Photovoltaic technology in the southern Arava: An Analysis of Public Acceptance

An Interactive Qualifying Project
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by:

Thomas DiPersio
Nicoli Liedtke
Aaron Rosenthal
Alexandra Wallace

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Report Submitted To:

Dr. Tareq Abuhammed
Arava Institute for Environmental Studies
Professor Isa Bar-On
Worcester Polytechnic Institute

This report represents the work of four WPI undergraduate students submitted to the faculty as evidence of completion of a degree requirement. WPI routinely publishes these reports on its website without editorial or peer review. For more information about the projects program at WPI, please see: http://www.wpi.edu/Academics/Projects.
Abstract

Though Israel’s southern Arava region has experienced a boom in solar infrastructure in the past decade, the public position on local solar installations has thus far been unknown. Public acceptance of renewable energy installations is key to their successful implementation. We sought to understand the level of acceptance of solar fields among southern Arava communities and identify the factors that contributed to the widespread implementation of solar infrastructure in the region. We distributed surveys to five local kibbutz communities to gauge their attitudes about renewable energy technology in general and their acceptance of solar installations in their community. We also conducted semi-standardized interviews with local solar planners and developers, and local government to gain qualitative background information about the solar implementation in this region. Both the survey data and interviews point to strong acceptance of solar technology in this region, both in principle and specific to their local installations. We identified several factors that contribute to this high level of support including kibbutz co-ownership of solar assets, open and transparent communication between planners and kibbutz members, and the kibbutz decision-making structure that provides members a channel for feedback.

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1. Introduction

Israel’s renewable energy initiatives have caused significant development in renewables, especially in the southern Arava. The southern Arava’s renewable energy growth has been exclusively solar and began in 2011. Since then, the southern Arava has since had a large influx of solar technology in most communities. As renewable energy development continues, it is imperative to analyze the public's response to new technologies implemented. To date, several research studies have examined the factors of successful public acceptance of renewable energy technology. However, the level of public acceptance of renewable energy in the southern Arava has yet to be researched. Furthermore, the factors contributing to any degree of success of the technology should also be evaluated.

The goal of this study is to analyze the public’s acceptance of solar technology including the decision-making process and implementation of the various technologies. Further analyzing the factors that affect public acceptance will allow stakeholders to adjust plans to better suit the needs of the public. By considering the public's opinion, stakeholders have a better chance of the technologies succeeding in the communities being analyzed. With more development currently in the planning stage, data supporting the claim that the public is in favor will be valuable.

Through our research, we examined the public acceptance of solar technology in the southern Arava. In addition to gaining an understanding of the degree to which kibbutzim members are in favor of solar technology, we worked to understand the factors that correlate to the degree of public acceptance.

To understand contributing factors of public acceptance in the region, we conducted interviews of kibbutz representatives to understand how their decisions are made. In addition, we distributed a survey questionnaire to kibbutz members to understand their values as they pertain to solar energy, involvement in the solar development process, their satisfaction with solar installations in their communities, and any concerns or preferences they have with regards to current or future solar infrastructure.

2. Background

2.1 Introduction to the Southern Arava

The Arava region is a long, narrow valley located along Israel’s southeastern border. It begins south of the Dead Sea and extends to the Gulf of Eilat (Israel’s Ministry of Tourism, n.d.).
In Figure 1, the Arava is divided into two different regions: the northern and southern Arava. The southern Arava is comprised of small communities and the city of Eilat which are separated by vast stretches of desert. This study will be focusing on the southern Arava and its implementation of solar energy.

2.1.1 Solar Radiation

In 1956, Israel’s Prime Minister Ben-Gurion predicted Israel’s success being hinged upon the productive use of the sun; he wrote, “The mightiest source of energy in our world is the sun, which favors us day by day, with astronomical quantities of energy, which runs to waste.” He called on scientists and engineers to find ways for “absorbing even a very small part of this tremendous energy and putting it to work for the growing and manifold needs of our variegated economy” (Schwartz, 2010). In order to derive the potential for solar electricity generation in a particular region, researchers use energy resource maps generated from satellite data. Below is a resource map created from on-site measurements of solar radiation. Solar radiation is a general term for the electromagnetic radiation emitted by the sun. Solar radiation can be captured and turned into energy.
Figure 2: Solar Radiation in the Arava

Figure 2 shows the solar radiation in southern Israel. The greatest amounts of solar radiation in Israel tend to be the southern Arava region. The southern Arava region receives about 2200-2400 kWh/m²/yr.

2.1.2 Open Land

Meeting society’s needs for electricity using solar requires a large amount of land. In order to reach the southern Arava regions’ goal of being 100% energy independent and free of fossil fuel and carbon emissions, the regional council created a strategic plan (Eilat Eilot, n.d.). This plan allocates 5,000 dunams (5 square kilometers) for construction of 400 MW of solar capacity. Though most of the desert land is declared to be a nature reserve, the government has also designated land for agriculture or solar technology. The southern Arava has open land suitable for solar fields due to a sparse population. The Eilot region includes 13% of Israel’s land mass, but has a population of less than 4000. (Jerusalem Post, 2008).

While the southern Arava has vast amounts of uninhabitable land, 75% of this land is allocated as nature reserves (Jerusalem Post, 2008). The figure below shows the land determined as nature reserves in southern Israel.
The area with a yellow orange border is land that has been determined to be used for agriculture or solar technology. The dark green area is land that has already been declared a nature reserve while the lighter green is land that is in the process of becoming part of the nature reserve. Despite the large amount of land designated as nature reserves, there is still land that is uninhabitable and could be used for solar technology.

2.1.3 Current Capacity

Solar power systems range in scale from small, distributed-generation residential setups to utility-scale power plants. Solar infrastructure dominates installed renewable energy capacity in Israel, with 96 percent being made up of photovoltaics (Israel Ministry of Environment Protection, 2013). In addition, photovoltaic panels are playing an increasingly important role in industrial processes such as wastewater treatment and desalination, which require high volumes of electric power to operate (Kannan & Vakeesan, 2016).

There are currently 15 solar plants of varying size in the southern Arava that supply 70% of the electricity consumption in the region (Eilat Eilot Renewable Energy Initiative, n.d.). The majority of these solar plants are medium to large sized fields near the different communities in the area. These solar plants were implemented as part of the regional council’s strategic plan for the development of renewable energy creating a production of up to 400 MW using 5,000 dunams of land by 2040. Their goal is to make the region 100% energy independent.
(Eilat Eilot Renewable Energy Initiative, n.d.). Presently, 122 MW of the 400 MW have been put into place.

2.2 The Kibbutz Community

Kibbutzim are small communal settlements that are unique to Israel. The very first kibbutzim were founded on the principles that manual labor and working the land made an ideal lifestyle. The original kibbutzim were based on socialist ideology (Russell, et al., 2013). Kibbutz residents did not individually own any assets; everything was shared as a community. Many kibbutzim have since privatized and moved away from socialism. These kibbutzim now have members earning differing salaries and with much more ownership (Russell et al., 2013). The southern Arava has kibbutzim of both types.

Decisions were traditionally made collectively on kibbutzim. As kibbutzim gained more members they designated a business manager and secretary to manage economic and community plans respectively (Russell et. al., 2013). These business managers and secretaries are elected democratically and only handle kibbutzim planning. Decisions still lie in the hands of the kibbutz members to approve plans and decisions. On each kibbutz there are other committees as well that may handle specific aspects of the kibbutz community. Less impactful decisions may not be voted on by all the members, but if any decision is not fully accepted the community can reject any decision made by business managers, secretaries, or committees.

Despite many kibbutzim no longer being traditional, kibbutzim are still best described as a collective society rather than an individualistic society. The traditional kibbutzim will consistently have a more collective society, but the same high level of cooperation among members occurs in both types of kibbutz. While farming is no longer the only source of income, many kibbutzim still rely on agriculture for much of their economic income. Even in the southern Arava where the climate and land conditions are harsh, agriculture persists. The southern Arava kibbutzim have many other income sources as well. A few kibbutzim have dairy cows, including the popular Yotvata dairy farm. Date farms are also prominent in the southern Arava. Most recently, all the solar fields that have been built have diversified kibbutzim economies. Both privatized and traditional kibbutzim in the southern Arava participate in many of these same economic activities.

2.3 Policy Overview

The Israeli government has been a key player in progressing development of renewable energy technologies. Annually, the Office of the Chief Scientist works with a budget of roughly $300 million USD to invest in research and development projects throughout the country. Eilat Eilot is a research initiative in the southern Arava that uses a portion of this money to research renewable energy technologies. (Ministry of Economy and Industry).

To support private efforts to research and develop renewable energies, the Israeli government has been creating new renewables policies since 1980. At that time, the Israeli
Knesset, or parliament, passed a bill requiring residential buildings up to 27 meters high to install solar water heaters (Israel Ministry of Environmental Protection, 2017). The policy was widely successful, as roughly 90% of residencies in modern-day Israel are equipped with solar water heaters (Israel Ministry of Environmental Protection, 2017).

Since 1980, the focus of policy-makers has shifted towards energy production. In 2004, the Public Utilities Authority created feed-in-tariffs (FITs) to incentivize private renewable energy efforts. These tariffs allowed renewable energy system owners to sell surplus electricity generated back to the national grid. As of 2014, these tariffs were determined by the system size, more specifically the total energy output. Fields ranging in size from 50 kW to 12 MW, considered to be medium-sized utility fields, were earning back 0.51 ILS/kWh. Over time, FIT rates have decreased, making solar fields less profitable for owners. Today, utilities offer proposals to national grid representatives and the lowest rate wins the bid and is able to sell back to the national grid (State of Israel Electricity Authority, 2016).

Production of cheap photovoltaics in China have contributed to a recent decline in the cost of solar installations (Jordan, 2013), which may help to offset the sharp decrease in FIT rates quoted by the Public Utilities Authority. Jordan (2013) states that low interest rates, favorable tax policies, renewable energy credits, and financing models are driving solar power towards price parity with fossil fuels in the consumer market. With Israel’s sole subsidy for solar energy quickly disappearing, it seems that solar installations will continue to represent a significant financial risk.

2.4 Public Acceptance

2.4.1 Local Context

When examining public acceptance for renewable technologies, there is a distinction between the public’s attitude towards renewable energy in principle, and their attitude towards the implementation of a facility in their area. The concerns of the public are largely determined by the local environmental conditions (Wolsink, 2007). Some explain this difference using the “not in my backyard”, or NIMBY, phenomenon. However, this explanation has been criticized for overlooking the complex dynamics of community acceptance and assuming that the public would support any facility if it is not built in their immediate vicinity (Wolsink, 2007; Wustenhagen et al., 2007; Devine-Wright, 2010). Facility siting decisions require approval from many stakeholders beyond the investors, and often become local political decisions (Wustenhagen et al., 2007) involving the public, environmental organizations, local businesses, and governmental institutions.

Recent research has been done to understand the components that influence a community’s acceptance of renewable energy systems in their area. In a review of this body of literature, the following factors were identified by multiple authors as influential on public acceptance of renewable facilities: The facility’s proximity to the community and its visibility,
transparency and good communication between the public and facility planners, public trust in the actors involved, and community co-ownership of the facility itself or its production.

The distance between a proposed renewable energy facility and populated areas and in turn the visibility of the facility to the population are major determinants of its acceptance by the public (van der Horst, 2007; Jobert et al., 2007). The NIMBY theory implies that there is a proportional relationship between proximity and public support; as the distance between a renewable energy facility and a community decreases, public support increases. Guo et al. (2015) found that in China, acceptance of wind farms is at its lowest when a proposed farm would be in the respondent’s village and is at its highest when the farm would be located in their county or a nearby city. Other studies have found the inverse to be true. Warren et al. (2005) found that respondents with wind farms “in their backyard” were amongst the most supportive of the technology. It should be noted that this relationship applies to respondents who already had a wind farm in their community, not those who were expressing their opinion about a proposed facility. Support for already installed facilities is often higher than support for proposed facilities (Warren et al, 2005; Krohn & Dambourg, 1999). Additionally, visual and landscape effects have been found to have a strong effect on public opinions of renewable energy facilities (Jobert et al., 2007; Warren et al., 2005; Wolsink, 2007).

Open and transparent communication between the planners of renewable energy facilities, potential stakeholders, and the public play a role in the success of the projects. These decisions must embrace a diverse range of knowledge and values (Reed, 2008), and reflect the positions of all parties interested in the outcome of the decision. Jobert et al. (2007) found that project developers that integrated themselves into the community, making contacts with local authorities, interest groups, organizations, and the public, were successful in building well-supported renewable energy facilities. These projects were precipitated by information meetings involving the public and local stakeholder organizations in which concerns were voiced and addressed by the developer (Jobert et al., 2007). In another case, a wind energy developer worked with the municipal council on siting but failed to inform the public until the project was approved by the council. The result was a series of protests and legal actions carried out by opposition to the project (Jobert et al., 2007). Reed (2008) states that early engagement between project planners and stakeholders is essential if participatory processes are to produce high quality and durable decisions.

The perceived fairness of renewable energy decisions is also a factor. Wustenhagen et al. (2007) discuss the issues of equity in a theoretical scenario in which a local government, project developer, and power company seek to place photovoltaic panels on the rooftops of a new housing district. First, ownership of the panels influences how equitable the deal is for all parties. Additionally, homeowners that are not given the choice of whether their house will have panels or not may feel “forced” to accept them, while others may feel “excluded” if their home does not have solar panels. Jobert et al. (2007), in a case study of a wind installation in Germany, found that the community felt excluded because an outside developer approached private landowners to
obtain a site for their turbines. Conversely, wind farms on publicly-owned land did not suffer the same support issues (Jobert et al., 2007).

Trust in the parties involved is a key consideration in all renewable energy facility siting issues (Wustenhagen et al., 2007). Trust between project planners and the local population is a condition that helps projects to work and for communities to feel positively about getting involved and about the project development process (Walker et al, 2010). Trust in project planners can also reduce public need for detailed information about the technology in question. Huijts et al. (2007) found, in a survey regarding carbon capture and storage systems, that respondents seemed to rely on feelings related to the technology and their trust in the parties involved, rather than technical information about the specific installation.

In many cases, community co-ownership of renewable energy installations correlates with increased acceptance (Kuik & Musall, 2011; Jobert et al., 2007; Sovacool & Ratan, 2012; Warren & McFadyen, 2010). Sharing assets with the community reduces the perception that project planners are out solely for personal gain and gives the community some aspect of control over the project’s direction.

2.4.2 Environmental Factors

An individual’s desire to be or appear environmentally friendly can drive their acceptance of renewable energy technology. The positive mental imagery associated with technologies such as solar panels and wind farms plays a crucial role in adoption of energy-friendly behaviors (Sutterlin & Siegrist, 2017). Graziano & Gillingham (2015) investigated the spatial neighbor effect associated with residential solar, finding that people’s relationships with the neighborhood environment is a primary determinant of the pattern of diffusion of photovoltaic systems. Renewable energy technologies are conspicuous indicators that one is “green” and “eco-friendly”. The more people think these indicators will benefit their identity and social status, the more likely that are to adopt renewables (Noppers et al., 2014). However, individuals tend to change their reported acceptance level when discussing a specific application of the technology (Sutterlin & Siegrist, 2017). Knowledge of the negative environmental impacts of renewable energy technologies can significantly decrease the acceptance of renewables (Sutterlin & Siegrist, 2017; Noppers et al., 2014). Public opinion polls asking general questions regarding renewable energy or the environment do not accurately predict the way people would feel about a specific application of renewable technology.

3. Methodology

3.1 Interviews

In order to gain qualitative background information about the institutions responsible for planning and developing solar technology, we held semi-structured interviews with those
involved with solar system planning. We compared these interview results to the public's responses in order to gauge the relationship between the stakeholders and public. The planners that were interviewed include, at the most local level, kibbutz leaders including the business managers and secretaries that oversee business dealings and daily kibbutz operations, respectively. Interviewing on the local level allowed us to understand how decisions were made, if there was any backlash from kibbutz members, and if they want further development of solar for their own kibbutz. Interviews were also conducted with representatives of the Hevel Eilot Regional Council and Eilat-Eilot Renewable Energy Initiative. Interviews with these representatives provided answers about the motivations behind putting solar technology in the region and what the future holds for the southern Arava and renewable energy. Lastly, representatives from the Arava Power Company (APC) were interviewed because they are responsible for the design and operation of the first solar fields in the area.

3.2 Survey

A questionnaire was developed to build understand southern Arava residents’ opinions on renewable energy as a whole, their preferences concerning the costs and benefits of local solar installations, and their feelings on usage of available land. Most questions required respondents to indicate the degree to which they agree or disagree with certain statements, and will be scored using a Likert scale between 1 and 5 where 1 is “strongly disagree” and 5 is “strongly agree”. The sum-total of the five-point Likert scale responses is a measure to the respondent’s propensity towards solar energy development. We anticipated that people with lower aggregate scores would answer negatively to questions regarding the future development of solar fields and the current allocation of land towards solar installations, whereas those who had high aggregate scores would see solar technology as an opportunity to bring wealth, jobs, and development to the region. Respondents were asked about their preferences for future land use on a hypothetical 250 dunams (0.25 square kilometers) plot of newly-acquired land. The respondent could choose from the following options: “agriculture”, “tourism”, “addition of new community buildings”, “renewable energy technology”, “nature reserve”, or “other”. This question allowed us to ascertain the respondent’s views on how they would prefer future land acquisitions to be used. Certain questions also had optional open-response fields in which the respondent can explain their answer, which gave us valuable qualitative data to include in our analysis. The survey was designed such that individual questions can be compared between groups of respondents, or added up to return an aggregate score that can then also be compared between groups. In total, the questionnaire contained 19 questions, and was translated from English to Hebrew to make it easier for respondents to understand. It was then hosted on the Google Forms survey platform and distributed by email in all but one community, who requested a paper version of the survey.

To better manage survey distribution and collection, five kibbutzim were selected and agreed to participate in this study. The five kibbutzim differed in size, length of existence, amount and type of solar technology, and economic development. Both privatized and traditional
kibbutzim are represented as well. The survey was only distributed to kibbutz members and residents.

3.3 Data Analysis

Written notes and audio recordings of the semi-structured interviews with solar project developers and planners in the region were analyzed. Interview analysis looked for dissimilar and nearly identical responses to various areas of interest. The areas of interest include:

The degree of public participation in the solar planning process as seen by kibbutz business managers, the Arava Power Company, and regional government representatives.

The goals for the future development of solar resources among the various respondents.

The motivations behind the adoption of solar by communities in the southern Arava region.

Public concerns about solar facilities, both during planning and after installation, from the perspective of solar planners.

Survey data was compiled and analyzed using MATLAB. For the Likert scale response questions, each answer was replaced with a number between 1 and 5, with 1 replacing “strongly disagree”, 2 replacing “disagree”, 3 replacing “neutral” or “indifferent”, 4 replacing “agree”, and 5 replacing “strongly agree”. One question was reverse-scored. For each question, median, mode, and frequency was calculated. Additionally, the numerical Likert scale responses were summed for each respondent to form a composite score. We then calculated the mean score and standard deviation for different sub-groups within our sample. A Wilcoxon rank-sum test was performed to determine if there was a significant difference in the central tendency of the composite score between those who reported themselves to be “not involved” in their kibbutz’s decision to implement solar energy and those who said they were “somewhat involved”, “involved”, or “very involved”. The same test was also performed to compare those who reported that they are in favor of the southern Arava fulfilling 100% of their electricity needs through solar power and those who were unsure or not in favor, to compare composite scores by sex, and to compare composite scores by work location (indoors and outdoors/both). A Kruskal-Wallis test was performed to compare the central tendencies of composite scores among those who reported different preferred land uses if their kibbutz were to obtain more land. For these tests, p-values less than 0.05 were considered significant.
4. Results

4.1 Survey Results

4.1.1 Quantitative Data

A total of 84 responses to the online and paper surveys were received, corresponding to a response rate of 10.8%. The mean age of respondents was roughly 58 years, and respondents have lived in the southern Arava for an average of 32.6 years. Median and frequency are reported for individual Likert-scale questions:

<table>
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<th>Question</th>
<th>Median</th>
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<td>It is important to use renewable energy sources to generate electricity.</td>
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<td>I consider myself to be well-informed regarding the advantages and</td>
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<td>disadvantages of solar technology.</td>
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<td>Preserving the natural landscape of the Arava Valley is important to me.</td>
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<td>I think solar fields have negatively affected the natural appearance of</td>
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<td>the landscape.</td>
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<td>I believe my community should commit time and money to reduce the</td>
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<td>amount of pollution it creates.</td>
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<td>It is important for Israel to work towards producing all of its</td>
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<td>electricity using domestic sources.</td>
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Table 2: Medians for Likert Questions 7-9

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<th>Median</th>
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<td>I see solar technology as a business opportunity for my community to</td>
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<td>earn income by selling electricity back to the national grid.</td>
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<td>I support the continued development of solar farms in the Southern</td>
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<tr>
<td>Arava...</td>
<td></td>
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<tr>
<td>I see solar technology as an effective way to sustain the environment</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>and the world's natural resources.</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

The central tendency for responses to the above questions was largely “agree” or “strongly agree”, except in the case of the question regarding the effect of solar fields on the natural appearance of the landscape, which was reverse-scored. Responses to questions were aggregated to form a composite score that measures the respondents propensity towards solar energy technology. The composite Likert score had a sample mean of 29.67 and a standard deviation of 3.55 out of a possible score range of 7 - 35. The minimum score was 16, and the maximum score was 35.
Though the data is not normally distributed or perfectly unimodal, the majority of the responses are clustered around the mean response, an observation consistent with the small standard deviation. Since the mean falls 10 points closer to the maximum possible score (35) than the median possible score (17.5) and only one response fell below the median, it follows that the respondents are on the whole supportive of solar energy.

To compare composite scores between different groups of respondents, multiple comparison tests were performed:

Table 3: Hypothesis Testing

<table>
<thead>
<tr>
<th>Grouping by:</th>
<th>Type of Test</th>
<th>P-Value</th>
<th>Reject H₀ at 95% Significance Level?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td>Wilcoxon Rank-Sum</td>
<td>0.138</td>
<td>No</td>
</tr>
<tr>
<td>Support for 100% Solar</td>
<td>Wilcoxon Rank-Sum</td>
<td>0.032</td>
<td>Yes</td>
</tr>
<tr>
<td>Involvement with Bringing Solar to Community</td>
<td>Wilcoxon Rank-Sum</td>
<td>0.488</td>
<td>No</td>
</tr>
<tr>
<td>Preferred New Land Use</td>
<td>Kruskal-Wallis</td>
<td>0.860</td>
<td>No</td>
</tr>
</tbody>
</table>
These tests show that there is not enough evidence to claim a statistically significant difference in overall propensity towards solar when respondents are split into groups based on their involvement with bringing solar to their community, sex, or their preferred use for new land. However, there is a statistically significant difference in propensity towards solar between those who are in favor of building enough local solar infrastructure to power the entire southern Arava (median = 31), and those who are not or unsure (median = 29).

Most respondents considered themselves only somewhat involved or not involved at all.

![Pie chart showing degree of involvement](image)

**Figure 5: Reported degree of involvement**

Every question on the survey had an overwhelming positive response to solar and solar’s impacts on the region. The survey question regarding solar field effects on the natural appearance of the Arava landscape had more mixed responses. However, the central tendency of the responses still very much leans in support of the solar fields.
4.1.2 Open Responses

Open ended responses were entirely optional and not a significant portion of the survey. However, common themes and ideas came forth through the open ended responses. The question, “Do you support a goal of the southern Arava region being powered completely by solar technology,” allowed an optional “explain your answer” afterwards. The majority of respondents did not provide and explanation for their answer, but those who did had similar reasonings. A group of respondents wrote about the regions need to develop an energy storage solution. No other questions in the survey addressed energy storage, so respondents must have already been aware and conscious of the storage issue prior to the survey.

Another group of respondents also expressed interest in diversifying energy production in the southern Arava area. There were sentiments that a diversified energy production would create a more reliable energy grid.

4.2 Interview Results

4.2.1 Introduction

Interview notes and recordings were analyzed and key points were grouped into one of the three aforementioned foci. Typically, representatives from the Renewable Energy Initiative,
the Arava Power Company, and the regional council were able to speak on the reasons to implement solar technology and any future plans for the regions. Additionally, interviews with kibbutz leaders provided insight to kibbutz involvement with solar technology. While points from interviews typically followed these trends, there was significant overlap from all groups of people interviewed in topics covered.

4.2.2 Implementing Solar Technology

In the southern Arava region, the Regional Council began its renewable energy initiative by educating its population through seminars. In 2005, Israel’s first seminar on the topic of renewable energy was held at Kibbutz Ketura before the implementation of their solar panels. Many who attended, questioned why the region didn’t have solar energy.

The regional council received 120,000 dollars to write a strategic plan to implement solar technology. It started as a five year program which has been expanded into a ten year plan that is currently in place. This plan included creating education plans for teachers to learn how to teach a curriculum on renewable energy, tourism projects, creation of jobs, and the creation of the Eilat-Eilot Renewable Energy Initiative.

When asking the reasons for solar energy being enacted in the area, the first point repeatedly made by APC and Renewable Energy Initiative members was the hope for Israel to go green and reduce the carbon emissions the country produces with fossil fuels. Those who moved into kibbutzim in the Arava region, did so for their love of nature. The idea of renewable energy aligned with the region’s resident’s values. Energy security was also discussed as an important benefit of solar development.

Another driver of the adoption of solar technology was profit. The kibbutzim saw it as a business venture that could diversify their income sources. In a desert environment with small access to water which has a high salinity content, the only profitable crop is dates. Dates make more money than solar, but solar requires much less water and makes more money than the other crops kibbutzim have tried (i.e. peppers, onions, etc).

Solar technology also had the potential of bringing more people such as engineers and their families into the region allowing the region to grow. While this was a goal of the regional council and Renewable Energy Initiative, solar did not create the amount of jobs or increase of population as they had planned for. It did however, create tourism in the area.

4.2.3 Future Plans

A representative of the renewable energy initiative brought up the goal for the southern Arava to have 400 MW of electricity produced by solar fields. Currently, this figure stands at 122 MW and accounts for roughly 70% of the southern Arava’s energy needs. These comments on tripling the current capacity of solar panels are only a portion of the many goals that planners of solar technology have for the region moving forward.
An Arava Power Company official elaborated on the energy goals of the southern Arava, stating that his aim is for the southern Arava to be 100% powered by renewable energies during daylight by 2020 and completely powered by renewables during nighttime as well by 2025. With these goals in mind, some planners see rooftop solar panels as an aid to large solar fields in achieving energy goals. One private company planner cited rooftop panels as a possible route moving forward as they do not require grid connection.

While diversifying the energy capacity is one possibility, regional planners also aim to increase the storage options and energy efficiency for current renewable energies. One research organization is currently waiting on grants to research alternative storage methods to have energy available outside of daylight hours. The idea of pumping water uphill during daylight hours and running the water back downhill to generate power has been introduced, but not implemented in the region. A representative from Arava Power Company points out that until 100% of energy needs are being met by solar during daylight hours, storage is not a priority. Focusing on the need to increase efficiency of energy collected, one regional planner spoke on the fact that the silicon in photovoltaic cells has a maximum efficiency of roughly 25% of the energy received by the sun. While research is being conducted to reach this maximum 25% figure, other researchers are investigating alternative materials with a higher possible efficiency.

Planners also aim for the solar technology to be beneficial outside of energy production. A member of the renewable energy initiative described their role as bringing energy to the region and in turn bringing in new opportunities and a new population. A member of the regional council elaborated on this view, seeing renewable energy projects as a way to create jobs that will attract people and their families to live in the region. As it stands, less than 5,000 live in the southern Arava excluding residents of Eilat. Some planners have set the goal of creating 200-300 more jobs in the region, which would significantly increase the current number of residents. Ultimately, planners view solar technology as not only a means to become energy independent but also, as a member of the region council put it, a means to become the “Silicon Valley” of renewable energy.

4.2.4 Kibbutz Involvement

The majority of the kibbutzim have similar decision making processes. The decision making process generally begins with a business manager proposing an idea. This idea or plan is discussed and voted upon in various committee meetings. If the idea if approved is it then shown to all members of the kibbutz to be voted upon. For example, in kibbutz A, each year, the business manager creates a business proposal for the next year which he/she feels will be the most effective in bringing more income into the kibbutz. The next year’s proposal is based on previous years of experience, ongoing business projects and future business prospects for the kibbutz. Any member of the kibbutz who is interested in being a part of the process and contributing to the business proposal is welcome to attend the economic management committees’ meetings and present his/her ideas. The secretary of the kibbutz (Maskir/a) is responsible for all of the social needs of the community. It is his/her job to represent these needs.
to the economic management committee (Hanhalat Calcalit) for consideration during the planning stage. After the economic management committee votes to accept the proposal it is then taken to the secretariat which is a smaller group of members made up of the two secretaries, business manager, treasurer, person in charge of human resources and 5 members who are voted in by the community. After they have approved the proposal it is then taken to the general assembly which consists of all of the members of the community. At this meeting the proposal is explained to the members in great detail by the business manager and all of the members have the opportunity to ask questions and discuss their views on what has been presented. A vote is then taken by the entire community to either approve or send back the business proposal for further discussion. In the end, it is the want and will of the people that allows plans to be enacted.

In interviewing kibbutz leadership, we were able to identify several key factors that drove kibbutzim to solar fields. Most business managers viewed the solar fields as a long-term investment for their kibbutz. One business manager highlighted the field’s payback period of roughly seven to ten years in discussing the length of the investment. While many saw the primary reasoning as an investment, business managers also cited diversifying their economy as a reason to go solar. One manager recognized that bringing water to the kibbutz would become increasingly expensive and in turn make agriculture less viable.

One former business manager interviewed said that any successful business was one that could adapt to the natural advantages of the region. Before the last decade, kibbutzim in the southern Arava relied heavily on agriculture for income. More recently, business managers have recognized how profitable the solar fields can be, even when the kibbutz was not the sole owner of the field. Business managers that were interviewed explained that the solar field projects almost always involved taking out loans or partnerships with private businesses. As a result, the kibbutzim we interviewed all had varying degrees of ownership; this could be anywhere from a 1% to a 100% stake depending on the kibbutz.

In talking with business managers about their kibbutz, we were able to gain a holistic view of members’ opinions on the solar fields. The general consensus from business managers was that members took pride in their fields and were typically happy with the projects. That being said, business managers generally had small cases of frustrations with the solar field projects. In one case, this was members being frustrated by additional pylons being built in the area. A member at another kibbutz voiced concerns about the field’s proximity to nearby sand dunes. In both these cases, planners worked with members of the kibbutz and reached compromises in the location of the pylons or the fields. One business manager elaborated that while there were minor concerns about the projects, members were overall more in favor of solar technology than other renewable energies such as wind energy.
5. Discussion

All of the results from surveys and interviews point towards a large acceptance for the current state of solar technology in the southern Arava. Answers to each survey question gave no indication of a significant group of people against solar technology for any reason questioned. This common level of acceptance is likely the result of the planning process of the fields, community involvement and trust, and community co-ownership.

We found that while residents of the southern Arava believe preserving the natural landscape of their environment is important, the majority of respondents do not feel that solar fields have negatively affected the appearance of the landscape. Numerous authors have cited visibility of renewable energy facilities and their proximity to population centers as key contributors to public acceptance (Jobert et al., 2007; Warren et al., 2005, Wolsink, 2007). Though the results do not validate the correlation between visibility/proximity of renewable energy installations and public acceptance, satisfaction with the appearance of the solar fields in the southern Arava could contribute positively to their acceptance in this region. A possible explanation for this satisfaction is that many respondents (62.8%) spend their working hours indoors, compared to those who work outdoors (16.3%) or both (19.8%). Those who work outside are more likely to see solar infrastructure for extended periods of time, so perhaps some relationship exists between the general satisfaction with the appearance of the solar fields and the fact that most residents work in an environment in which solar infrastructure is out of sight. Additionally, some kibbutzim have made efforts to conceal their solar systems. One kibbutz hid a solar field behind a large grove of date groves, another placed their field far enough away from the kibbutz that their business manager suspected that some members do not even know that there is a solar field at all. Other kibbutzim have solar panels on the roofs of dairy sheds, which are unsightly to begin with. Planners of the solar systems worked with kibbutz members to address concerns regarding the visual effects of solar, which contributed positively to public acceptance.

We anticipated opposition to solar infrastructure from individuals who believe in the traditional kibbutz ideals of working the land through manual labor and those who want to preserve untouched land. It is possible that the financial benefits of the solar systems when compared to field agriculture outweigh traditionalists’ desires to work the land by hand, or perhaps there are simply not many people who still support this traditional ideology in a modern market economy. More than 85% of respondents agree or strongly agree that preserving the natural appearance of the Arava Valley is important to them. Despite this overwhelming support for preserving the environment of the Arava Valley, overall public acceptance of solar technology is high. The vast nature reserves in south Israel may satisfy residents desire to leave the land untouched.

Interviews with kibbutz business managers and secretaries revealed that the objectives of solar planners, including kibbutz business managers, power companies, and the regional council, were communicated with kibbutz members during the proposal process. Proposals are voted on
by the entire general body of members; kibbutz members have the final say on what happens in their community. However, a surprising percentage (40.2%) of respondents reported that they were not involved at all in their community’s decision to incorporate a solar field. While it is possible that some of those that reported no involvement were not living in the area at the time the solar fields were installed, or were not voting kibbutz members at the time, only 11.8% of respondents fell into either of those two categories. It is thus unlikely that many respondents were not around for the planning and installation of the solar fields. It is also unlikely, given what kibbutz leadership explained about community participation in decisions, that any respondent did not at least vote on the proposal to install solar technology in their community. Those who reported little to no involvement perhaps did not participate in the planning process aside from hearing the proposal in a meeting and submitting their vote. The statistical results in Table 3 show no difference in propensity towards solar energy between those who reported no involvement and those who reported at least some involvement, which indicates that the ability to vote on the issue after being presented with the details of a proposal is sufficient to satisfy the public’s desire to participate in decisions.

The profitability of the solar fields was a common theme in many interviews. Kibbutz leaders expressed a desire to diversify their income sources away from simply agriculture, which is no longer profitable and is not water-efficient. Most survey respondents agreed that solar technology is a business opportunity for their community. Literature shows that community co-ownership is a key driver of public acceptance (Kuik & Musall, 2011; Jobert et al., 2007; Sovacool & Ratan, 2012; Warren & McFadyen, 2010), but does the share that is owned by the community need to yield a significant profit? Solar installations in the southern Arava still benefit from the high return of 20-year feed-in-tariff contracts signed when the systems were put in place. The share of solar assets held by the community varies among the kibbutzim surveyed, but business managers all reported that their kibbutz receives income from the solar systems. This is key to the acceptance of solar energy in this area, as renewable energy developers who negotiated rent contracts with private landowners rather than placing systems on publicly-owned land have experienced public backlash (Jobert et al., 2007).

Statistical testing revealed a difference in propensity towards solar between those who were in favor of powering the southern Arava completely using solar technology, and those who are unsure or not in favor of this idea. We expected those with greater propensity towards solar power in general to support greater solar usage in the southern Arava communities. However, other studies have noted that despite high support for renewable technology, there is a low success rate of planning specific installations (Bell et al., 2005). Our results show that those who are less inclined towards solar technology also balk at the idea of using solar as the only source of electricity in the southern Arava. Many of these respondents were concerned with nighttime production, as the southern Arava currently has no ability to store excess solar power produced during the day for nighttime use. Others felt it would be smarter to rely on a variety of renewable energy sources rather than depending completely on solar. Some commented on the amount of land solar fields take up, saying that given Israel’s land shortage, rooftop solar should be
prioritized over the large fields that dominate the southern Arava. While it is possible that these specific views on the preexisting solar infrastructure influenced respondents’ answers to the questions that measure propensity towards solar, individuals’ attitudes towards solar power in general may have more of an influence on their acceptance of specific applications than previously thought.

6. Conclusion

As one business manager said, “The successful businesses on the kibbutz are businesses that use our relative advantage in the area.” For kibbutzim in the southern Arava, the most adapted business has been solar technology in the last decade. Taking advantage of open land area and high solar radiation, it should come as no surprise that most kibbutz members are in favor of the solar fields. Our research found that 56.2% of respondents supported goals for the southern Arava to be completely powered by solar technology with 33.7% unsure and 10.1% opposing this goal. In pairing quantitative survey findings with qualitative interview data, we were able to determine factors contributing to the high public acceptance in kibbutz communities such as kibbutz co-ownership of solar assets, open and transparent communication between planners and kibbutz members, and the kibbutz decision-making structure that provides members a channel for feedback.

While there has been significant solar development in the southern Arava region within the past decade, our research into the level of public acceptance was the first of its kind. Our data conclusively shows that the extensive development of solar resources in the southern Arava has been welcomed by its residents and provides insight into why this is the case. Future studies building on this research could examine the degree to which the factors we identified contribute to the high public acceptance of solar technology, which would provide concrete evidence of how to build extensive solar capacity in a region in cooperation with the public.

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Appendix A: Sample Questionnaire
Solar Technology in the Southern Arava region

The following survey is part of a study to understand the Southern Arava region’s social acceptance of solar technology. Several Kibbutzim/Settlements in the area will be participating in this study. All responses will be kept completely anonymous, and any identifying information will be kept private. We thank you for taking the time to answer this survey. For questions or comments regarding this survey or the study, the authors can be reached via email at israel-isro@wpi.edu or by contacting the Arava Institute for Environmental Studies, Kibbutz Ketura.

* Required

Background Information

Please tell us about yourself.

1. What is your age in years? *

2. What is your sex? *
   Mark only one oval.
   - Female
   - Male
   - Other:

3. On which Kibbutz do you live? *

4. Where do you spend most of your work hours? *
   Mark only one oval.
   - Indoors
   - Outdoors
   - Both
   - Other:

5. How long have you lived in the Southern Arava region? (In years) *
6. Are you a member of your Kibbutz/settlement? *
   Mark only one oval.
   ☐ Yes
   ☐ No

7. If not, what is your status?

---

Survey Questions

For the following questions, please select the answer which best applies to you.

8. It is important to use renewable energy sources to generate electricity. *
   Mark only one oval.
   ☐ Strongly disagree
   ☐ Disagree
   ☐ Indifferent
   ☐ Agree
   ☐ Strongly Agree

9. I consider myself to be well-informed regarding the advantages and disadvantages of solar technology. *
   Mark only one oval.
   ☐ Strongly disagree
   ☐ Disagree
   ☐ Neutral
   ☐ Agree
   ☐ Strongly Agree

10. To what degree were you involved in your community’s decision to incorporate a solar field? *
    Mark only one oval.
    ☐ Not involved at all
    ☐ Somewhat involved
    ☐ Involved
    ☐ Very involved
11. Preserving the natural landscape of the Arava Valley desert is important to me. *
   Mark only one oval.
   [ ] Strongly disagree
   [ ] Disagree
   [ ] Indifferent
   [ ] Agree
   [ ] Strongly Agree

12. I think solar fields have negatively affected the natural appearance of the landscape. *
   Mark only one oval.
   [ ] Strongly Disagree
   [ ] Disagree
   [ ] Indifferent
   [ ] Agree
   [ ] Strongly Agree

13. I believe my community should commit time and money to reduce the amount of pollution it creates.
   Mark only one oval.
   [ ] Strongly disagree
   [ ] Disagree
   [ ] Indifferent
   [ ] Agree
   [ ] Strongly Agree

14. It is important for Israel to work towards producing all of its electricity using domestic sources. *
   Mark only one oval.
   [ ] Strongly disagree
   [ ] Disagree
   [ ] Indifferent
   [ ] Agree
   [ ] Strongly agree
15. Imagine your Kibbutz/settlement has obtained permission to develop 250 dunams of new land. If your community could choose one thing to do with this land, which use of the land would you advocate for? *
   Mark only one oval.
   - [ ] Agriculture
   - [ ] Tourism (i.e. nature reserve)
   - [ ] Expansion of the Kibbutz/settlement
   - [ ] Renewable energy technology (i.e. solar fields, wind farms, etc.)
   - [ ] Other: __________________________

16. (Optional) Please explain your answer
   ________________________________________________________________
   ________________________________________________________________
   ________________________________________________________________
   ________________________________________________________________

17. Do you support a goal of the Southern Arava region being powered completely by solar technology? *
   Mark only one oval.
   - [ ] Yes
   - [ ] No
   - [ ] Undecided

18. (Optional) Please explain your answer
   ________________________________________________________________
   ________________________________________________________________
   ________________________________________________________________
   ________________________________________________________________

19. I support the continued development of solar farms in the Southern Arava, including the building of more solar farms and upgrade of existing ones *
   Mark only one oval.
   - [ ] Strongly disagree
   - [ ] Disagree
   - [ ] Neutral
   - [ ] Agree
   - [ ] Strongly agree
20. I see solar technology as a business opportunity for my community to earn income by selling electricity back to the national grid. *
   Mark only one oval.
   □ Strongly disagree
   □ Disagree
   □ Indifferent
   □ Agree
   □ Strongly agree

21. I see solar technology as an effective way to sustain the environment and the world's natural resources. *
   Mark only one oval.
   □ Strongly disagree
   □ Disagree
   □ Indifferent
   □ Agree
   □ Strongly agree
Appendix B: Sample Questionnaire (Hebrew)
טכנותيلا ס参与到 עברית הד或者是

סקר זה ינקיי קול מתקוקק שמשמות לא כל התובubes בערבבע דרופוסים ומכלליTan טכנה ס参与到 עברית הדוז

במהלך調查 זה שיתוף קול מתקוקקיו לאו היישובים בחברת השוחטויותertainment ודרי שיתוף נאמנים בתחום שלקדים. זה

לשימוש בустройствנו עקביות של הנדיבות, סקר זהครบ גלוסן זר, אך פגועות לכר הנושאים. והמודרני בכר

ששדוקסט מזנק זテスト על הסקר. לשלוחת את העזרה לגלוב הסקר ונתמוך, יתכןUFFISON ב￡ chambre מביואודורר洗脸ברפ

אם יש ליزيد לפי עם מדון ישיבת יומית, המבנה בקווים קון. אם עזרתי לוח ישיבת סוכנות

"סקר ס参与到 עברית הדוז" 16/2/2018
* Required

מגיעה – רקע איש

אוס ובר לא על עץ

1. בגילך בשנייה? *

2. ממה? *

Mark only one oval

- ציך
- כובד
- Other

3. באיזה קיבוץ/ יושב אתה ב? *

4. misconduct האRegExp או דוב שעון העבורה של? *

Mark only one oval

- בחורستان
- בחור
- שינואר
- Other

5. מה זמך בין גר באומר העבורה הד或者是? (בשנים) *

1 of 5 3/23/2018, 10:42 AM
6. **Mark only one oval**
   - [ ] Yes
   - [ ] No

7. **Mark only one oval**
   - [ ] Yes, let them stay all the way

**Questions**

8. **Mark only one oval**
   - [ ] Mostly all the way
   - [ ] Mostly not all the way
   - [ ] Mostly
   - [ ] Treated
   - [ ] Treated mostly

9. **Mark only one oval**
   - [ ] Mostly all the way
   - [ ] Mostly not all the way
   - [ ] Mostly
   - [ ] Treated
   - [ ] Treated mostly

10. **Mark only one oval**
    - [ ] Mostly all the way
    - [ ] Mostly not all the way
    - [ ] Mostly
    - [ ] Treated
    - [ ] Treated mostly
11. תשבח על הנשים המגייסות לארועה. *
   Mark only one oval
   Madonna or Marilyn
   Madonna or Meryl
   Madonna or Meryl
   Madonna or Meryl

12. *
   Mark only one oval
   Madonna or Marilyn
   Madonna or Meryl
   Madonna or Meryl
   Madonna or Meryl

13. *
   Mark only one oval
   Madonna or Marilyn
   Madonna or Meryl
   Madonna or Meryl
   Madonna or Meryl

14. *
   Mark only one oval
   Madonna or Marilyn
   Madonna or Meryl
   Madonna or Meryl
   Madonna or Meryl

15. *
   Mark only one oval
   Madonna or Marilyn
   Madonna or Meryl
   Madonna or Meryl
   Madonna or Meryl
16. תאר לעצמך שניהבך / הנושר שלך بكול העת לעתים 250 דוגמ נספם. אם הקהילה שלך חוכל לברך.
* אדר לשוב עם הק整改措施, או יהיה שים יתי בברך?
  - Mark only one oval
    -lekot
    -חיות (כלומר משפחת כלבים)
    -הצבב הלקסן/הנולס
    -ספווניות ארגוניות מתחדשות (כלומר שדות סולאריים, חוף וздר)
    -Other

17. (אופציונלי) הסבר את השיבותך

18. אני יודע/нимаש מה рынון של חול פאלארה, בצבע ובדרגת השמירה.
  - Mark only one oval
    - שנהאר
    - לא שנהאר
    - או גם כן, מסוים
    - מowość

19. האם אתה בודק את כל התוך של אחורי ברבעה ימק בakedown טכנולוגיית סולארית?
  - Mark only one oval
    - כן
    - לא
    - לא בוחן

20. (אופציונלי) הסבר את השיבותך
21. המנולוגי המ العالي جميع אטרקציות למעון אחר התנ;;;ים של המיסיפה והתוכנות של הערבה.

Mark only one oval
- מואר
- לא מוכן
- אדיש
- מוכן
- מוכן מואר

22. א;י ראה המנולוגי המ上年同期 ייעלה על מסגרת הסיבוב של הסיבוב עניבים עניבים עולמיים*

Mark only one oval
- מואר
- לא מוכן
- מוכן
- אדיש
- מוכן
- מוכן מואר

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