Measurement and Verification of Savings in the Oncor Texas Solar PV Pilot Program

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Introduction

Frontier Associates (FA) and Clean Energy Associates (CEA) have administered the Oncor Texas Solar PV Pilot Program since its inception in 2009. As part of the program administration contract, FA/CEA is required to complete persistence inspections of at least 20% of PV systems that have been operational for 12 months or longer.

This document describes how the persistence inspections were conducted, outlines methods for analyzing data, presents findings from the study, and makes recommendations for program and savings calculations modifications based on those findings.

1. Data Population and Study Selection

Beginning in May 2011, FA/CEA randomly selected projects from our 2009 and 2010 program database with recorded completed/paid dates of July 1, 2010 or earlier. This population consisted of 318 projects eligible for study, including 276 (87%) residential, 39 (12%) commercial, and 3 (1%) government or non-profit sites. Fifty-three different service providers were involved in installations of systems in the eligible population.

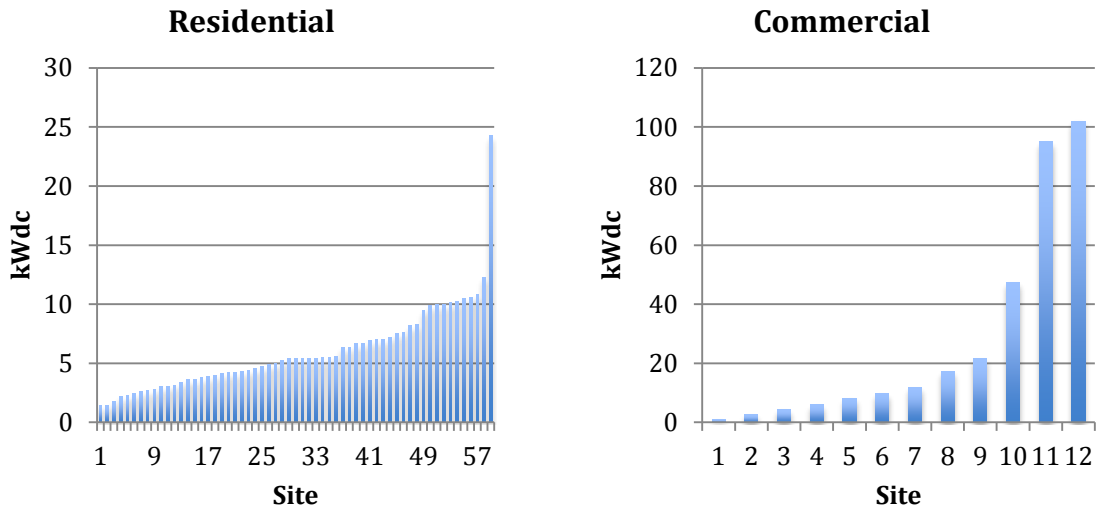
FA/CEA selected and inspected 72 of the 318 eligible projects (23%) in the summer of 2011, in excess of the 20% contractual inspection requirement. Of the 72 selected for inspection, 58 (80.5%) were residential projects, 12 (16.6%) were commercial projects, and 2 (2.7%) were government projects. Twenty-nine service providers were represented in the selection.

Data were collected through an onsite visit to each selected project. Customers were contacted in advance to set up a time for the site visit, but were not required to be present unless needed to provide access to system meters and inverters. Data collected included:

- Meter reading date
- Cumulative kWh solar energy production reading from both the system inverter(s) and the installed solar meter
- Utility meter reading, including readings of inflows and outflows, inverter, solar meter, and utility meter make and model information
- Additional comments on system operation

Selected system capacity ranged from 1.05 kWdc to 236.13 kWdc with an average capacity of 12.984 kWdc. The average capacity of the sample is higher than the average capacity of 7.87 kWdc in the population eligible for study due to the higher percentage of large commercial and governmental projects present in the sample. The sample average capacity for residential projects is 6.07 kWdc, slightly higher than the population average of 5.67 kWdc. The average commercial capacity in the sample is 27.22 kWdc, 10 kWdc larger than the 17.4 kWdc population average. Government and non-profit system capacity averages 128 kWdc in the sample compared to 86.4 kWdc in the population of eligible sites. Figure 1 depicts residential and commercial sample system sizes.

Figure 1: Sample System Size kWdc



2. Methods for Data Analysis

Annual Energy Savings

Analysis of energy production data involved comparing actual energy production obtained from meter readings to deemed savings values as well as to estimates of annual energy production provided by service providers prior to construction.

- **Actual Energy Production**. Metered solar energy production values were converted to an annualized basis in order to account for differences in installation date and to facilitate comparison to deemed energy savings values and estimates of annual energy production.

- **Deemed Energy Savings Values.** The current approved methodology for calculating deemed energy savings for PV systems assumes a conforming[1] PV system will produce 1,600 kWh per kWdc installed on an annual basis.
- **Estimated Annual Energy Production.** Estimates of annual energy production were provided by each service provider in the initial application for funds. These estimates were derived from the PV Watts version 1 model developed by the National Renewable Energy Laboratories[2], with modifications to account for measured onsite shading as described in the Program Guidebook.

Peak Capacity Savings

We compared modeled peak capacity of installed PV systems against deemed peak capacity during two defined peak periods:

- 1:00 PM through 7:00 PM in the months of June through September, and
- 4-5 pm on August 23, 2010, the hour of Oncor's system peak in 2010

The modeled and deemed capacity savings were obtained as follows:

- **Modeled Capacity.** Data on the actual capacity of PV systems studied during peak periods was not available. Instead, we derived estimates of actual capacity during peak periods by adjusting the PVWatts model by a factor to account for the observed difference between measured and estimated production values, re-running the model to obtain hourly output data, and selecting hours or periods that were most similar to defined peak capacity hours in 2010. The model assumes 70% of systems are oriented directly south, while 15% face southwest and 15% face southeast.
- **Deemed Capacity.** The current approved method for deriving deemed capacity assumes a PV system will produce 0.83 kW per kWdc installed.

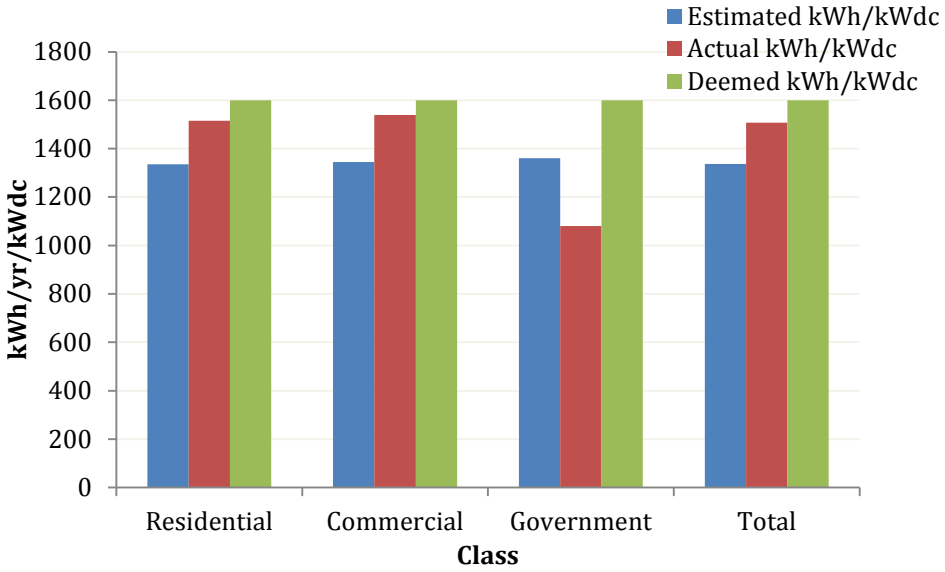
[1] The deemed energy savings value is used statewide, and assumes a PV system array "azimuth shall be within +/- 20 degrees of south" and the "tilt angle shall be between 0 (horizontal) and latitude +15 degrees." The sample fleet used in this study conforms with this definition on average, with an estimated 70% oriented directly south (180 degrees) with a 30 degree tilt and an estimated 30% of the sample oriented within 50 degrees of south at a 30 degree tilt.

[2] See http://rredc.nrel.gov/solar/calculators/PVWATTS/version1/US/Texas/.

3. Energy Savings

Figure 2 depicts actual annualized average energy savings versus estimated and deemed energy savings per kWdc installed for the systems selected for study. Actual energy production was greater than service provider estimates for most systems but were lower than deemed energy savings estimates in most systems.

Figure 2: Average Actual, Estimated, and Deemed Energy Savings



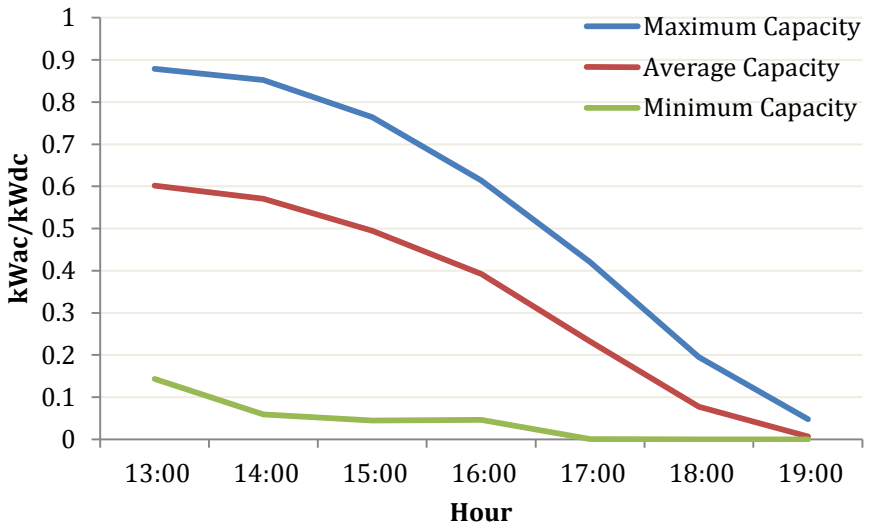
On average, actual energy savings were 1507 kWh/kWdc, greater than estimated energy savings (1337 kWh/kWdc average), but less than the deemed energy savings (1600 kWh/kWdc).

Governmental systems were the only systems to produce less than estimated by service providers. This is explained in part by inverter and metering malfunctions at the larger of the two government sites inspected during the first few months of operation.

4. Capacity Savings

Figure 3 illustrates the hourly maximum, average, and minimum modeled capacity delivered by the selected PV systems over the defined peak period of 1-7 p.m. in June through September. The peak period maximum capacity of 0.879 kWac/kWdc occurred at the 1 p.m. hour, while the minimum value of 0 kWac/kWdc occurred at the 7 p.m. hour. Average capacity over the six-hour peak period was 0.34 kWac/kWdc installed.

Figure 3: Average PV Capacity During Peak Hours



In 2010, Oncor incurred its peak energy demand between 4 and 5 p.m. on August 23 during which time we estimate the average system from our sample to have delivered a capacity of approximately 0.31 kWac/kWdc installed.[3]

[3] Estimate derived from TMY data for similar irradiance and weather conditions and adjusted for extreme heat of 2010.

5. Findings and Discussion

Finding #1: ***Sample data indicate that, on average, systems selected for study produced 1,507 kWh/kWdc, a level greater than estimated production (1,337 kWh/kWdc) but less than the deemed savings value (1,600 kWh/kWdc).***

We suspect the variation between actual production and estimated production can be at least partially attributed to these factors:

- **Variation in actual 2010 weather conditions versus "typical" weather data used in PVWatts modeling.** PVWatts utilizes "typical meteorological year" (or "TMY") weather data sets to produce estimates of annual energy production. However, those TMY data sets are constructed from measured weather data collected between 1960 and 1990, whereas measured weather data throughout the past decade has shown to be some of the hottest (and by inference, sunniest) weather on record. A comparison of 2010 and TMY weather data indicate an increase in average daily maximum temperatures of about 2 degrees F in 2010. Though higher temperatures are known to cause a small decrease in PV system efficiency, they are also likely to be associated with an increase in solar radiation, which would have a larger and positive effect on system production.
- **Discrepancies between actual and reported installation dates.** Annualized actual production data may be slightly over reported due to potential discrepancies between the recorded and actual installation dates. Recorded installation dates were based on the date we first a received final application for each system. However in some cases receipt of the final application may have been delayed relative to the actual operational date.

We believe average actual production was less than deemed production primarily due to assumptions behind the deemed savings model being poorly applicable to Oncor's service area. The deemed energy savings factor was derived from actual and modeled performance of a PV system located in central/west Texas (Abilene). Average daily solar radiation in Oncor's service area is approximately 94% of that in central/west Texas.

Decreasing the deemed energy savings value by this factor would yield a deemed savings estimate of 1,504 kWh/kWdc for Oncor, approximately equal to the actual annualized energy savings of 1,507 kWh/kWdc, but higher than the estimated production values provided by service providers in their initial applications (1337 kWh/kWdc on average).

Finding #2: ***System modeling derived from actual production data indicate that capacity provided by PV systems during Oncor's 2010 system peak hour was approximately 0.31 kW/kWdc installed. During peak periods (1-7 p.m. from June to September), capacity provided by PV systems ranged from 0 to 0.879***

kW/kWdc installed, with an average of 0.34 kW/kWdc installed. These figures compare to PV's deemed capacity value of 0.83 kW/kWdc installed.

PV provides decreasing capacity over summer afternoon peak hours, but provided average peak capacity during Oncor's 2010 peak hour. This is consistent with other findings that positively correlate PV availability to utility peak capacity needs, although production decreases rapidly in the late afternoon. Conversely, the current deemed capacity value of 0.83 kW/kWdc is a closer representation of PV's maximum capacity delivered during the defined peak period, which may overvalue PV's contribution during the peak period as a whole and during actual hourly system peaks.

6. Recommendations

PV Energy Savings

The current deemed energy savings estimate of 1,600 kWh/kWdc is inappropriate for Oncor's service area and results in over-reporting of energy savings achieved by PV installations.

Recommendation: We recommend further consideration of different approaches to more accurately account for PV energy savings:

- ***Option #1: Revise deemed energy savings estimate of 1,600 kWh/kWdc to 1507 kWh/kWdc.*** This initial sample indicates a realistic deemed savings value in the neighborhood of 1507 kWh/kWdc. However, further study is warranted based on the limited time period over which performance could be assessed.
- ***Option #2: Replace the standard deemed savings value with a system-specific estimate derived from PVWatts.*** Calculate the energy savings for each system based on an estimate derived from PVWatts but with the DC-to-AC derate factor adjusted to account for the greater energy production observed to date.[4]

PV Capacity Value

We believe the capacity at the hour-of-peak demand may be more appropriate than average capacity during all peak hours for PV in measuring capacity contribution, though further study of Oncor's system peaks is warranted to validate that conclusion.

Recommendation: If PV capacity is intended to reflect the maximum capacity delivered during peak periods, then the existing value of 0.83 kW/kWdc installed is consistent with the observed value of 0.86 kW/kWdc installed and may be appropriate. However, if other interpretations of capacity value are warranted, we would recommend beginning with further analysis of PV's performance during actual system peaks.

Finally, we note that these findings and recommendations are relevant only to the calculations of reported savings from PV installations. These findings along with other factors, such as ease of implementation, ease-of-use by customers and service providers, and consistency with other programs, should be considered in any separate analysis of the optimal means for structuring incentives in the Oncor PV incentive program.

[4] A derate factor of 0.83, for example, instead of the PVWatts default of 0.77, would result in a production estimate for an optimal system of 1,515 kWh/kWdc, close to the observed average of 1,507 kWh/kWdc.