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MERCY CORPS 2013-2014 PHOTOVOLTAIC PROJECT IMPACT EVALUATION

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MERCY CORPS PHOTOVOLTAIC SURVEY REPORT - 2015

USAID JORDAN ENERGY SECTOR CAPACITY BUILDING

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Acronyms and Abbreviations

CBO	Community Based Organization
CFL	Compact Fluorescent Lamp
DISCOs	Distribution Companies
EE	Energy Efficiency
EMRC	Electricity and Mineral Regulatory Commission
EDCO	Electricity Distribution Company
ESCB	USAID Energy Sector Capacity Building project
GoJ	Government of Jordan
IDECO	Irbid District Electricity Company
JEPCO	Jordan Electric Power Company
JLGF	Jordan Loan Guarantee Facility
JD	Jordan Dinars
JREEEF	Jordanian Renewable Energy and Energy Efficiency Fund
kWp	Peak power
LED	Light Emitting Diode
MEMR	Ministry of Energy and Mineral Resources
NEPCO	National Electric Power Company
NERC	National Energy Research Center
NGO	Non-Governmental Organization
PPP	Public-Private Partnership
PV	Photovoltaic
SME	Small and Medium Enterprise
TA	Technical Assistance

Executive Summary

On June 8 2014, Mercy Corps and the USAID-funded Electricity Sector Capacity Building (ESCB) project entered into an agreement to cooperate on a monitoring and evaluation activity for Mercy Corps household solar PV pilot program. Mercy Corps worked with community based organizations (CBOs) to install 75 rooftop PV systems in five rural communities across Jordan.

Methodology

ESCB and Mercy Corps worked together to survey the customers who received PV systems in late 2014. ESCB drafted the questionnaire with Mercy Corps' input. The goal was to survey all 75 households with installed systems, 30 in EDCO's service territory, and 45 in IDECO's.

Mercy Corps staff completed surveys of 59 of the 75 total households, 33 in IDECO's service territory and 26 in EDCO's service territory. The survey effort attained an overall 79% response rate.

ESCB received customer meter information from Mustakbal Clean Tech, the company that installed the PV systems, and used that information to match the survey to the household's utility bills in EDCO- and IDECO-provided databases.

a) Household characteristics

All PV pilot program participants own their homes and live in dar housing.[1] Neither of these characteristics is surprising; the pilot actively targeted rural homeowners whose energy use fell below a particular level. The households that purchased PV systems through this program tend to have higher average incomes than the average Jordanian household. ESCB's recent load survey found that more than two-thirds of Jordanian households have an income less than 500 JD per month, compared to just over one-third (37.3%) of the PV pilot program participants surveyed.

b) PV System Benefits and Concerns

Customers consider saving money (53%) to be the greatest benefit associated with installing a PV system.

More than half (60%) of those surveyed said they had no problems with their PV systems. Concerns reported were that the system did not meet the home's full electricity needs, and that there were maintenance issues.

c) Billing Analysis

An energy savings evaluation was conducted using electricity billing data for a full year before and a full year after the July 2013 installation of the PV systems. Table ES-1 summarizes the billing analysis results. Households with PV systems installed achieved an average savings of 1,516 kWh annually, almost half (43%) of average previous usage. The evaluated savings were 72% of the savings estimated from an engineering analysis.

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

Table ES-0-1 Annual Electricity Savings

Annual Pre (kWh)	Annual Post (kWh)	Annual Saving (kWh)	% Reduction	Planning Estimate (kWh)	Realization Rate
3,526	2,010	1,516	43%	2,104	72%

Figure ES-1 shows the trajectory of savings following PV system installation, as well as seasonal variations, beginning with the first full monthly billing cycle (October 2013) after system installation. Apparent in this depiction is a "learning curve" as households adapt to the PV system installation and its effect on monthly electricity bills. Interviews with households as well as the monthly savings trajectory suggest that households initially increased their electricity consumption in the mistaken belief that the PV system would provide them with unlimited free electricity. This higher post-installation consumption increasingly offset the PV production, culminating in December bills which were actually higher than the corresponding monthly electricity bill from a year before. Most households then realized that the PV savings could not compensate for their higher consumption, and adjusted their behavior to reduce their consumption back to pre-installation levels. The result was much higher electricity savings for the nine months beginning in January 2014.

Superimposed on this "learning curve" are seasonal variations due to household consumption patterns, PV production levels, and annual religious observances. Electricity savings are generally higher in the spring and summer months, due to lower consumption and higher PV production. The exception is the July-August-September billing cycles, which in 2014 corresponded to the Holy Month of Ramadan (June 29 – July 28) – known to be an annual period of higher household consumption.

Figure ES-1 Electricity Use Trajectory: October 2013-September 2014 (kWh)

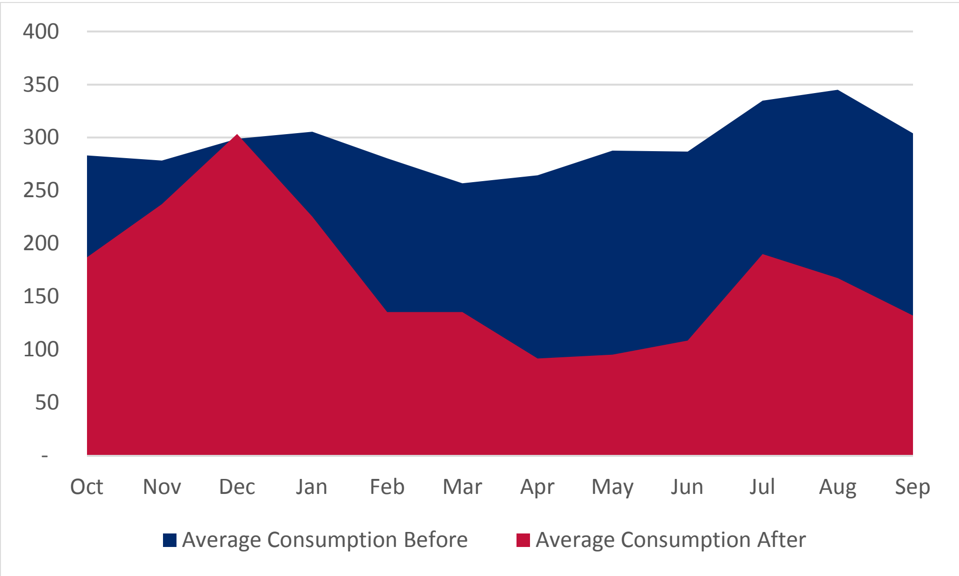
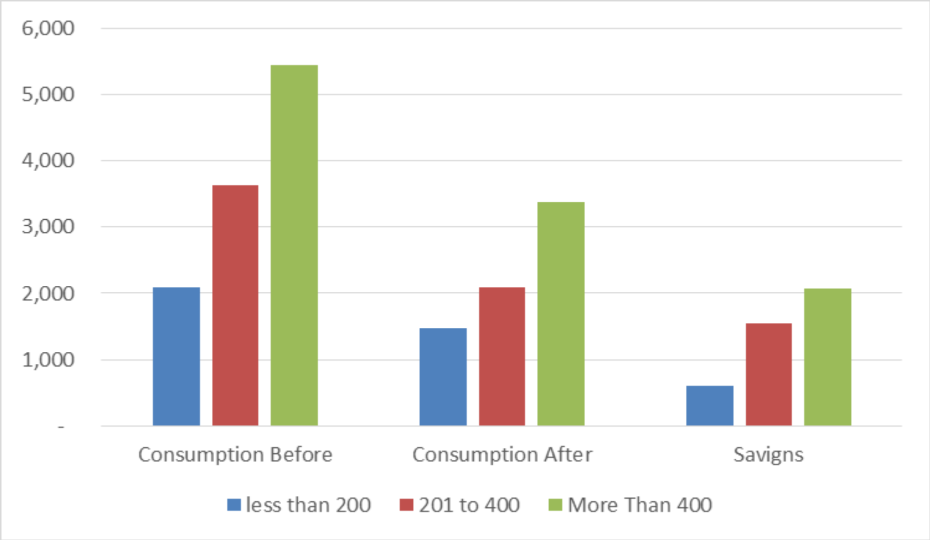


Figure ES-2 shows that savings are dependent on initial consumption levels, with high users having higher savings. The only group that achieved its planning estimate savings was the one whose pre-installation average consumption was greater than 460 kWh per month.

Figure ES-2 Electricity Savings and Consumption Levels (kWh)



d) *Conclusions and Recommendations*

- The program achieved 72% of savings estimated from an engineering analysis. Only large customers (approximately at an average of 5,500 kWh annually) achieved the full planning expected savings. If energy savings is the primary goal, then future programs should target larger electricity users.
- Most systems are operating as expected, and customers are realizing significant energy savings.
- Participants should be educated in order Include to manage their expectations about the PV systems. Customers should not expect not to have any electricity bill at all; only one of the 59 survey respondents had that experience. Most of those who installed the systems have large enough homes and families that they will continue to use more electricity than the systems produce, particularly if they increase air conditioning or water heating use, or add appliances.
- The utilities need to educate their meter readers about the PV systems. Several participants indicated that the utility staff did not know how to read the meters after the systems were installed; ESCB review of customers' billing records often showed no bills at all for a month or more after PV system installation, followed by very large bills once the utility began reading the meter again.
- Using before-and-after electricity bills to evaluate the saving of household PV systems is an imperfect evaluation method. Adding a meter to directly measure the PV production - at least on a representative sample of participants - would greatly improve the evaluation process and the accuracy of impact estimates.

1 Background and Study Methodology

1.1 Introduction

On June 8 2014, Mercy Corps and the USAID-funded Electricity Sector Capacity Building (ESCB) project entered into an agreement to cooperate on a monitoring and evaluation activity for the solar PV pilot program. Mercy Corps worked with five community based organizations (CBOs) to install 75 rooftop PV systems in five rural communities across Jordan. The systems were installed in June-July 2013. This report presents the methodology used to conduct the evaluation study and its key findings.

1.2 Mercy Corps' Pilot

The Mercy Corps PV Initiative installed 75 photovoltaic (PV) systems of 1.25 kW peak capability at 75 homes located in five rural areas, each of which is served by a CBO. These CBOs generally operate in economically-depressed areas; the pilot's intent was to provide those households that invested in PV system with both lower electricity bills and more affordable access to livelihood-improving electricity consumption.

Mercy Corps worked with each CBO to undertake the community awareness-building needed to create interest in the PV offering. Mercy Corps was able to cover 75% of the system cost (JD 1,200) through USAID funding; the participants covered the remaining 25% (roughly JD 400). Mercy Corps jointly set the technical PV specifications with the then-Electricity Regulatory Commission (ERC).

CBOs solicited applications from the target communities. To be eligible for the installation, households needed to use less than 500 kWh per month, to ensure that the PV system output would be sufficient to meet most of their electricity demand.

Mercy Corps issued a competitive tender to procure the systems. Mustakbal Clean Tech was awarded a contract in February 201 and installed the systems, connected them to the grid, and tested them during the period June-July 2013. All systems were in operation by the end of July 2013.

The Mercy Corps PV Initiative was designed to deliver the following impacts:

1. Economic, by reducing household electricity expenditure;
2. Improved livelihood, by reducing the cost of additional electricity consumption;
3. Environmental, by reducing emissions; and
4. Social, by creating an understanding of how PV systems can improve livelihoods and thus increasing demand for the technology.

1.3 ESCB's Role

The USAID ESCB Activity is a four-year USAID-funded technical assistance project focused on building the capacity of Jordan's energy sector to develop energy efficiency, demand-side management, 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. Through its mandated scope of work, ESCB is interested in helping customers to save electricity, especially those customers served on retail tariffs where electricity prices are below the cost of service. ESCB is evaluating potential electricity saving activities for households, and has identified efficient lighting, solar water heating, and rooftop photovoltaic systems as particularly promising. Cooperating with Mercy Corps to measure and verify its PV Initiative's impacts was an excellent opportunity to build technical capacity, evaluate the extent to which PV technology helps households save on electricity bills, and to collect data that will help in designing future programs for electric utilities.

1.4 Survey Objectives

ESCB and Mercy Corps undertook the PV survey to determine whether those households that received rooftop PV systems were, in fact, receiving the projected economic and livelihood benefits. Specifically, the survey explored electricity bill savings and other benefits associated with the rooftop PV system installation.

1.4.1 Survey Methodology and Organization

ESCB and Mercy Corps worked together in the fourth quarter of 2014 to develop and implement the survey.

1.4.2 Survey Instrument

The ECSB team prepared the survey instrument in collaboration with Mercy Corps. The survey instrument included seven sections covering:

1. Identification and household member information
2. Unit and household information: type, surface area, number of rooms, and appliances
3. PV system information: changes in number of rooms and appliances since installing the PV system; changes in electricity bills; advantages of and challenges associated with installing PV systems
4. Lighting information: number and type of lighting fixtures, and hours of operation during summer and winter
5. Electrical appliances: number, size/capacity/wattage, manufacture, vintage year, and usage
6. Space and water heating and cooling equipment: number, capacity, manufacture, vintage year, and usage
7. Household income and expenditures

1.4.3 Field Work

ESCB trained Mercy Corps staff to conduct the actual household survey.

1.4.4 Data Processing

ESCB first identified missing or unclear information. When possible Mercy Corps provided additional information or clarifications. Revised surveys were sent to a data processing firm to be entered and verified. The data processing firm provided an SPSS database for analysis.

1.5 Surveys Completed

Mercy Corps staff completed surveys with the 59 of the 75 households that installed PV systems, 33 (56%) of which are in IDECO's service territory and 26 (44%) in EDCO's. The completed survey number represents a 79% response rate.

2 Customer Characteristics

This chapter presents the social, economic and housing characteristics of the customers surveyed.

2.1 Household Demographics

Table 2.1.1 shows the distribution of households selected for the survey. Nearly (42%) have more than six family members.

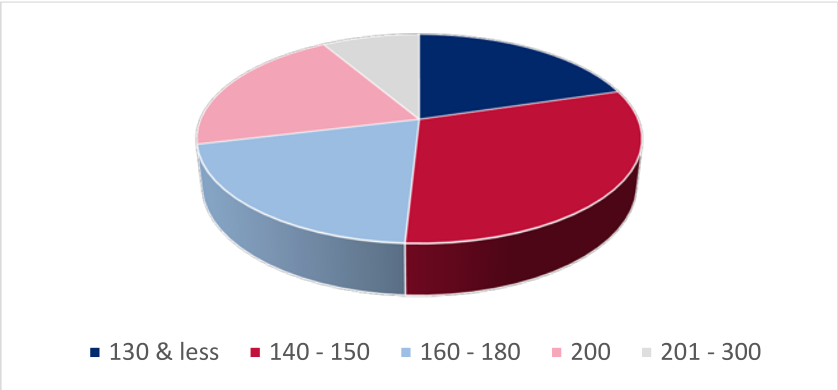
Table 2.1 Family size of participating households
Table 2

Family Size	Frequency
2-4 family members	18.6%
5-6 family members	39.0%
7-9 family members	35.6%
10+ family members	6.8%
Total	**100%**

2.2 Housing Types

All of the pilot program participants live in owned dar housing.[2] Figure 2.2.1 shows participants' housing size, which ranges from relatively small (less than 130 $m^{2)}$ to large (over 200 m^2).

Figure 2-1 Home size (m2)



Two thirds of those surveyed (68%) live in homes with four or five rooms, while 20 percent live in homes with six rooms. All of those surveyed have both a separate kitchen and separate bathroom within their homes.

2.3 Household Income

ESCB recently conducted a load survey across Jordan's three distribution companies. That study found that between two-thirds and three-quarters of Jordanian households have a monthly income less than JD 500. Overall, PV pilot program participant households tend to be more affluent; only 37% of the households surveyed earn less than JD 500 per month. Because PV pilot program participants had to pay JD 400 for their systems, it is not surprising that, on average, they have more disposable income than is typical of most households.

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

3 Changes in Household or Dwelling Characteristics

Installing the PV systems should cover most of the household's electricity bills, particularly since the pilot program screened out applicants with very high monthly electricity use. If a household electricity profile changes due to adding new appliances or from a change in household composition (e.g., adding a new baby), however, higher electricity use offsetting the PV-related savings can be the result.

The survey asked respondents to describe any changes in their household composition, appliance holdings or dwelling characteristics in the one year since installing the PV system.

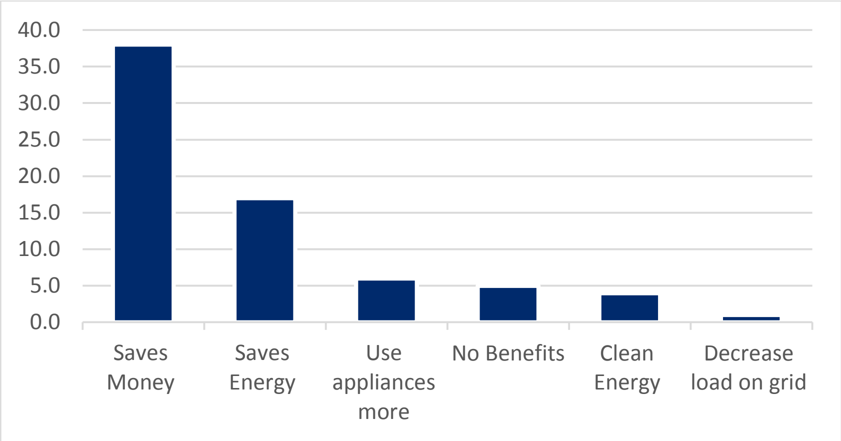
No household added a room to the house. Three households (5%) reported an increase in the number of family members, and one household reported a decrease. Twenty-two percent of those surveyed said they replaced or added an appliance. While most of the appliances added were small (e.g., irons or vacuum cleaners), five homes added or made changes to heating systems.

3 PV system benefits

3.1 Benefits Associated with the PV Systems

Respondents were asked to list the benefits of installing a PV system. Figure 4.1 shows that saving energy and money were by far the greatest PV system benefits reported.

Figure 4-1 Participant-reported PV Benefits (percent reporting)



3.2 PV System Issues

Over 60% reported no problems or concerns with their PV systems or their operation. Two customers (3%) noted that the system did not meet the home's full electricity needs, as they had expected. Five customers (9%) said their systems had maintenance issues; one noted that their system had failed and needed replacing.

Twelve customers (20.4%) noted that it took time to receive bills/invoices for their systems, but noted no other concerns about the PV installation. Other customers commented that the system did not have enough PV cells (1) that panel location was not appropriate (1) and that the electricity company did not have sufficient experience with the systems (1).

3.3 Estimating Electricity Savings from Billing Data

ESCB obtained electricity billing data from IDECO for the participating households. One full year of electricity bills before the installation of the PV systems was compared to one full year after installations for a total of 43 households. Basing the estimated savings on a full year of pre- and post-usage allowed the effect of seasonal patterns of household consumption and solar PV production to be included.

The estimated energy savings based on billing analysis were compared to an engineering calculation of PV system output. According to Mercy Corps, the average output of a 1.25 kilowatt peak (kW_p) system is 175 kWh per month or 2104 kWh annually.[3] Actual monthly output varies by season/weather.

[3] PV Pilot Project Completion Summary Report, Mercy Corps, 2015

For a number of IDECO customers, consumption increased during the first winter following the PV installation. Based on anecdotal evidence it seems that many customers thought that installing the PV system would mean that they had free electricity, so they increased their consumption. For most of these customers their bills dropped in January, after they received a December bill reflecting higher consumption that offset the PV system savings. This unanticipated start-up effect demonstrates the importance of a participant awareness program providing realistic expectations of PV system benefits.

Table 4.1 summarizes the results of evaluating pre- and post-PV changes in electricity bills. Electricity savings averaged over 43 households with 1.25 kW PV systems and two years of complete data was 1,516 kWh annually. This represents a reduction of 43% of average household usage before the PV installation, which is 72% of the engineering estimate of a PV system operating in northern Jordan. This represents a "realization rate" of 72% of the savings estimate based on engineering analysis.

Table 3-1 Actual Electricity Savings

Annual Pre (kWh)	Annual Post (kWh)	Annual Saving (kWh)	% Reduction	Planning Estimate (kWh)	Realization Rate
3,526	2,010	1,516	43%	2,104	72%

Figure 4.2 presents average monthly electricity consumption for the 12 months before and after PV system installation. Because the billing data represents the household consumption net of solar PV production, the before-and-after differences reflect both consumption behavior and seasonal variations in solar PV production. The before-and-after differences are consistent across most months, except for the first several months following PV installation (October-November-December) and the July-August period.

Analysis of the billing data together with interviews with households suggest that the progressively lower net electricity savings from October through December reflects a "learning curve" as households adapt to the PV system installation and its effect on monthly electricity bills. Interviews with households as well as the monthly savings trajectory suggest that households initially increased their electricity consumption in the mistaken belief that the PV system would provide them with unlimited free electricity. This higher post-installation consumption increasingly offset the PV production, culminating in December bills which were actually higher than the corresponding monthly electricity bill from a year before. Most households then realized that the PV savings could not compensate for their higher consumption, and adjusted their behavior to reduce their consumption back to pre-installation levels. The result was much higher electricity savings for the nine months beginning in January 2014.

Superimposed on this "learning curve" are seasonal variations due to household consumption patterns, PV production levels, and annual religious observances. Electricity savings are generally higher in the spring and summer months, due to lower consumption and higher PV production. The exception is the July-August-September billing cycles, which in 2014 corresponded to the Holy Month of Ramadan (June 29 – July 28 in 2014) – known to be an period of higher-than-average household electricity consumption.

Figure 4-2 Electricity Use Trajectory: October 2013-September 2014 (kWh)

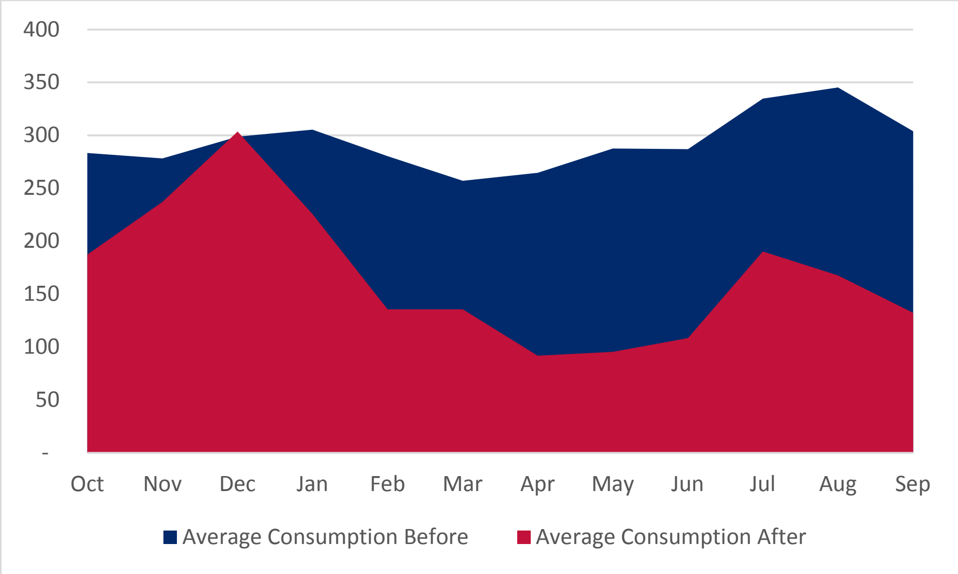


Figure 4.3 shows the trajectory of before-and-after consumption, expected savings, annual savings, and the "realization rate" (actual savings/expected savings). As in Figure 4.2, savings and "realization rates" are the lowest in the months following completion of PV installations, due to both higher consumption and lower solar PV production. The "realization rate" is highest in the shoulder and summer months – April-September – with the exception of July-August-September period, which in 2014 included Ramadan and Eid El Fitr.

Figure 4-3: Monthly consumption, expected and actual savings, and "realization rate"

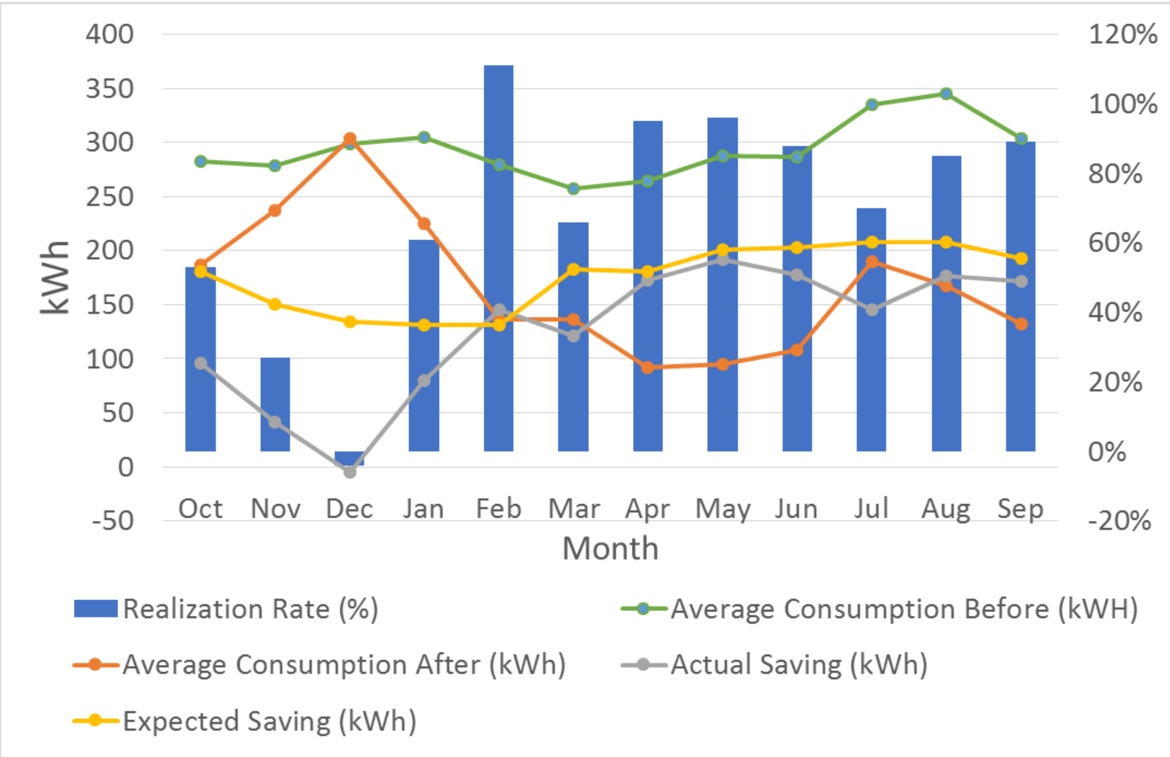


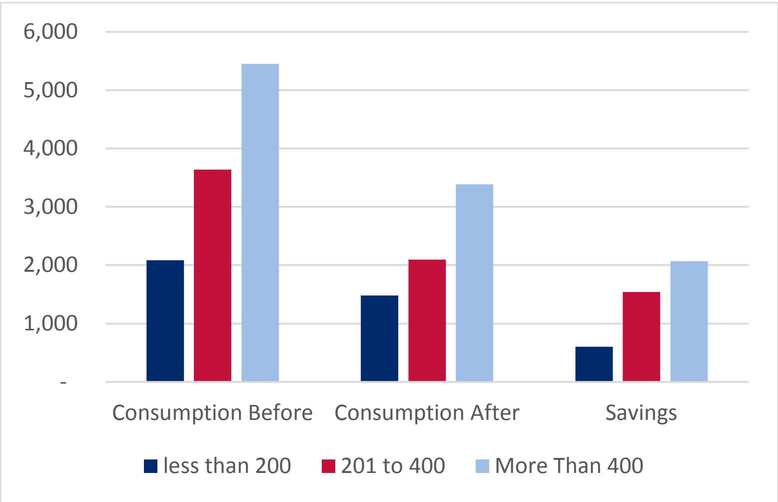
Table 4.2 and Figure 4.4 illustrate that electricity savings are highly dependent on pre-installation consumption levels. High users achieve significantly greater savings than low-users. The only households that consistently achieved their planning estimate of savings were those with pre-installation annual consumption levels of 5,500 kWh or more (realization rate of 98%).

Table 4-2 Electricity Consumption and Savings Pattern

Table 2

Consumption Group (kWh)	Consumption Before	Consumption After	Savings	Realization Rate
less than 200 (≤2,400/year)	2,084	1.483	600	29%
201 to 400 (2,412-4,800/year)	3,639	2,095	1,543	42%
More Than 400 (≥ 4800/year)	5,451	3,385	2,066	98%

Figure 4-4 Electricity Savings by Consumption Level (Annual kWh)



4 Conclusions and Recommendations

- Overall, the installed systems achieved 72% of the planning estimates of savings. Only large customers (approximately at an average of 5,500 kWh annually) achieved the full planning expected savings. ***In the future, if energy savings is the primary goal, the effort should target larger customers.***
- The billing data and anecdotal evidence obtained through household interviews suggest that participants were misinformed or unaware regarding the impacts of the PV system on their electricity bills. Many household expected that the PV system would provide them with unlimited, free electricity, and adjusted their consumption behavior accordingly. This resulted in diminishing electricity savings over the first few months. ***Additional customer education about system operations and expectations of impact on electricity bills is needed.***
- Several participants indicated that the utility staff did not know how to read the meters after the systems were installed; ESCB review of customers' billing records often showed no bills at all for a month or more after PV system installation, followed by very large bills once the utility began reading the meter again. ***The utilities need to educate their meter readers about the PV systems.***
- Using before-and-after electricity bills to evaluate the saving of household PV systems is an imperfect approach. ***Adding a meter to directly measure the PV production - at least on a representative sample of participants - would greatly improve the evaluation process and the accuracy of impact estimates.***

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