IMPACTS EVALUATION

JREEEF - JORDAN RIVER FOUNDATION SOLAR HOT WATER HEATER PROGRAM

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JREEEF - JORDAN RIVER FOUNDATION SOLAR HOT WATER HEATER PROGRAM

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Acronyms and Abbreviations

CBO	Community-Based Organization
DISCOs	Distribution Companies
DSM	Demand Side Management
EDCO	Electricity Distribution Company
EE	Energy Efficiency
ESCB	USAID Energy Sector Capacity Building project
GoJ	Government of Jordan
IDECO	Irbid District Electricity Company
JD	Jordan Dinars
JEPCO	Jordanian Electric Power Company
JREEEF	Jordanian Renewable Energy and Energy Efficiency Fund
JRF	Jordan River Foundation
M&E	Measurement and evaluation
NGO	Non-Governmental Organization
PV	Photovoltaic
SPSS	Statistical Package for the Social Sciences
SWH	Solar Water Heater

Executive Summary

Over 60% of Jordanian households heat their water with electricity (NHLS 2015). At the same time, only 13% currently utilize solar energy to heat their water. Therefore the potential market for solar water heating (SWH) is quite significant.

On April 22, 2014, Jordan River Foundation (JRF) and the USAID-funded Electricity Sector Capacity Building (ESCB) project entered into an agreement to evaluate the impacts of JRF's pioneering SWH program. JRF promotes household investment in solar water heaters (SWHs) through Directed Revolving Loan funds operated by 70 Community Based Organizations (CBOs) throughout Jordan. Initial funding for JRF's SWH program was provided by the Jordan Renewable Energy and Energy Efficiency Fund (JREEEF). Such a cooperation on evaluating JR's SWH program made sense in light of ESCB's mission to establish robust evaluation, measurement and verification (EM&V) systems for energy efficiency and renewable energy programs.

a) Methodology

ESCB and JRF worked together to implement the study. ESCB drafted the questionnaire with JRF's input. ESCB worked with JRF to identify which of the 70 CBOs implementing the SWH program had the capacity and willingness to conduct the data collection needed to measure and evaluate the SWH program results. Based on these discussions a sample size of 1,525 households representing all 12 governorates was identified, and 53 CBOs were mobilized to conduct a survey of participating households. ESCB staff provided training to JRF and CBO staff on how to implement the survey. The training took place during September and October 2014, and field teams comprising volunteers from each CBO conducted the surveys over a two month period. ESCB conducted the EM&V analysis and provided capacity building to JRF staff on EM&V techniques.

b) Household characteristics

JRF's SWH Program participants closely resemble Jordan's overall population in terms of dwelling size and type, and family size. Participating households have a slightly higher income than the average found in a recent survey of Jordanian households (NHELS 2015).

c) SWH Benefits

Customers consider saving money to be the greatest benefit associated with installing a solar water heater, followed by reduced time to heat water, and increased comfort and safety. Customers also reported that they believed they are benefiting from significant savings (averaging 36%) on their monthly electricity bills

d) Billing Analysis Results

ESCB staff analyzed customers' actual electricity consumption before and after SWH installation. ESCB found that actual reductions in electricity use are smaller than customers' perceived (self-reported) savings. The reduction in summer monthly electricity usage was 37 kWh on average across all consumption classes, an average reduction of about 11.6 %. By contrast, the average change in the electricity bill amounts (JD) was 13.9%.

ESCB also found that the impact of JRF's SWH program varied according to the consumption level of the participants. Consumption of Tier 1 participants actually increased

after participation, suggesting that these participants were possibly “taking back” some of the water heating bill savings in the form of more electricity consumption on other end-uses. In contrast, the high-consuming participants (Tiers 4, 5 and 6) showed reductions in summer monthly electricity usage considerably more than engineering estimates (50 kWh hours per month). This suggests that these high-consuming customers were possibly reacting to other factors in play over the 18-month period analyzed (e.g., the 15% electricity price increase these customers faced over this period of time). The different electricity bill impacts according to consumption level demonstrate the difficulties of designing and implementing evaluations of energy-saving programs. Traditional evaluations would use a group of similar customers as a comparison group to remove the effect of such external factors.

ESCB analyzed the impact of participant demographics on SWH electricity bill savings. ESCB considered consumption levels, income, family size, and home size. The results show a strong relationship with pre consumption levels, moderate positive relationship between electricity savings and household income, and a stronger positive relationship with home size. ESCB also found a slight positive relationship between savings and family size.

*e) **Conclusions***

The JRF SWH M&E study results are useful to any entity considering funding or delivering a household SWH program.

- Average reduction in usage was estimated at 37 kWh. Expected savings were estimated at 50 kWh in the planning stage.
- Participants with low usage before SWH installation generally had lower-than-average or even negative savings. Participants with higher usage before SWH installation had higher-than-average savings.
- The lower than expected savings were driven almost entirely by the participants in Tier 1 consumption level. Tier 1 customers actually increased usage after participation. One possible cause is take back of savings in the form of improved standard of living.
- Pre-installation usage is the best predictor of savings. Future programs may consider using existing usage as a targeting variable for increased savings.
- Comparing self-reported and actual electricity bill savings suggests that more education and awareness-building should accompany SWH programs. Household SWH programs should include education for consumers about their expected savings, and how their other energy-consuming behaviors can affect these savings.
- The relationships noted between SWH electricity savings and certain demographic variables may be useful for entities wishing to target their SWH programs for maximum impact. Targeting customers with large usage and larger homes, for example, might produce more overall electricity savings.
- Future EM&V plans should take into account the difficulties in matching electric meters with household surveys, either by better quality assurance or through the use of IT technology such as iPads in the survey process.
- Future EM&V plans might also include data loggers or separate meters installed on the electric water heater

- Future EM&V efforts should make every effort possible to include a comparison group in the billing analysis.

1 Background and Study Methodology

1.1 Jordan River Foundation's SWH Initiative

The JRF SWH Initiative established Directed Revolving Loan funds operated by 70 CBOs throughout Jordan. Each qualifying CBO was awarded a JD15,000 grant to set up a Revolving Loan facility and finance household SWH installations. These CBOs generally operate in economically-depressed areas. A household SWH can improve livelihoods through more affordable access to sufficient quantities of hot water than is possible with electricity, kerosene, fuel oil, or biomass. JRF worked with each CBO to develop the community awareness needed to create demand for the solar water heater offering. JRF also set up procedures to financially qualify interested households for a loan. The CBOs offered no-interest loans for 24 months with a monthly payment of 20 JD. SWH installed cost was JD 450.

A JD1.362 million grant from JREEEF financed JRF's SWH initiative.

The solar water heater units were manufactured and installed under a contract between JRF and Hanania Solar Water Heater Company. The SWHs were of the flat-plat type construction with a water capacity of 200 liters. Hanania was selected through a competitive tendering process for which only Jordanian companies were eligible. Hanania worked with each CBO in the community awareness-building process. Hanania technically qualified households to receive a SWH installation and the CBO financially appraised the applicant. After the CBO signed an agreement with the household, Hanania installed the solar water heater and the CBO paid Hanania on-the-spot for the installed unit. The monthly repayments flowed back into the CBO-operated Directed Revolving Fund, and the CBO was responsible for addressing any repayment problems.

The Initiative was expected to have the following impacts:

1. Energy savings, by replacing electricity and gas for water heating with solar energy
2. Economic, through the reduction of household water heating expenditures
3. Livelihood improvement, through access to larger quantities of affordable hot water
4. Environmental, through reducing GHG emissions and negating the need to cut down local trees (for those previously heating water with biomass)
5. Social, through creating capacity within participating CBOs to manage revolving funds that can be used for other purposes in the future
6. Employment, since the solar water heater installer uses local labor and provides vocational training
7. Access to financing, since the CBO-operated Revolving Loan funds will become available for other lending once the Initiative concludes in 2017

The evaluation conducted by ESCB addressed only the energy saving impacts, although the survey included questions regarding other benefits of the program.

1.2 ESCB's Role

The USAID Jordan ESCB is a four-year funded technical assistance project focused on supporting Jordan's energy sector to develop energy efficiency (EE), demand-side management (DSM), and renewable energy investments. ESCB seeks to build the technical

and institutional capacity of all institutions active in Jordan's energy sector, including government, regulators, energy providers, the private sector, and NGOs. ESCB focuses attention on low-usage household consumers, who are served on tariffs with prices that are below electricity production costs. ESCB has identified efficient lighting, solar water heating, and rooftop photovoltaic systems as particularly promising for these subsidized households. ESCB cooperation with JRF to measure and verify the impacts of its SWH Initiative offered an opportunity to build technical capacity, evaluate the electricity and other savings associated with the technology for households, and collect data that can help in designing future DSM activities for electric utilities.

1.3 Evaluation Objectives

ESCB and JRF undertook the impact evaluation to quantify the benefits for households receiving a solar water heater installation. The evaluation utilized both a household survey and electricity billing analysis to estimate actual electricity bill savings and other benefits.

1.3.1 Survey Methodology and Organization

ESCB and JRF cooperated to develop and implement a survey of the program beneficiaries. ESCB drafted the questionnaire and worked with JRF to identify which of the 70 CBOs delivering the program had the capacity and willingness to implement the survey. After discussions, ESCB and JRF agreed to a sample size of 1,525 households (out of 2,100 total households), representing all 12 governorates, and including 53 CBOs.

A total of 1,459 surveys were completed by volunteer interviewers mobilized by the CBOs and trained by ESCB. Although multiple efforts were made to complete the remaining surveys, some customers refused to participate. The 95.7% overall response rate is considered excellent by household survey standards.

The study methodology called for household demographic and energy use information collected via surveys to be combined with electricity billing data provided by utilities. Linking these two data sets would allow analysis of how a SWH installation changes household energy use and livelihood. CBO interviewers collected meter identifying information which was used to match household survey with billing data. However, the completed surveys contained meter identity errors that did not become apparent until ESCB staff attempted to match the survey with the billing data. Almost one-third of the total surveys could not be linked with billing data. ESCB staff removed another 10% of households from billing analysis to eliminate factors which might confound the before-and-after comparison of electricity bills. Data from households who did not own their homes, who added or changed the number of household members, who recently purchased a major appliance, or who participated in other parallel energy-saving programs were excluded. Consequently, the billing analysis presented in Section 5 represents about half of the total number of surveyed customers.

1.3.2 Disposition of survey and billing data sets

Table 1.1 summarizes the process of elimination between surveyed households and households for which billing analysis was conducted.

The Incomplete Survey condition includes surveys which were not completed because no household member was available or if the building was found not to be a household (e.g., mosques or commercial buildings).

The Invalid Data Condition resulted in the largest loss of sample points. This condition had multiple causes - the household could not be identified from the utility records, the household had a number of missing months in their billing history (likely because of a skipped meter read), or the household does not have any billing data records for the period of interest.

Households indicating changes in the number of rooms and changes in household members were removed because of the potential intervening effect on estimated electricity savings from the SWH installation.

Not all households reporting purchases of new appliances were removed. However, those households reporting purchases of large appliances - freezers, refrigerators, washing machines, electric water heaters, dishwashers and ACs - were removed.

Household non-ownership was a condition for removal since there is no guarantee that the data collected refers to one or multiple tenants.

Some of the households surveyed were installed in July whereas the cutoff for analysis was June. These households could not be added because the savings analysis utilized July – October.

Three households that participated in the Mercy Corps PV project were also removed.

Data Discrepancy Conditions also had multiple causes, including households with outlier or illogical data values (e.g., multiple equal bills in the analysis period) which were deemed not to represent true monthly consumption.

Table 1.1 Billing analysis sample disposition

Condition	Number	Remaining
Total Sample Households	1,525	
Incomplete Survey – (*Ref: Column (Result) - Value (2 to 6))*	66	1,459
Invalid July to October Data 2013 - (*Ref: Column (Invalid 2013) - Value (TRUE))*	514	945
Invalid July to October Data 2014 - (*Ref: Column (Invalid 2014) - Value (TRUE))*	9	936
Change in number of rooms - (*Ref: Column (q303) - Value (2 and 3))*	11	925
Change in number of household members (*Ref: Column (q304) - Value (2 and 3*))	55	870
New Large Appliances - (*Ref: Column (q3051) - Value (1,3,5,6,10,13))*	11	859
Household Ownership - (*Ref: Column (q202) - Value (2 and 3*))	27	832
Installed After June - (*Ref: Column (instal_m) - Value (7-12))*	3	829
Mercy Corps PV project participation – (*Manual Removal - ID (641,647,653*))	3	826
Data Discrepancy – (*Manual Removal - Invalid 2013 or 2014 July to October Data*)	48	778

1.3.3 Survey Instrument

The ECSB team prepared the survey instrument in collaboration with JRF. The survey included four sections:

1. Identification information
2. Dwelling information: type, surface area, number of rooms, and appliances
3. SWH information: household uses electricity to heat water; changes in number of rooms and appliances since installing the SWH; changes in electricity bills; advantages of solar water heaters
4. Demographics: number of people in household and income

The survey questionnaire is included as an Annex to this report.

1.3.4 Data Processing

ESCB reviewed all submitted surveys to identify missing data or unclear entries. Incomplete or unclear surveys were returned to the CBOs for attention. Completed surveys were sent to a data processing firm for data entry. The data processing firm provided an SPSS database to ECSB for analysis.[1]

1.3.5 Field Work Results

Table 1.2 shows the number of interviews scheduled by governorate, along with the number actually completed.

Table 1.2 Interviews, by Governorate, Scheduled and Completed

Governorate	Number of Households		Response Rate (%)
	Intended	Completed	
Amman	73	67	91.8
Balqa	134	125	93.3
Zarqa	123	115	93.5
Madaba	124	121	97.6
Irbid	164	154	93.9
Mafraq	64	61	95.3
Jarash	48	48	100.0
Ajloun	172	169	98.3
Karak	200	199	99.5
Tafilah	217	213	98.2
Maan	153	151	98.7
Aqaba	53	36	67.9
Overall response rate	1,525	1,459	95.7

1.4 Data Analysis

The impacts evaluation combined survey with electricity billing data to analyze the impact of a SWH installation on overall household energy use, and measure the actual vs. perceived benefits of the program.

[1] SPSS is a widely used program for statistical analysis in social science.

2 Customer Characteristics

This chapter presents the demographic characteristics of the SWH program participants surveyed, based on all 1,459 survey responses. Results presented include:

- Household composition
- Dwelling characteristics – type, ownership, and size
- Household income

2.1 Household Composition

Table 2.1 shows the distribution of households selected for the survey. Two-thirds of the households surveyed have between four and seven family members.

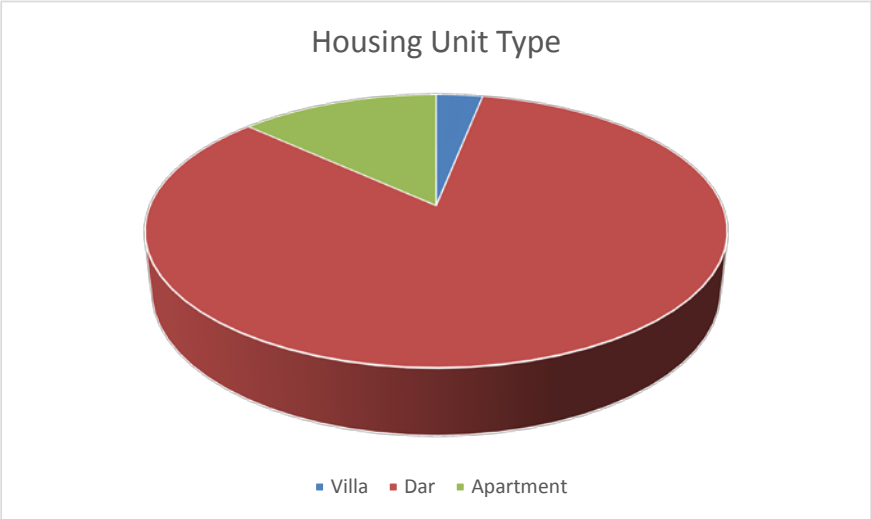
Table 2.1 Family Size in SWH Households

Household Size	Total (%)
1-3 family members	16%
4-7 family members	65%
8+ family members	19%
Total	**100%**

2.2 Dwelling Types

Figure 2.1 shows dwelling types reported by survey respondents. Only 3.1% live in villas, while 13.2% live in apartments, and the remainder in dar housing.[2]

Figure 2.1 Dwelling Unit Type

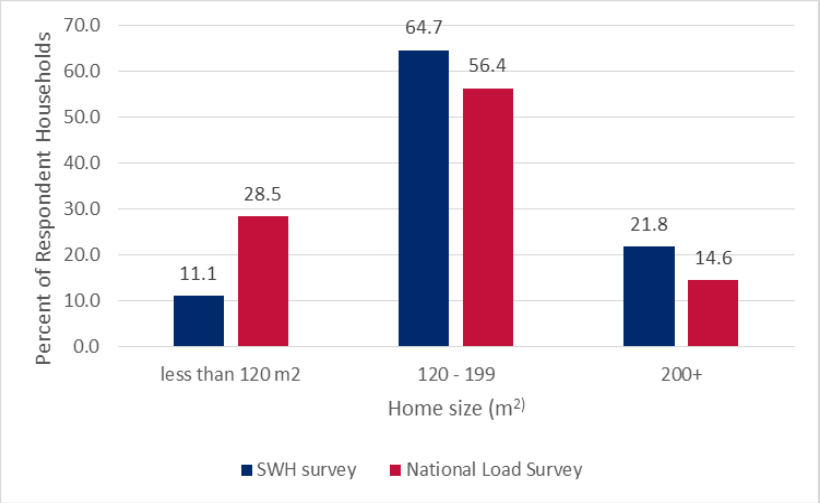


Almost all (97.6%) of surveyed customers own their homes. Over half (60.3%) live in homes with four or five rooms, while nearly one fifth (18.7%) live in homes with three or fewer rooms. Nearly all (95.4%) have a separate kitchen within their homes, and a slightly higher number (96.4%) have a private bathroom.

[2] A rural or suburban abode encompassing a house and outbuildings, usually within an enclosed yard.

Survey respondents tend to live in homes that are somewhat larger than the household average as reported in ESCB's household load survey (NHLS 2015). ESCB's load survey found that 28.5% of Jordanians live in homes smaller than 120 m,^{2} compared to 11.1% of those who responded to the SWH survey. Figure 2.2 shows the range of dwelling sizes among survey respondents.

Figure 2.2 Dwelling Size



2.3 Household Income

Between two-thirds and three-quarters of Jordanian households have an income less than 500 JD per month (NHLS 2015). Overall, solar water heater participant households tend to be more affluent than the average household; only 39% of the households surveyed have a monthly income less than 500 JD. Sixty one percent have a monthly income over 500 JD.

2.4 Appliance holdings

Survey respondents were asked about their other electricity-using appliances, in order to better understand the relative contribution of electric water heating to their electricity bill. Table 2.2 compares SWH participant appliance ownership to national household (NHLS 2015).

Table 2.2 Household Appliance Holdings

Appliance	SWH Ownership %	National Ownership %
Refrigerator	99	98.8
Freezer	23	13.4
Washing Machine	98.5	97
Air Conditioning	18.2	27
Fan	90.1	82

2.5 Source of fuel for heating water

Nearly three quarters (74.2%) of those surveyed reported using electricity to heat water in prior to the SWH installation (compared to 61% nationally). Twenty-three percent of SWH participants previously heated water with bottled gas, compared to only 9% nationally.

3 Household Changes

A key benefit of a SWH installation is reducing household expenditure on electricity or other fuels. Households replacing an electric water heater with a SWH should see lower electricity bills, while households using gas should see lower expenditures on bottled gas. However, new appliance purchases or changes in household size (a new baby, for example) can increase electricity use, masking the savings from the SWH installation.

The survey asked respondents to describe what changes, if any, had taken place in their homes since installing the solar water heater. As the survey was conducted only three months after installation, few indicated having made changes. The two figures below show the changes respondents reported. Only 18 households, or 1.2% of the total survey respondents, reported a change in household size after installing the solar water heater. Given the unknown effect on SWH benefits, the ESCB team chose to exclude these households from the billing analysis.

A small group of customers (about 2.5%) reported purchasing a major appliance (e.g., washing machine, refrigerator, freezer, or air conditioner) subsequent to SWH installation. Given the potential masking effect on SWH benefits, the ESCB team chose to exclude households which added major appliances from the billing analysis.

Figure 3.1 Change in Household Size

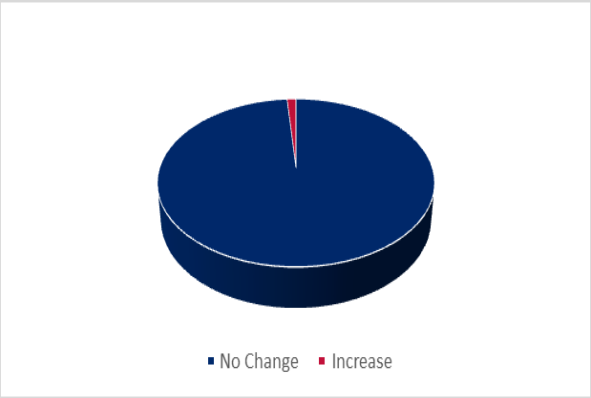


Figure 3.2 Change in major appliance holdings

The survey also asked whether there had been any change in the number of household rooms since installing the solar water heater. Three percent of those surveyed said the number of rooms had increased, and 2.7% said the number decreased. The ESCB staff chose to exclude these customers from the billing analysis as well.

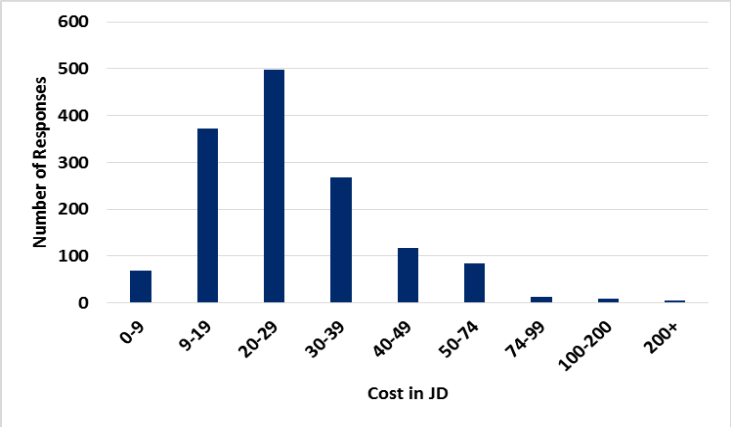
4 Survey Results - Solar Water Heater Benefits

Most (74.2%) of the households surveyed previously heated water with electricity; almost all of the remainder (23.5%) previously used bottled gas. Customers indicated that they would continue to use those fuels to heat water should the SWH fail to meet all of their needs.

4.1 Self-reported electricity bill savings

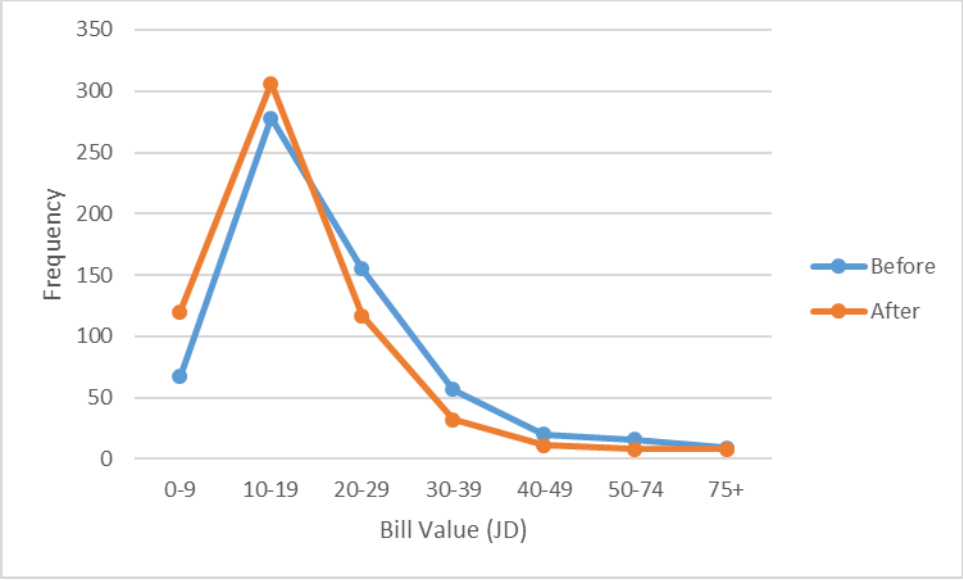
The survey asked the households how much they paid for electricity before installing the solar water heater. Nearly one-third (30.2%) reported paying less than 20 JD per month, with an additional one-third (34.1%) reported paying between 20 and 29 JD per month. Less than one-fifth (18%) reported paying over 40 JD per month (see Figure 4.1).

Figure 4.1 Participant-Reported Monthly Electric Bill Prior to SWH Installation



Participants reported that the solar water heater installation had an effect on their electric bills. The percentage of customers who reported paying 0 to 9 almost doubled. The percentage of customers that paid 10 to 19 JD in period before the installation also increased, but only slightly. The opposite occurred for every bill group past 20 JD per month.

Figure 4.2 Participant-Reported Average Monthly Electric Bill Before and After SWH Installation

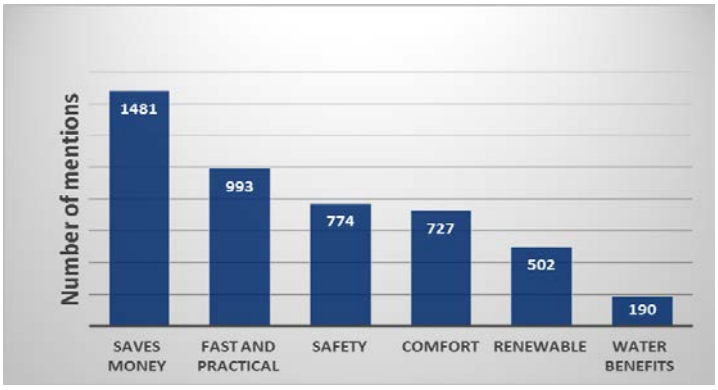


4.2 Perceived Benefits of Using Solar Water Heaters

The survey asked respondents to list the five main benefits the household receives from having installed the solar water heating system. The interviewers recorded customer comments verbatim, which were then grouped into benefit categories. For example, responses such as “saves electricity and money,” “saves gas,” “economic,” and “less expense” were all grouped under “saves money.” Not all households provided five responses, and only two-thirds offered as many as three responses. Overall, 1,459 households provided nearly 5,000 total responses. Figure 4.3 shows the top six responses.

Saving money was cited by all households. Two-thirds of households said that solar water heating was faster and easier than electric or gas water heating. Over half of households see SWH as safer than other water heating methods (e.g., natural gas or propane. Over half praised the added comfort of solar water heaters. JRF can use all of these benefits in its marketing materials in order to attract a broader range of potential participants.

Figure 4.3 Participant-Reported SWH Benefits



Note: Responses sum to more than the number of households surveyed as multiple replies were allowed

4.3 Monthly Savings

The survey also asked respondents how much they believe they are saving each month by using the solar water heater. As Figure 4.4 shows, 83% of respondents said they are saving some money, even if the amount is less than 5 JD. Over half (52%) of respondents reported saving between 5 and 14 JD per month; less than one-quarter (22%) reported saving 15 JD or more per month. The average monthly saving reported was 10 JD per month.

Figure 4.4 Participant-Reported Monthly Electric Savings from using SWH (in JD)

5 Billing Analysis Results

5.1 Customer Data Records

ESCB obtained billing information from JEPCO, IDECO, and EDCO for the purpose of estimating the program impact on usage. This data can also be used to compare actual with participant-reported SWH electricity bill savings.

The billing data acquisition problems described in Section 1.3.1 and efforts to eliminate any effects that might mask SWH electricity bill savings reduced the total number of electricity billing records that could be matched with survey data, as summarized in Table 1.1.

The billing analysis included 778, or 51%, or the 1,525 surveyed customers. Table 5.1 summarizes the billing data set.

Table 5.1 Organization of the electricity billing data set

Household	IDECO	JEPCO	EDCO	TOTAL
Not using electricity for heating water	44	41	91	176
Using electricity for heating water	190	143	269	602

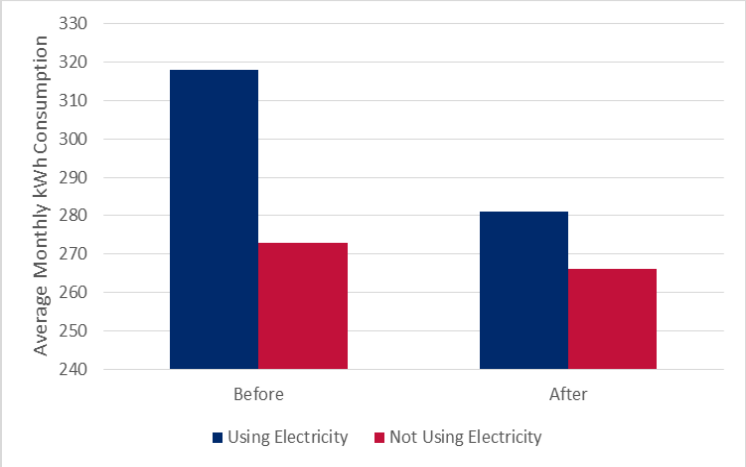
5.2 Electricity Savings Calculations

The electricity savings from installing a SWH can be estimated by comparing the monthly consumption before and after installation of SWH. This study conducted the analysis using data from the four months (July-October) before and after SWH installation.

As expected, before-and-after electricity usage for households not using electricity to heat water in the pre period was about the same - within 6 kWh or 2.5%. This change is statistically negligible relative to the natural variation in monthly consumption.

In contrast, households that used electricity to heat water in the pre period, showed a significant reduction – 37 kWh or 12% of consumption before the SWH installation. Combined, the average savings was 30 kWh.

Figure 5.1 Before-and-after electricity usage for the "control" and "treatment" groups



Electricity use before-and-after the SWH installation varied significantly according to consumption tier, as shown in Table 5.2. Households in Tier 1 who previously used electricity to heat water actually increased their usage by an average of 31 kWh or 23 %. Usage for all of the other households previously using electricity went down – as expected -

but by significantly different amounts. Reductions in electricity usage for Tiers 2 and 3 are roughly in line with engineering estimates of monthly electricity savings for a Hanania SWH installation (50 kWh), as well as the 37 kWh reduction average across all 602 households in the billing data set using electricity for water heating. However, reductions in electricity usage for the higher tiers – Tier 4 and 5 – were significantly greater than what might be expected from a SWH installation alone. Clearly there are factors influencing before-and-after electricity usage for these different households other than the SWH installation. Future use of comparison group will shed light on this issue.

Table 5.2 Change in monthly electricity usage (kWh) according to tier

Tier	Monthly kWh Impact	Percentage change	Frequency
Tier 1	31	23.2	44
Tier 2	-14	-5.93	287
Tier 3	-59	-15.8	221
Tier 4	-131	-24.1	27
Tier 5	-166	-25.2	14

Table 5.3 displays change in energy use by Tier and prior fuel type. As the table shows, Tier 3 to 7 is where the electricity savings are most pronounced and have either come close or far exceeded the engineering initial estimate of 50 kWh per month. No attempt was made to estimate the other fuel savings due to this program.

Table 5.3 Change in monthly electricity usage (kWh) according to tier and prior fuel

	Using Electricity		Not Using Electricity	
	kWh / month	Frequency	kWh / month	Frequency
Tier 1	-31	44	-41	22
Tier 2	14	287	-2	97
Tier 3	***59***	221	18	48
Tier 4	***131***	27		
Tier 5	***166***	14		
Tier 6	***100***	4		
Tier 7	***42***	5		

5.3 Interpretation of results and other factors affecting SWH energy saving analysis

Although billing data provides an important basis for measuring the savings of a SWH installation, there are limitations to its effectiveness. Interpreting the results of an analysis using before-and-after billing data must consider what intervening variables or events might affect electricity usage for a given group of households. These intervening variables include differences in weather across the two summers, the impact of electricity price increases enacted in January 2015, differences in household composition or appliances for specific participants, and differences in consumption behavior as a result of information and awareness-building delivered through the program itself.

This analysis tried to eliminate some intervening factors that were likely to affect electricity usage. Households who reported adding a major appliance, adding a household member, adding a room to their house, or participating in another program were eliminated from the billing analysis. However, the billing analysis could not account for other intervening events, such as the electricity price increases that took place in January 2014 and January 2015. Other factors which are difficult to quantify include participant "take-back" of electricity savings from SWH installation.

Table 5.3 illustrates movement by participants between consumption tiers following SWH installation. The table shows the consumption tier customers fell into before and after participation. The diagonal (grey cells) shows percentage of customers that remained in the same tier after participation. Blue cells show customers who moved into a higher tier after participation. Finally, yellow cells show those that dropped to a lower tier.

- One-third of the 44 Tier 1 participants increased their consumption, moving to Tier 2. This result may suggest a "take-back" factor in which participants reinvest their energy savings in more electricity consumption for other end-uses.
- Ten percent Tier 2 participants moved to Tier 3. Perhaps also a result of take back.
- Very few (1%) of Tier 3 customer moved to Tier 4.
- Of the Tier 2 participants, 17% dropped their use significantly enough to drop to Tier 1 further savings more money due to lower rates.
- A total of 47% of Tier 3 customers dropped to Tier 2 (45%) and Tier 1 (2%)
- Large savings causing a customer to drop to lower Tier may suggest the presence of intervening factors that magnify reductions in electricity consumption following SWH installation.
- Note that the movement to a lower tier will lead to larger electricity bill savings to the customer, as both the quantity used and the average price is reduced.

Table 5.3. Participants' Tier Migration

	Post-Installation Tier			
Pre-Installation Tier	1	2	3	4
1	67%	33%		
2	17%	72%	10%	
3	2%	45%	51%	1%

5.4 Regression Analysis

A regression analysis was conducted to explore whether demographic variables - dwelling or family size - might explain differences in SWH electricity savings. Understanding the effect of these variables on electricity savings would help JRF to predetermine which households might benefit most from a SWH program.

ESCB staff analyzed the relationship between electricity usage and three variables: household size (number of people), home size, and household income.

Table 5.5 display the results of running a multiple regression analysis exploring explanations for saving variations. Regression analysis uses "explanatory variables" to explain the changes in the "dependent variable." In this analysis, the dependent variable is energy

saved, and the explanatory variables include consumption before the installation, income, size of home, and number of people living at home.

Overall "goodness of fit" of regression is measured by R^2 (a number between 0 and 1). The value of R^2 reflects the variation in the dependent variable (savings) that can be explained by each explanatory variable. In this case, R^2 is 21% implying that other variables not included in the regression analysis have an impact on savings. Such other variables might include weather differences between the summer months before and after installation, reaction to electricity price increases, or other unknown effects. Despite the low explanatory power of the model, the impact on individual explanatory variables can still be measured with some degree of certainty if they pass the statistical test associated with each. The test for each explanatory variable's ability to provide useful information is measured by the t statistic (t Stat in table). In general for 90% confidence and ±10% (the standard in DSM evaluations), we look for values of the t Stat around 1.645. Any value greater than 1.645 or lower than -1.645 is considered statistically significant at the 90% confidence and 10% precision levels. Alternatively, we can examine the associated p-values that lead to the same conclusion. P-values less than 10% are considered significant at 10% or lower level of precision.

Table 5.5 indicates that the best predictors of savings from the SWH program are size of the home (HH Area) and consumption before the installation. For each square meter increase in home size, savings can increase by 0.05 kWh monthly (see coefficient value in table). This result is counterintuitive and may be caused by some unobserved relationship between size of home and savings. It could also be due to data errors. However, the relationship to pre usage is significant and intuitive. The model estimated that for each kWh of pre usage, savings from SWH install can be expected to increase by 0.26 kWh per month.

Table 5.5 SWH Savings Regression Model

R Square	0.21			
	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	(52.79)	9.18	(5.75)	0.00
Income	0.00	0.01	0.24	0.81
HH Area	0.05	0.04	1.23	0.22
Consumption Before	0.26	0.02	11.33	0.00

6 Conclusions and Recommendations

6.1 Conclusions

The following are the main conclusions of the study:

- Participants are generally pleased with JRF's SWH program. They are satisfied with the amount of money they think they are saving on their electricity bills – even if the estimated savings are considerably less than the perceived savings.
- Participants also were pleased with the other benefits of a SWH installation, including more rapid access to hot water, greater comfort and safety, and access to easy and affordable financing.

- Billing analysis shows that on average customers that start out using electricity to heat their domestic water are saving 37 kWh per month on their summer month electric bills.
- The pre/post electricity usage change varied dramatically according to the electricity tariff tier of the household. Tier 1 households actually consumed more that the predicted SWH savings while Tier 4 and 5 households saved higher amounts than expected originally.
- Pre usage is the best predictor of future savings. For each additional kWh of use in the pre period, savings are expected to increase by some 0.26 kWh monthly. Also, for each additional square meter of home size, the savings are expected to increase by 0.05 kWh.

6.2 Recommendations

- Selecting participants based on household size and pre consumption will increase the savings significantly.
- Targeting by consumption tier will increase savings significantly.
- Future evaluations should consider more accurate data collection (e.g., direct metering of electric water heater usage or improved methods to identify meter number) and use IT technologies that will help reduce data entry errors.
- Future evaluations should use a randomly selected group of customers to act as the comparison group.
- Program goals in the future need to be made clear. If the goal is to reduce electric consumption, then the program should target customers in Tier 3 or higher with existing electric water heat. However, if other fuel savings are also desirable, then the goal may need to be stated in Btu terms and existing fuel should not be used as a screening tool.
- Future EM&V should address other fuel savings.
- Future EM&V should address non-summer months' savings. The goal should be to estimate annual savings.

7 References

National Household Load Survey, USAID-Energy Sector Capacity Building Project, 2015.

Annex

JRF

Effect of Solar Water Heater on the Beneficiaries Survey 2014

Information is confidential according to the Statistics Law No. 12 for the year 2012

Questionnaire No. |__|__|__|__|

1. Identification Information

101	Governorate |__|__|	107	Name of household Head:
102	Locality |__|__|		
103	Name of CBO |__|__|	108	Address: ……
104	Subscription number:			……
105	Meter number:		109	Telephone number:
106	Name of subscriber:		110	Date of installation SWH:
			111	Number of HH Member: |__|__|

Interviewer visits

	1	2	3	Final visit	
Date	----------	----------	----------	Day	|__|__|
Name of interviewer	----------	----------	----------	Month	|__|__|
Result*	----------	----------	----------	Year	2014
Next visit: Date: Time:	 ---------- ----------	 ---------- ----------		Interviewer's code No. of visits	|__|__| |__|
*Result of final visit	1. Completed 2. No one present or no person to respond 3. Household not living there 4. Postponed 5. Rejected 6. Other ----------				|__|

Work stages

Name	No.	Date	Name	No.	Date
Supervisor	|__|__|	/ /2014	Coder	|__|__|	/ /2014
Editor	|__|__|	/ /2014	Data Entry	|__|__|	/ /2014

Hello. My name is ___. I am working with the JRF. We are conducting a survey about Solar Water Heaters all over Jordan which were install in the houses. The information we collect will help the JRF and other related agency of future plans of the important of the SWH and measure their deferent impact on households and population. Your household was selected for the survey, I would like to ask you some questions about your household. The questions usually take about 20 minutes. All of the answers you give will be confidential. But we hope you will agree to answer the questions since your views are important. If you would like to ask any question, please do. In case you need more information about the survey, you can contact this Telephone No. .

2. Housing Unit and Household Information				
No	Question	Alternatives	Code	Notes
201	Type of Housing Unit	Villa	1	
		Dar	2	
		Apartment	3	
		Barracks	4	
		Other (specify)	5	
202	Housing Surface area(In m^2)	Surface area(In m^2) Surface 997+ record 997	|__|__|__|	
203	How many rooms do you have in your house?	Number of Rooms:	|__|__|	
204	Do you have a separate room which is used as a kitchen?	Yes …….. No ……..	1 2	
205	Do you have a private or shared bathroom?	Private …….. Shared ……..	1 2	
206	What is the main source of water for the household?	PIPED INTO HOUSING UNIT SPRING RAINWATER/Well TANKER/ TRUCK BOTTLED WATER Other (SPECIFY)	1 2 3 4 5 6	
207	Does your household have "Refrigerator":…. et	Appliances A refrigerator? A freezer? A washing machine? A dish washer? Air conditioner? Fan?	Yes No 1 2 1 2 1 2 1 2 1 2 1 2	
3. SWH Information				
No	Question	Alternatives	Code	Notes

301	What type of fuel did your household use for heating water before installing the solar water heater?	Electricity Propane or bottled Gas Kerosene / Diesel Biomass (Wood, Jifft, etc.)	1 2 3 4	
302	Please indicate the main another way to heat water if the solar system is unavailable (such as cloudy weather, SWH out of order, others) ?	Electricity Propane or bottled Gas Kerosene / Diesel Biomass (Wood, Jifft, etc.) Other (specify)…….. Non	1 2 3 4 5 0	
303	Has there been any "**change on the number of household members**" Since installing the solar water heater?	1. No Change 2. Increase 3. Decrease	1 2 3	
304	Has there been any "**change on the number of household rooms**" Since installing the solar water heater?	1. No Change 2. Increase 3. Decrease	1 2 3	
305	Please indicate whether you have purchased any new major electrical appliances since installing the solar water heater?	1…….. 2…….. 3…….. 4…….. 5…….. None (Record 00)…….	|__|__| |__|__| |__|__| |__|__| |__|__| |_0_|_0_|	
306	Average monthly amount of EB before installing the SWH		|__|__|__|	
307	Average monthly amount of EB after installing the SWH		|__|__|__|	
308	How much have you saved on expenditure because you are using SWH?	Amount in JD……	|__|__|__|	
309	Please define the main five advantages that household get of installing the SWH and using the hot water?	1…….. 2…….. 3…….. 4……..	|__|__| |__|__| |__|__| |__|__|	

		5……..	|__|__|

4. Information on Household Members

401	402	403		404		405	406		407		408	
SN	Please give me the names of the persons who usually live in your household (3 part)	What is the relationship of (NAME) of the household head? Husband/Wife…….. 02 Son/daughter……..03 Wife of the Son ……04 Grandchild ……05 Father/mother …….. 06 Brother/ Sister……..07 Grandfather /Mother 08 Other Relative…….. 09 Not Related ……10 DK ……98		Does (name) Male or Female?		How old is (name)? Less 1 Year REC. 00. 95+ Rec 95	Does (Name) usually sleep in the housing unit of the household?		Is (Name) registered in childcare or in any education level?		10+ years Is (Name) working?	
XX			Code	M	F	XX	Yes	No	Yes	No	Yes	No
1		Head Of HH	01	1	2		1	2	1	2	1	2
2				1	2		1	2	1	2	1	2
3				1	2		1	2	1	2	1	2
4				1	2		1	2	1	2	1	2
5				1	2		1	2	1	2	1	2
6				1	2		1	2	1	2	1	2
7				1	2		1	2	1	2	1	2
8				1	2		1	2	1	2	1	2
9				1	2		1	2	1	2	1	2
10				1	2		1	2	1	2	1	2
11				1	2		1	2	1	2	1	2
12				1	2		1	2	1	2	1	2
13				1	2		1	2	1	2	1	2

14				1	2		1	2	1	2	1	2
15				1	2		1	2	1	2	1	2
16				1	2		1	2	1	2	1	2
17				1	2		1	2	1	2	1	2
18				1	2		1	2	1	2	1	2
19				1	2		1	2	1	2	1	2
20				1	2		1	2	1	2	1	2

5. Household Income and Expenditure Information

No	Question	Alternatives	Code	Notes
501	Average monthly income for all household members from all sources in JD.	Average Amount ……	|__|__|__|__|	
502	Average monthly expenditure for all household members in JD.	Average Amount ……	|__|__|__|__|	
End of Interview				

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