answered - LED lighting scheme has huge energy saving potential, with a payback period of at least 18 months.
5.) Can indoor fans conserve energy?
   - If “yes” is answered go to question 6.
   - If “no” is answered - Widespread indoor fan use has the potential to reduce energy demand and greenhouse gas emissions.
6.) Can a new programmable thermostat conserve energy?
   - If “yes” is answered go to question 7.

- If “no” is answered - Savings in daily energy consumption were maximum with a new programmable thermostat.

7.) Can motion sensor lighting conserve energy?
- If “yes” is answered go to question 8.
- If “no” is answered - Motion sensors can contribute to reduce the electricity bill.

8.) Can energy conservation improve the health of occupants?
- If “yes” is answered go to question 9.
- If “no” is answered - Energy efficiency interventions led to a small but significant improvement of the health of residents, social problems can also arise from energy inefficient housing.

9.) Do you think that people should do more to promote energy conservation awareness?
- If “yes” is answered go to question 10.
- If “no” is answered - A great deal of effort and money is going into basic and applied research in new energy technology. Nuclear, solar, and wind power cycles have tremendous potential.

10.) Do you think the government should do more to promote energy conservation awareness?
- If “yes” is answered go to end of survey.
- If “no” is answered - China will be carbon free by 2060.
- Data:

Table 4: Fall 2024 Survey

####	Q#1	Q#2	Q#3	Q#4	Q#5	Q#6	Q#7	Q#8	Q#9	Q#10
1	1	2	1	1	1	1	1	1	1	1
2	2	1	1	1	1	2	1	2	1	1
3	2	2	1	2	1	1	2	2	1	1
4	1	2	1	1	1	2	2	2	2	2
5	1	1	1	1	1	2	1	2	1	1
6	2	1	1	1	2	1	1	1	1	1
7	1	1	1	1	1	1	1	2	1	1
8	1	1	1	1	1	1	1	1	1	1
9	1	1	1	1	1	1	1	2	1	1
10	2	1	1	1	2	1	1	1	1	1
11	1	1	1	1	1	2	2	1	1	1
12	1	1	1	1	1	1	1	1	1	1
13	2	2	1	1	1	1	1	1	1	1
14	1	1	1	1	1	1	1	1	1	1
15	1	1	1	1	2	2	1	2	2	1
16	1	1	2	2	2	2	1	1	1	1
17	1	1	1	1	1	1	1	1	1	1
18	2	2	2	1	1	1	2	2	2	1
19	1	1	1	1	1	1	1	1	2	2
20	2	2	2	2	2	2	2	2	1	1

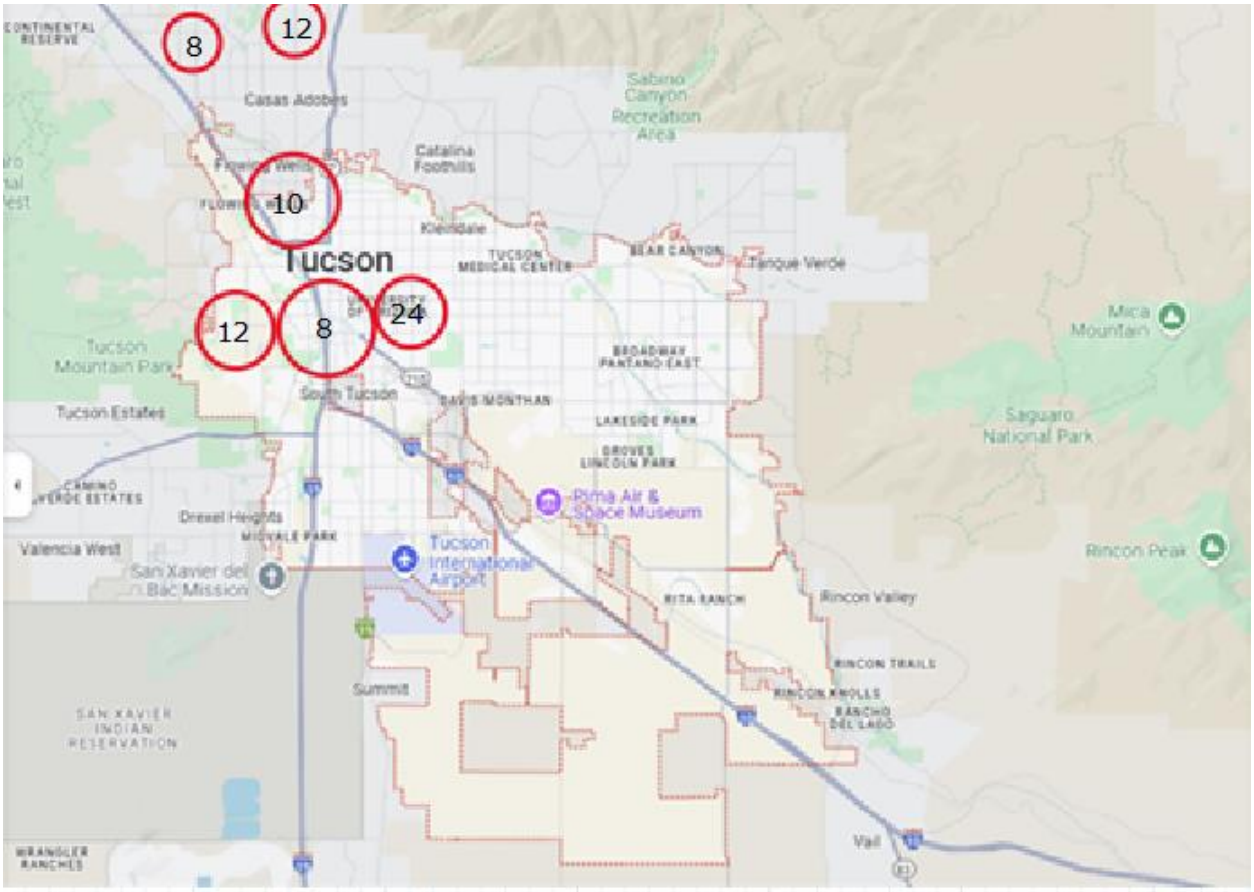
Table 5: Spring 2025 Survey

####	Q#1	Q#2	Q#3	Q#4	Q#5	Q#6	Q#7	Q#8	Q#9	Q#10
1	2	2	2	2	2	2	2	2	2	2
2	1	1	1	1	1	1	1	1	1	1
3	1	1	1	1	1	1	1	1	1	1
4	1	1	1	1	1	1	1	1	1	1
5	1	1	1	1	2	1	1	1	1	1
6	1	1	1	1	1	1	1	1	1	1
7	1	1	1	1	1	1	1	1	1	1
8	1	1	2	2	2	2	1	2	2	
9	2	1	1	2	2	1	1	2	1	1
10	2	2	1	2	1	2	2	1	2	1
11	2	2	2	2	2	2	2	2	1	1
12	2	2	2	2	2	2	2	2	2	2
13	1	1	1	1	2	1	1	1	1	1
14	2	2	2	2	2	2	2	2	1	1
15	2	1	2	1	2	1	2	1	2	1
16	1	1	1	1	2	1	1	1	1	1
17	1	2	2	2	1	2	2	2	1	1
18	1	1	1	1	1	1	1	1	1	1
19	2	2	2	2	2	2	2	2	1	2
20	2	2	2	2	2	2	2	2	2	2

1= Yes: 2= No

I collected data on the survey using the export data button on the data collection page. I used the numeric option to show yes=1 and no=2. I have only collected a little data and still have not interpretated the data yet.

Table 6: Map of Tucson, Arizona: Survey location circled in red with number of participants



Interview Design:

There will be interviews to help answer my research question. These interviews will be of a few door-to-door solar energy salesmen to find out the attitude towards energy conservation, and what the solar energy future looks like for this area of Pima County. These interviewees also agreed to take the survey's so can get some feedback from people that get the basic first impression/attitude about the solar industry in first person context. These interviews will answer the question of can better solar education change the way people purchase/manage or make decisions about solar energy technologies in Pima County, Arizona? They help us answer the question by giving us information about whether education will promote solar adoption in Pima County, Arizona.

Interview Summary:

One interview with a door-to-door solar salesman led two a couple more, where we find out if these people are really in it for the purpose of energy conservation. Some people just want to save some money and have money themselves. The first door-to-door solar salesman was the manager of the other two, he has a family of a wife and two kids, so he wants more leads. He said a lot of solar companies come from out of town and they sell their customers solar energy that can last for twenty years. After ten years, you will never hear from them again. He said these companies go out of business for some reason, leaving their customers in the dark, with no future, forcing them to go somewhere else, or back to grid power.

Power purchasing agreements is the way to go is what they said. Even though they make ten cents every watt they sell. He said with an agreement the customer pays for so much power for so many years in which he doesn't pay for the actual array and panels. Stuff that's all a part of the agreement, they just pay for the power so there is no installation cost with an agreement. The installation of some of these systems can be expensive, so that's a good arrangement that they only have to purchase the power, and the system is guaranteed to make so much power for so long. Leaving the technical work to the professionals, and people that really understand that stuff, and not up to some unqualified individuals that just wants to have an energy solution.

The manager of the two door-to-door solar salesmen said he always saves it for last, but he is trying to conserve energy cut emissions and save the planet. That's the last thing he brings up because he said most of the time the consumer is uneducated, and they just want a cheaper price than their current energy bill. They do not really care about energy conservation and cutting emissions or do not care about climate change. He said climate change is a hard topic to bring up because the world is changing, and what can the average person do about our impact on the planet? If the average person could understand that if

we all practiced just a little energy conservation, then we could be healthier and have a better planet.

The manager and both door-to-door salesmen agreed that the “people” or “government” should do more to promote energy conservation, so that people can learn to solve their energy problems the right way. They also believe that more should be done in this county to promote solar energy technology. They also agree that energy inefficient housing can have social problems, and some sort of policy/public hearing/intervention about energy efficiency would be a good thing. This would be good because we could plan for the future and educate people on how to handle where we are going. They also last thought the education was good, because it gives people helpful information, so they are left in the dark with no knowledge.

Data Triangulation:

There were a total of responses again like my fall survey which had 68 total responses, and the interviews went well. It seems like some sort of energy management program could be possible. They could use some sort of energy management program, because both the survey’s said that almost half (47%) were educated people, and if we could educate people, and provide energy management programs, so more people can help solve their energy problems. In Pima County, Arizona even all three solar salesmen think some sort of energy management program could be useful to, to help people better manage their energy problems, even some sort of education being implemented on how to provide energy solutions.

The survey also said that 90% of people said the people or the government should do more for energy conservation and solar power in Pima County, Arizona. The 63% surveyed, and the people interviewed said, that people really should care about energy conservation, and what we are doing to the environment, and our own lives, because a lot goes into nuclear, wind, and solar power, and if we can get more people into these fields

then we could make things better. By having things like education and energy management programs available to people, almost half surveyed (47%) said we can help people also live a healthier life with energy conservation, because there are also many social problems that can arise from energy inefficient housing. There can be many ways to make better decisions, because 71% of people surveyed believe in the products they were surveyed about.

Pima County, Arizona wants more solar education/energy management programs. We get a lot of sun in Pima County, Arizona and there should be some way to manage it to help solve your energy problems. Both the government should both try to help the people manage their energy needs, because in places of constant irradiance, where the sun's intensity remains high year around, people can manage the sun effectively through a mix of architectural design, lifestyle practices, and technological solutions. The idea of educating Pima County, Arizona is one of the most powerful tools for helping people in high irradiance regions manage the sun wisely. It empowers communities with knowledge about health, technology, and sustainable living practices. Things like indigenous practices often contain wisdom for sun management, from desert architecture to clothing choices, integrating this with modern science can be highly effective. Schools, media, and community workshops can help reinforce knowledge about sun protection and heat adaptation.

Table 7: Results: Survey #1

Questions:	Yes	No	Percent (+ = yes; - = no)
Q1: Are you happy With the price people Are paying for solar?	20	40	-66% say “no” they are not happy with the price people pay for solar
Q2:Did you know that in places of constant irradiance with high temperatures solar is “inefficient”?	28	32	-52% say “no” they did not know solar is inefficient in high temps.
Q3:Did you know that the quality of silicon affects the “efficiency” of the solar panel?	42	18	+70% say “yes” they know that silicon affects the efficiency
Q4:Did you know the PV panels solar cell is sensitive to temperature?	19	41	-68% say “no” they did not know the solar panels are sensitive
Q5:Did you know the solar cell makes more energy out of magenta light than green light?	28	32	-52% say “no” they did not know the solar cell makes less light out of green light

Q6:Shouldn't more sunshine equal more solar power?	43	17	+72% say "yes" more sun should equal more solar power
Q7:Have you heard of solar thermal?	42	18	+70% say "yes" they have heard of solar thermal
Q8:We can use the sun to solve the worlds energy problems?	38	22	+63% say "yes" we can use the sun to solve our energy problems
Q9:We should be interested in educating people about making energy from the sun because it does not cost anything or pollute?	57	3	+93% say "yes" "we" should do more to make solar available for everyone
Q10:Do you think the government should give more money for solar Research so we can produce better, cheaper, more efficient solar panels?	57	3	+93% say "yes" the government should do more so everybody can have solar
Total	**382**	**218**	**+64% - say "yes" to solar policy.**

Data Charts Survey 1:

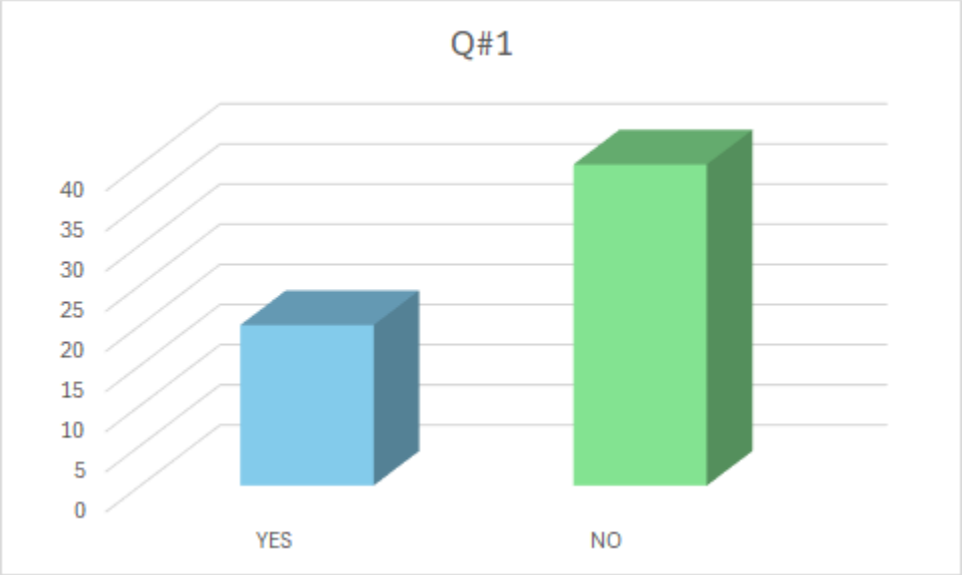


Figure 4: Question 1

Over half the participants said they were not happy with the cost of solar.

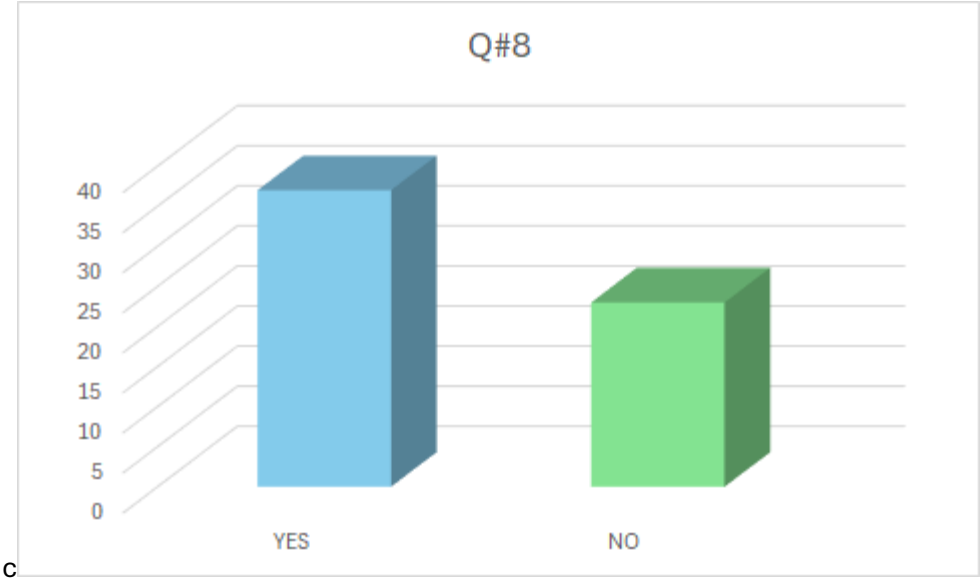


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Figure 5: Question 8

Over half the participants surveyed believed we can use the sun to solve our energy problems.

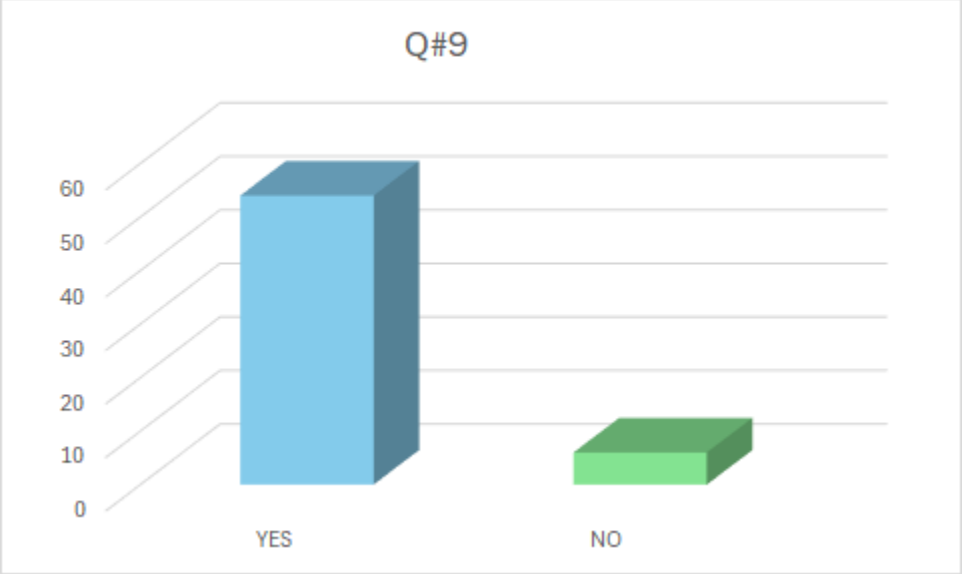


Figure 6: Question 9

97% of people surveyed believe that the people should promote solar energy more.

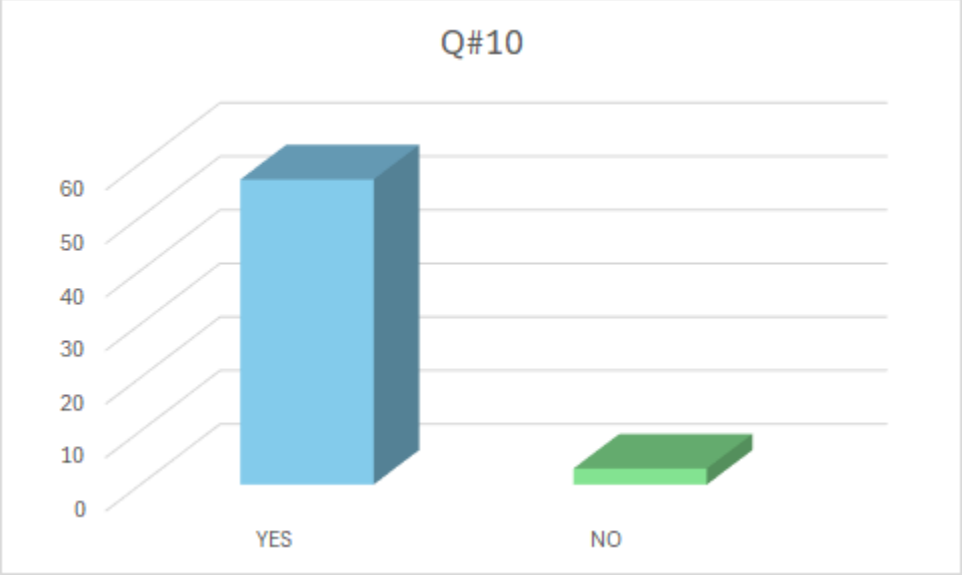


Figure 7: Question 10

94% of people surveyed believe that the government should do more for solar energy.

Results: Survey #2 –

Table 8: Results: Survey #2:

Questions:	Yes	No	Percent (+ = yes; - = no)
Q1: Should we care about energy conservation?	47	27	+63% say "yes" we should care about energy conservation.
Q2: Can I save money with energy conservation?	30	44	+41% say "yes" we can save money with energy conservation..
Q3: Would you drive an electric car?	41	33	+56% say "yes" they would drive an electric car
Q4: You can conserve energy with LED lights?	29	45	-61% say "no" they did not know they could save energy with LED lights.
Q5: Can indoor fans conserve energy?	38	36	+52% say "yes" they did know indoor fans can conserve energy

Q6: Can a new programmable thermostat save energy?	20	50	-68% say “no” They did not know a new programmable thermostat saves energy.
Q7: Can motion sensor lighting conserve energy?	24	50	-68% say “no” they did not know motion sensor lighting can save energy.
Q8: Can we live healthier lives with energy conservation?	35	39	-53% say “no” practicing energy conservation does not make you healthier.
Q9: We should be interested in promoting energy conservation?	67	7	+90% say “yes” “we” should do more to promote energy conservation
Q10: Do you think the government should we promote energy conservation more?	67	7	+90% say “yes” the government should do more to promote energy conservation.

Total	**398**	**338**	**+54% - say "yes" to energy conservation.**

Data Charts Survey 2:

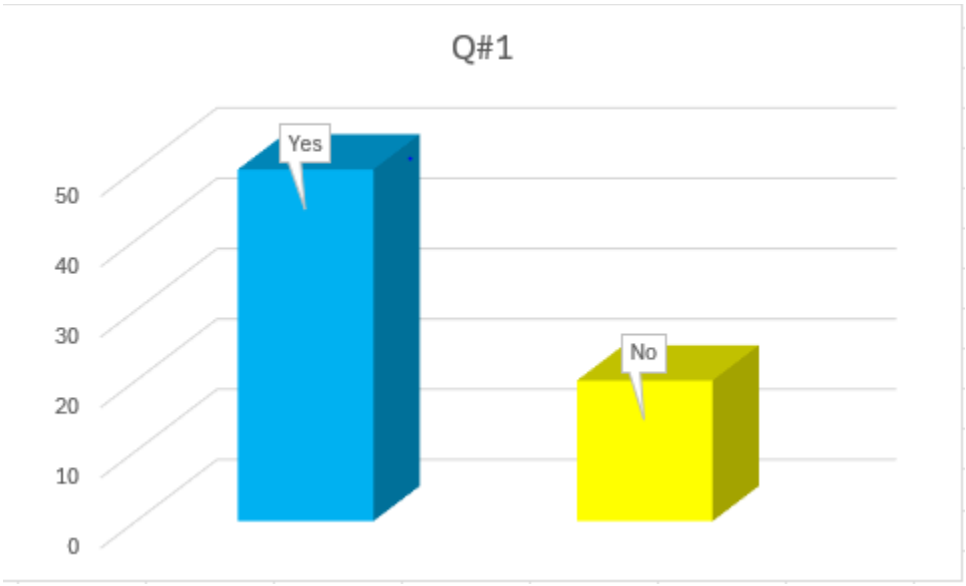


Figure 8: Question 1:

63% of people surveyed believe “we should care about energy conservation”.

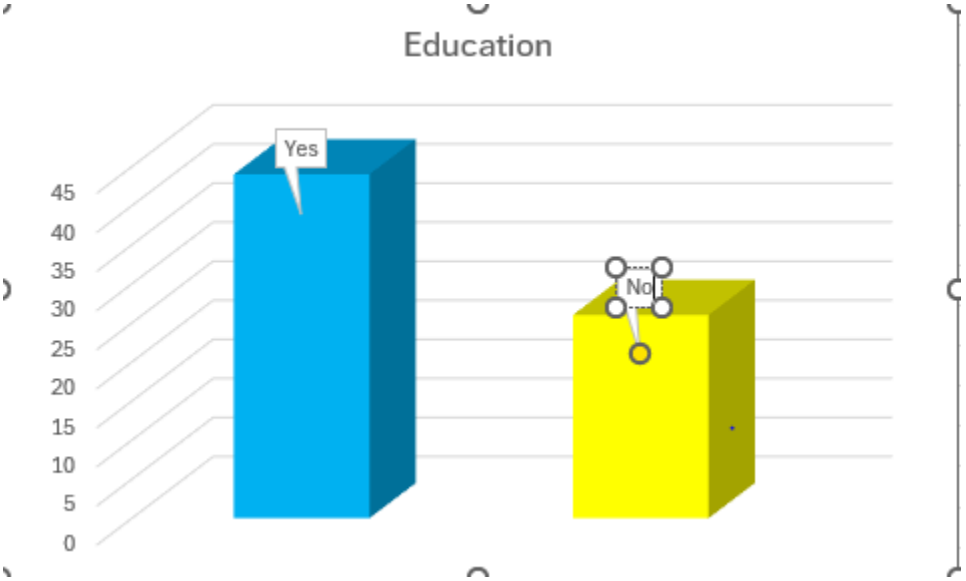


Figure 9: Question Education:

47% of people surveyed are educated and believe education could help give people energy solutions and help solve their problems.

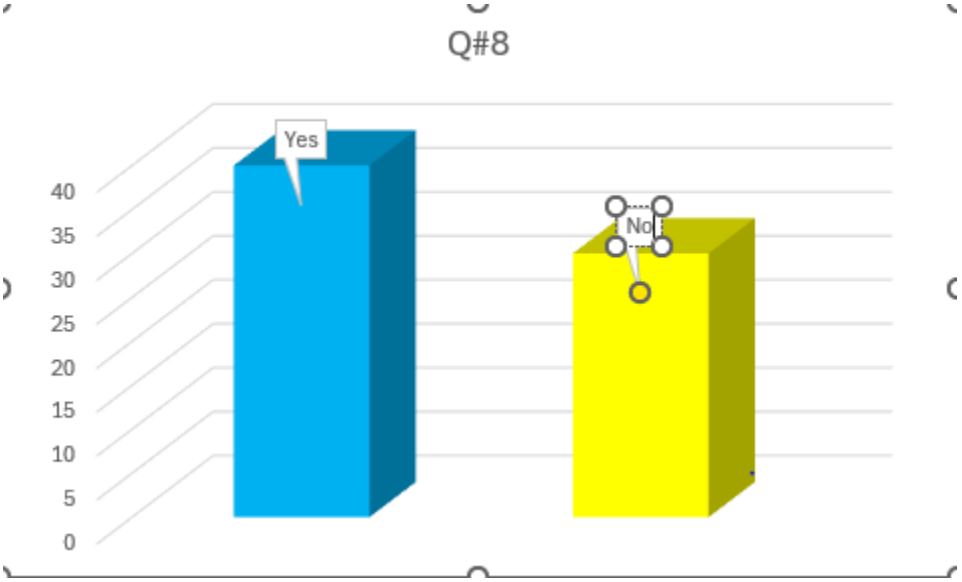


Figure 10: Question 8:

47% of people surveyed believe they can live a healthier life with energy conservation.

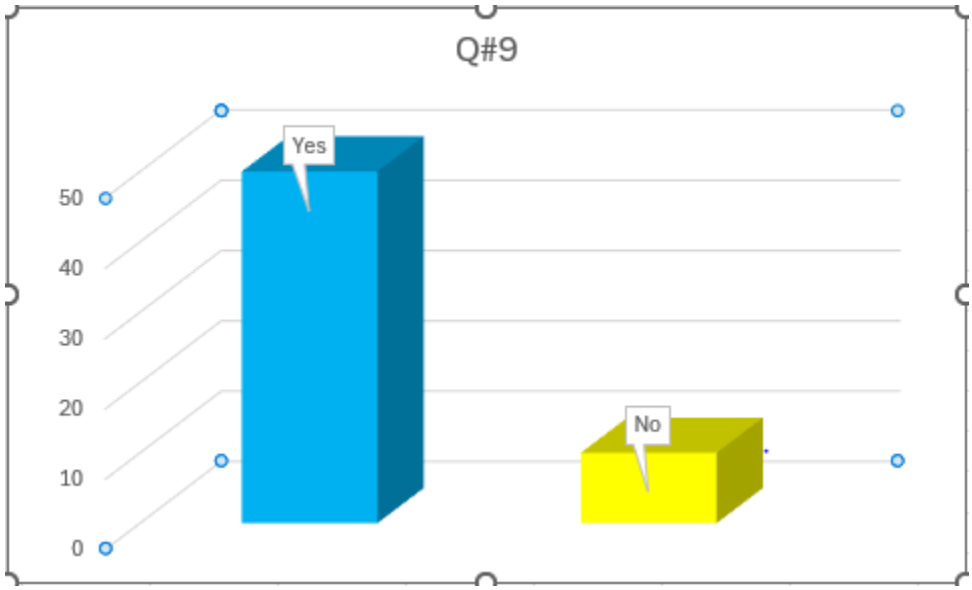


Figure 11: Question 9:

90% of people surveyed believe that people should do more to promote energy conservation.

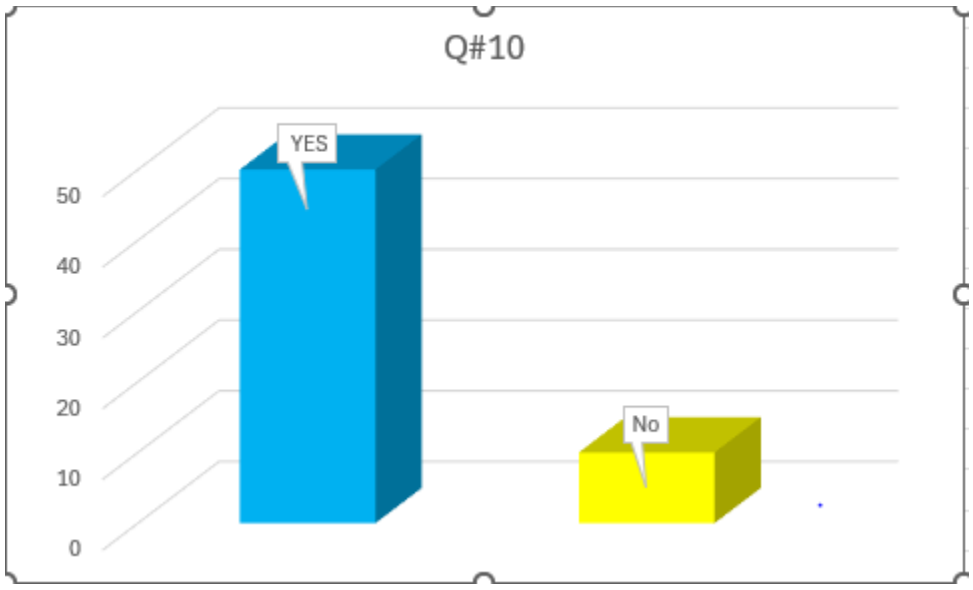


Figure 12: Question 10:

90% of people surveyed believe that the government should to more to promote energy conservation.

Data Analysis:

We find that education will positively impact solar adoption, aligning with existing trends in sustainable energy awareness. As Pima County, Arizona being an ideal location for solar energy adoption, because it gets 80% sunshine during the year or almost 300 days of sunshine. Existing solar installations are low while TEP has 447,000 customers that it serves. There is also presence of major educational institutions like the U of A and Pima College. The two 10-question longitudinal surveys from Fall 2024 to Spring 2025 in Qualtrics, with the QR code passed around town. This research incorporates triangulation.

We found public awareness and knowledge gaps. It was found that 56% of respondents believe better solar education can improve purchasing decisions, while 52%

did not know solar is inefficient in high-temperature regions, and 68% were unaware that solar panels were temperature sensitive. So, the knowledge gaps exist with the last two percents and with people wanting education in the first percent, I think we should give Pima County solar education.

Economics and policy show 66% of people were not happy with the current cost of solar, 43% believe incentives and rebates, 90% believe the government should do more for solar education and investment promotion. So, with some solar education, some solar policy(incentive/rebate) could be put into place to make the cost of solar energy cheaper.

The community believes 93% want to expand solar education. The attitudes say 72% believe more sun should equal more solar power so there is a knowledge gap in efficiency, and 63% believe solar can help solve global energy issues. So, if we lack knowledge but we believe solar is a solution and want education, how do we educate our county on how to manage the sun to solve our energy problems? To make Pima County a better place.

Interviews: The study shows from the interviews many customers prioritize cost savings over environmental concerns. Solar companies that operate with questionable business practices leave customers with long-term issues after the contract ends. PPA's are seen as a option for those who can't afford the upfront cost of solar. The solar salesmen believe the public or government should do more to promote energy education and policy initiative.

The survey results confirm the salespeoples observations, many respondents do not understand solar efficiency, incentives, or purchasing options. Interviews show public education matters because consumers often make uninformed decisions or fall into misleading solar contracts. If people knew more about solar incentives, energy efficiency, and trusted providers, making education and regulation essential, solar adoption in Pima County could increase significantly.

Further Analysis: My study further concludes and is strong proof that better solar education programs could increase solar adoption rates. Supporting findings that increase government incentives and expand energy management programs in high irradiance regions. Public education programs could clear up misconceptions about inefficiency in hot climates. If more people understand solar incentives, adoption rates could increase, creating job opportunities in Arizona's clean energy sector. Addressing issues with solar company reliability could help prevent consumer distrust. Energy education and conservation efforts are linked to better public health, reduced emissions, and mor resilient communities. Public support for government involvement in solar education (90%) suggest policy shifts could be well received.

Discussion –

The analysis to the data collected brought light to whether solar education change how people make decisions about implementation of solar energy technologies in Pima County.

The study further shows that better solar education programs could increase solar adoption rates in Pima County, Arizona. Supporting findings that increasing government incentives and expanding energy management programs in high irradiance regions is supported by 90% of people surveyed. Public education programs could clear up

misconceptions about inefficiency in hot climates and provide better solutions. If more people understand solar incentives, adoption rates could increase, creating job opportunities in Arizona's clean energy sector providing for people and future families. Addressing issues with solar company reliability could help prevent consumer distrust and further harm to the solar industry and its employees. Energy education and conservation efforts are linked to better public health, reduced emissions, and more resilient communities. Public support for government involvement in solar education (90%) suggest policy shifts could be well received.

The survey results confirm the salespeoples observations, many respondents do not understand solar efficiency, incentives, or purchasing options. Interviews show public education matters because consumers often make uninformed decisions or fall into misleading solar contracts. If people knew more about solar incentives, energy efficiency, and trusted providers, making education and regulation essential, solar adoption in Pima County could increase significantly boosting economy and make consumers happy that they can know they made the right decision. Making wiser energy management decisions can result in the reduction of energy bills, saving the owner some money, because most of the time the consumer just wants to see a reduction in their energy bill. And, since 90% of people surveyed wanted more involvement from the government then maybe some sort of energy management intervention that helps people reduce their energy bill while helping improve their overall health.

Places like Germany, Australia, India, and U.S.A. have things like the state funded California Solar Initiative (CSI) that educates people and informs the residents and businesses on how to incorporate solar into their life. It could be the Arizona Solar Initiative (ASI), Pima County sector, because Arizona so far does not have a program like that, and we get a lot of sun in this state. It said that the CSI boosted solar adoption across the state from expected 3,000 MW by 2016 to a total of 4,500 MW by 2016 which exceeded the target and planned for another 12,000 MW of distributed power by 2020 in the future. So, if Arizona could get serious or at least our sample of Pima County, Arizona wanted to be an example for the rest of the state and start a Pima County Solar Initiative (PCSI) then it could possibly manage the sun in this region with the support of pro-solar policy. Because the CSI offered $2.50 per AC watt, covering up to 50% of system costs when combined with federal tax incentive. And, in 2015 California had installed 3,391 MW of rooftop solar, leading the nation in distributed solar photovoltaic systems. Pima County, Arizona could be a leader in this state.

CONCLUSION

The research highlights the critical role of solar education in increasing adoption rates, with 56% of participants acknowledging its importance in improving solar management. However, significant knowledge gaps persist, particularly regarding solar panel efficiency and performance in various environments. Addressing these misconceptions can lead to more informed decisions and higher adoption rates.

Economic barriers and policy support are also crucial factors. A significant 66% of respondents are dissatisfied with the cost of solar energy, and 43% believe that deductions and rebates could make it more affordable. Furthermore, 90% of those surveyed think the government should enhance its efforts to promote solar education and investment in energy management.

Interest in solar energy is substantial, with 93% of participants supporting solar education programs. Many believe that solar energy can play a pivotal role in addressing global energy needs. Interviews reveal real-world challenges, such as the need for savings on current energy bills and the lack of environmental concerns driving most consumer decisions. Power Purchase Agreements (PPAs) offer a viable alternative to the upfront costs of solar, but the presence of untrustworthy solar companies underscores the need for better education and regulation.

Solar education not only drives policy but also fosters community development. Energy education and conservation programs have the potential to improve public health, reduce emissions, and create job opportunities in Arizona's clean energy sector. With strong support (90%) for government involvement, policies aimed at enhancing solar education and energy management programs are highly desired. This comprehensive approach can lead to a more sustainable and informed adoption of solar energy, benefiting both individuals and the broader community.

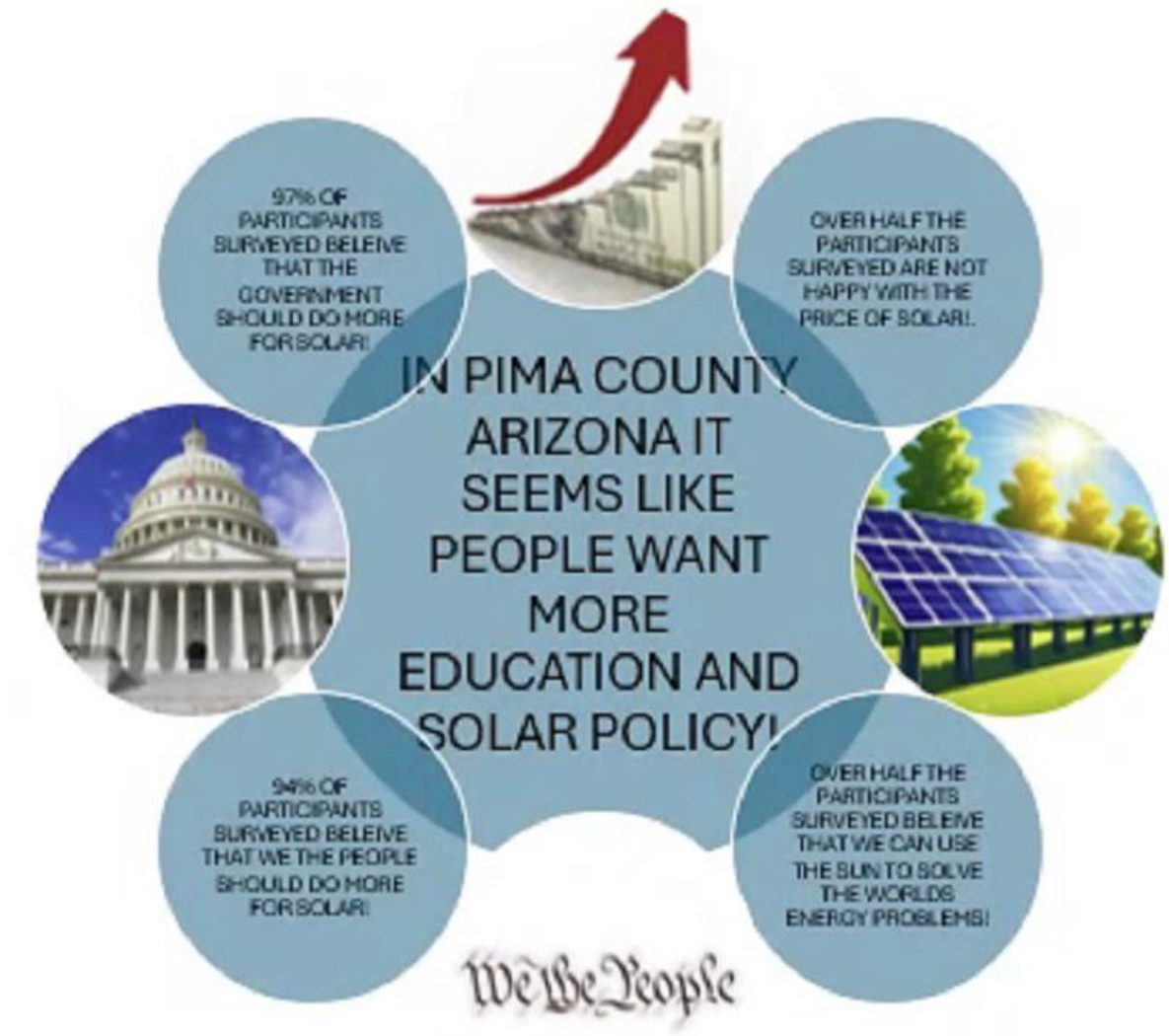
Like California, who has their CSI, Arizona has not implemented a overall comprehensive, state-funded incentive program to promote solar energy adoption. The lack of such initiatives may be due to differing political priorities, budgetary constraints, or the influence of utility companies concerned about increased solar adoption. While Arizona possesses abundant solar resources, policy decisions, regulatory changes, and the absence of state-level incentive programs have limited the state's solar adoption rate, compared to initiatives like California's CSI program.

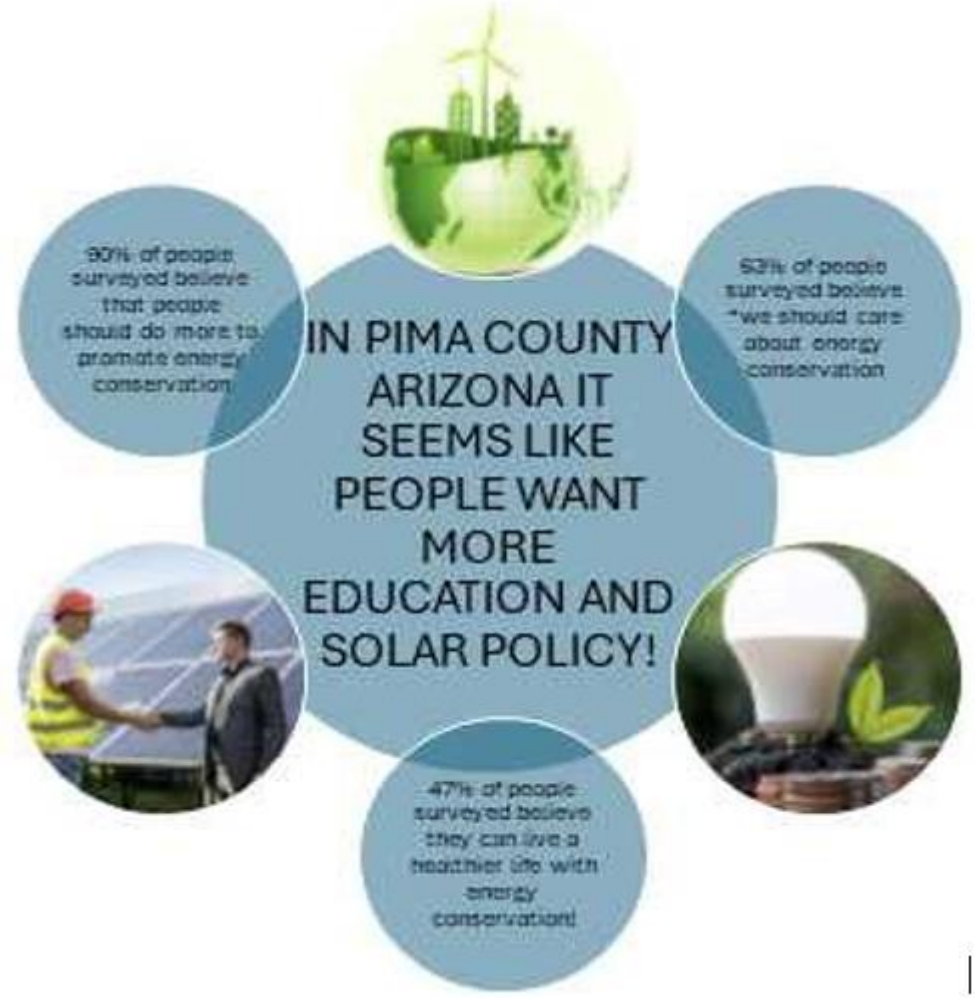
Besides the CSI, San Diego has implemented Property Assessed Clean Energy (PACE), and San Diego Community Power (SDCP). All of these things help San Diego achieve 100% renewable energy by 2035, so why doesn't Arizona and Pima County, possibly Tucson want to be 100% renewable energy? Besides the University of California, San Diego adding a graduation requirement of a course in Climate Change. All of this could be a start for Arizona having a comprehensive approach to addressing climate change through policy, infrastructure, and education like San Diego. Even in Los Angeles they are going to have all buildings decarbonized including new buildings that are all to be net-zero whether new or old construction besides their solar generation incentives.

Recommendations: Addressing these misconceptions can lead to more informed decisions and higher adoption rates.

Limitations or lessons leaned: After presenting the survey results, it was found that there could be bias towards the participants of the survey, because of the title "Solar

Survey 1 & 2", the title could have attracted a certain crowd that leans towards energy efficiency.




90% of people surveyed believe that people should do more to promote energy conservation
IN PIMA COUNTY ARIZONA IT SEEMS LIKE PEOPLE WANT MORE EDUCATION AND SOLAR POLICY!
53% of people surveyed believe "we should care about energy conservation
47% of people surveyed believe they can live a healthier life with energy conservation!

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