Commonwealth Solar Hot Water Program

Residential Performance Monitoring

Interim Report

Issue Date: June 1, 2012

MASSACHUSETTS CLEAN ENERGY CENTER

JOIN THE INNOVATION REVOLUTION

55 Summer Street, 9th Floor

Boston, MA 02110

www.masscec.com

Prepared By:

BEAM

BEAM Energy & Engineering
Boston, MA
www.beamgrp.com
888 662 6986

Chris Beebe, PE, cbeebe@beamgrp.com - Lead Author

Jennifer Taylor, jtaylor@beamgrp.com - Supporting Author

Ken Beebe, kbeebe@beamgrp.com - Supporting Author

Supported by the Massachusetts Clean Energy Center (www.masscec.com)

Contents

Executive Summary

In February 2011, the Massachusetts Clean Energy Center ("MassCEC") launched the Commonwealth Solar Hot Water Program, a pilot program providing rebates through a non-competitive application process for the installation of solar hot water projects by professional installers at residential and multi-family (1-4 unit) homes.

As part of the Massachusetts Clean Energy Center's (MassCEC) investment in solar heating technologies under the Commonwealth Solar Hot Water Program, a performance monitoring program was established to understand and quantify the performance of solar thermal systems deployed in Massachusetts. Forty residential systems were accepted for monitoring. There are currently 30 of the target 40 residential solar hot water projects online. With 30% of the target amount of data (12-months each project) having been collected, preliminary comparisons have been made between modeled performance, monitored performance, and SRCC OG-100 performance benchmarks. Additionally, field issues related to performance monitoring installations have been identified.

Overview: One of the primary goals of the pilot program was to meter a subset of solar hot water systems to gather and analyze performance data to help develop subsequent program design. MassCEC offered additional funding to system owners who volunteered to install performance monitoring equipment. MassCEC funds the equipment and installation cost in full, up to $1,000 for a 'single' BTU calculation (four data points) and $1,500 for a 'double' BTU calculation (eight data points).

Premise - By understanding the actual, real-time performance of solar hot water systems incentivized under the Commonwealth Solar Hot Water Pilot Program, best-practices can be encouraged in future iterations of the program. Not fully understanding real-life performance of solar hot water systems has hindered market growth, as financing, sources of system risk, proper design, or the longevity of system performance. The design of the MassCEC Performance Monitoring program seeks to address and understand these concerns, with the intention of alleviating these issues, and paving the way for sustained, understandable growth in the solar hot water industry.

Innovation - The approach is innovative in the sense that for the first time in the country, a statistically significant set of projects have been monitored to better understand solar hot water technologies. Other programs have pursued a non-funded, "opt-in" approach to monitoring, which has had poor customer participation results, and subsequently extremely high administrative costs. The decision of the MassCEC to allocate funds to project monitoring costs directly has been well received by the contractor base and customers alike, with robust customer participation and delivery coming in substantially under comparable programs.

Participation - A total of forty (40) customers had monitoring systems installed by nineteen (19) different contractors. Five (5) monitoring technologies were deployed, with the majority (35) being the SunReports system. These systems are monitoring twenty-seven (27) glazed flat plate collector projects, eleven (11) evacuated tube collectors projects, (1) combined flat plate and evacuated tube project, and one (1) parabolic concentrating collector project; the collector-types include seventeen (17) manufacturers. These systems will displace fuel costs related to fifteen (15) oil systems, twelve (12) natural gas, eight (8) electric, four (4) propane, and one (1) wood.

Costs - Due to increasingly streamlined system integration, costs for monitoring systems have been dramatically reduced over the past few years. Average system cost for the residential performance monitoring program was $1,138 per project. Typical equipment costs are $400 - $1,000; install labor costs $200 (assuming 2-3 additional hours of installation time). Additionally, data services may add cost if internet is not already present. MassCEC capped 'single' BTU calculation (four monitored data points) systems at $1,000 / project and 'double' BTU calculation (eight monitored points) systems at $1,500 per project.

Progress to Date: The program has compiled approximately 30% of the required 480 months of data (40 projects times 12 months each = 480 data-months). Thirty (30) projects are now online and accessible by the MassCEC. The remaining ten are expected to come online within the next few months.

Performance - Energy generated from all 40 systems is modeled to be 4,931 therms annually (144,446 kWh equivalent). Actual system performance has measured 393.3 therms for the customers that are online. Expected monthly monitored energy production has varied from 26.7% to 134.6% of expected. Projects known to have other issues, as well as intermittent internet availability has skewed results, and this must be corrected for the full analysis of the data.

Preliminary Findings - When reporting correctly, the performance monitoring system has the ability to track expected production quite closely to modeled energy production. Actual production appears to be within 80%-110% of the expected generation indicated by energy modeling. The statistical signification of these findings and influencers has yet to be determined.

As we reviewed the data from the monitored sites, we recognized that drastic variations in performance are often due to inconsistent installation practices. The improper placement of sensors or erroneous configuration entries will adversely affect the results displayed in the performance monitoring system. The only way to establish valid and accurate information is to develop consistent installation practices and verification procedures that can be implemented for every new installation. A detailed installation checklist, including pictures, could be created emphasizing the criticality of proper placement and verification.

1. Program Criteria: Goals and Benefits

Commonwealth Solar Hot Water Pilot Program

The Commonwealth Solar Hot Water (CSHW) Residential Pilot Program offers rebates through a non-competitive application process for solar hot water (SHW) construction projects at single-family and multi-family (up to 4 units) residences. The CSHW Program established eligibility requirements as follows:

- Solar water heating systems for domestic water heating and space heating are eligible; pool heating is not eligible
- Systems may offset any fuel type (electricity, oil, propane, natural gas, other)
- Equipment must be OG-100 or OG-300 certified by the Solar Rating and Certification Corporation ("SRCC")
- Collectors must be subject to at least 5 hours per day unobstructed sunlight (75% shade-free)
- All systems shall have appropriate stagnation and freeze protection and must have insulation on all exposed and accessible hot water piping.

Performance Monitoring Program Criteria

Standards were established for performance monitoring program participation. The program allowed contractors to choose any manufacturer or solution provider of performance monitoring equipment, given it met program criteria. In many cases, contractors were not familiar with installing performance monitoring equipment and were provided with guidance on performance monitoring options. Performance monitoring program criteria includes:

- Refund up to $1,000 for four points of monitoring (3 temperature sensors, 1 flow fate), and $1,500 for eight points of monitoring (6 temperature sensors, 2 flow rates)
- Contractors and customers jointly decided to participate or not participate in the program
- Remote access capability by customers, contractors, and program administrators
- System must monitor and calculate thermal energy input to solar tank or into the target hot water load or both

Performance Monitoring Program Goals

- Understand actual solar hot water system performance for a variety of systems across Massachusetts
- Establish an acceptable standard deviation to define accuracy of savings data, whether it comes from a contractor, SRCC, or performance monitoring equipment.
- Provide a low or no cost monitoring solution for customers
- Build hands-on experience for contractors with performance monitoring solutions
- Create case studies and share production information to create awareness and confidence in the technology, thereby increasing adoption of the technology

- Utilize the results of this program in the implementation of a full scale solar hot water incentive program
- Build foundation for potential future incentive structure so administration and installation issues are known and understood

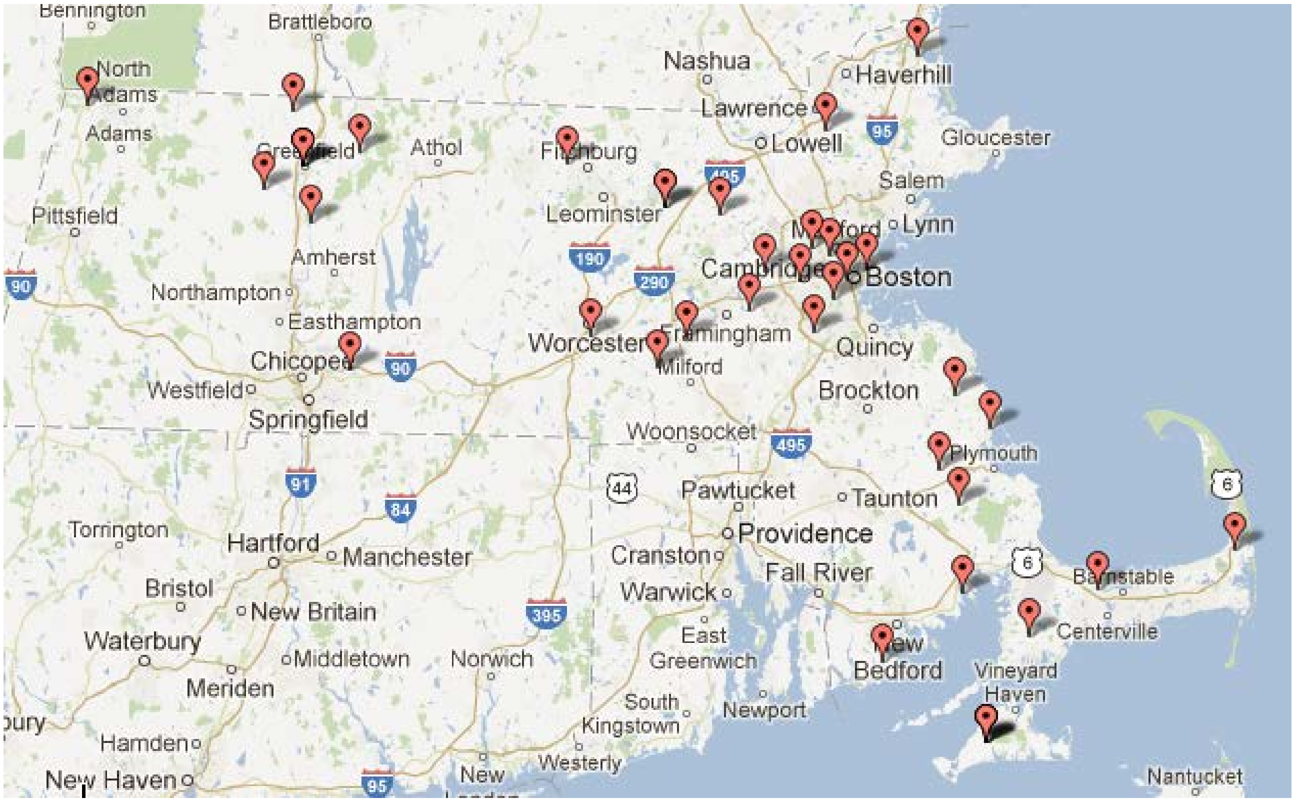
Project Benefits of Performance Monitoring

- Ensure normal operation and optimal system production
    - Notification of operational system issues which may reduce downtime and extend system's functional lifetime
    - Peace of mind for homeowner that their investment is producing expected energy
- Build and improve customer relationships and marketing opportunities
- Improve future solar hot water system design with additional understanding of system performance and components and identify which solar hot water systems or technologies outperform or underperform in this region.

2. Program Participation

Through the Commonwealth Solar Hot Water Pilot Program, MassCEC offered additional funding to solar hot water system owners who volunteered at the time of application to install performance monitoring equipment. MassCEC reserved funding for 40 projects on a first come first serve basis. Below is a summary of the cross section of projects analyzed.

Type of Residence	35 single family 5 multifamily (up to 4 units)
Solar Hot Water Application	29 domestic hot water (DHW) heating 11 combination DHW and space heating
Collectors	25 glazed flat plate 11 evacuated tubes 2 unglazed flat plate 1 combination flat plate and evacuated tube 1 concentrating dish
System Type	29 pressurized, closed loop glycol 10 drainback 1 open loop
Displaced Fuel	15 Oil 12 Natural Gas 8 Electric 4 Propane 1 Wood
Monitoring Solution Providers	35 SunReports Apollo 1 2 Resol DL2 1 Heliodyne Delta T Pro 1 Locus L Gate 1 SolarTron Solarbeam
Points monitored	33 "single loop" - four points of monitoring (3 temperature sensors, 1 flow fate) 7 "double loop" - eight points of monitoring (6 temperature sensors, 2 flow rates).
Installing Contractors Participated in Program	19 contractors


Bennington
Brattleboro
North Adams
Adams
Nashua
Haverhill
Lawrence
Lowell
Gloucester
Athol
Pittsfield
Leominster
Salem
Lynn
Amherst
Cambridge
Boston
Northampton
Easthampton
Worcester
Framingham
Quincy
Chicopee
Milford
Westfield
Springfield
Brockton
Woonsocket
Plymouth
Pawtucket
Taunton
Torrington
Hartford
Providence
Manchester
Cranston
Fall River
Barnstable
Bristol
Warwick
New Britain
Centerville
East Greenwich
New Bedford
Waterbury
Middletown
Norwich
Vineyard Haven
Meriden
South Kingstown
Newport
Hamden
New Haven
Westerly
Nantucket

3. Methodology

Important note: We modeled each system using the project-specific parameters identified in section 3.5 using T*SOL, a widely accepted software program used for detailed solar thermal performance models. <u>This model will serve as the baseline for comparison to other performance indicators,</u> including the installed monitoring equipment, SRCC estimations, and savings numbers provided to the MassCEC by the installers when applying for the construction rebate.

3.1 Monitoring Costs

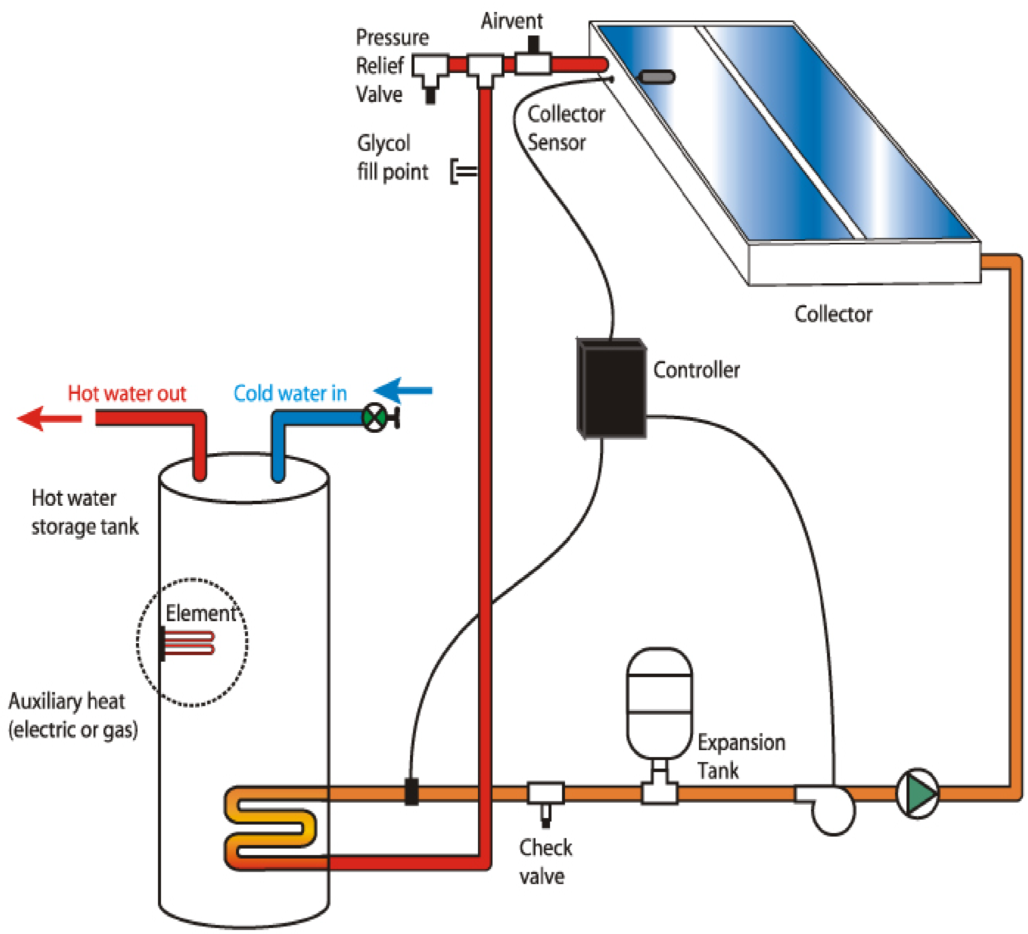
Average system cost for the performance monitoring program was $1,138 per project. MassCEC capped the refund at $1,000 for four points of monitoring (3 temperature sensors, 1 flow fate) per project, and at $1,500 for eight points of monitoring (6 temperature sensors, 2 flow rates) per project. The "single loop" BTU approach calculates heat entering one of the system components, either the solar hot water storage tank or the target hot water load. The double BTU calculation monitors the amount of heat entering both of the solar hot water storage tank and the target hot water load.

Costs are typically driven by three major sources:

Cost Source	Description
Equipment	• Monitoring unit, sensors including temperature, flow meters, current transducers, and pressure; $400 - $1,000
Labor for Installation	• System installation typically requires 1-2 hours, depending on number of data points; $150
Data Services	• Performance data stored on an accessible remote server (i.e. cloud based), server costs can be incurred in two ways: o Internet connection - Costs vary, $0/month if service already present, $20/month to $80/month if new connection needed o Data hosting - Costs vary, $2/month up to $30/month

3.2 Data Points and Sensors

Monitoring systems collect data from solar thermal collectors through a network of sensors that deliver information about temperatures, flow rates, pump operation, valve positioning, system pressure, power usage, solar radiation and humidity. Descriptions of these system components are provided below.



Controller – The controller processes system information from the various sensors and sends system control signals to the systems to instruct proper operation. Performance data can be held locally (i.e. on an SD card) or remotely via an internet based cloud server.

Temperature Sensors – Thermistor type sensors are typically used for temperature monitoring in solar hot water applications. These types of sensors use variations in resistance as a function of temperature to indicate the temperature of the monitored point. Typical temperature points of interest are collectors, storage tanks, ambient air temperature, incoming cold water, or delivered hot water temperature.

Flow Meter – A flow meter can indicate the amount of fluid passing through the solar system or the amount of DHW consumed at the site. Flow meters come in a number of forms, including paddle, sonic, and vortex type. Vortex flow sensors are typically less expensive, last longer, and are more accurate than pulse or paddle-wheel sensors, and thus are often selected for the long term monitoring of solar hot water systems.

Pressure Sensors – Pressures sensors are an optional piece of equipment which are used to indicate the operating pressure of the solar system and can be used to notify the installing vendor if the system is operating outside design parameters.

Solar Resource – A pyranometer measures available solar radiation (insolation) at a given location, panel angle, and orientation. This amount of energy is equal to the maximum amount of thermal energy input to the solar hot water system and is important in calculating the real-time collector efficiency.

Pump Motor Operation – Electricity monitoring with compatible current transformer can provide a number of electric parameters including voltage, current, energy consumption (kWh), and power factor. Pump energy consumption is considered a parasitic loss and is thus important in understanding the overall energy impact of the solar hot water system.

Element - Often the system has fossil-fuel based heat input to the hot water system. This additional heating element can be monitored in order to better understand the contribution of carbon emitting fuels in the production of usable heat energy.

The identification, function, and critical installation notes for various sensor types are discussed below. Each sensor input on the controller may be compatible with one of multiple sensor types (i.e. flowmeter, electric transducer, pressure, etc.), therefore care must be taken to ensure that system settings and integration are correct.

3.3 Energy Calculation

Solar thermal systems absorb energy from the sun and transfer that energy into useful heat used to preheat domestic hot water or provide space heating. Operational efficiencies of this process may vary substantially based on project specific conditions such as equipment used, installation practices, climate zone, and load profile. Metering of solar hot water systems allows owners, installers, and program administrators to better understand system performance and inefficiencies that will help inform program design and encourage high-performing systems.

This program monitored either the energy input to the storage tank or energy input to the target load, or both. Quantification of the thermal energy production is based upon the following heat transfer equation:

$$Q = \Sigma\,(m \times c \times (T_2 - T_1))$$

Where,

Q = Energy (btu or W)

m = mass of fluid (lb or kg)

c = specific heat of fluid (Btu/lb°F or kJ/kg K)

T2 = Energy after heat exchange (F or C)

T1 = Energy before heat exchange (F or C)

Data Point Input	**Irradiation on Collectors**	**Energy Delivered from Collector to Storage Tank**	**Energy Input to Target End-Use Load**
Temperature (T1)		Collector Out	Load Cold Out
Temperature (T2)		Collector In	Load Hot In
Mass Flow Rate (m)		Collector Fluid (convert to lb)	Target Water Load (convert to lb)
Specific Heat (c)		0.9 (if 40% propylene glycol) or 1.0 (if water)	
Solar Resource	Pyranometer		

Net energy savings of the solar hot water system are equal to the thermal energy input to the target hot water load minus parasitic loads (i.e. electric energy required by pumps, controller, monitoring). Pump energy is required to move fluid through the collectors, tanks, and exchangers to facilitate useful heat transfer and was not directly monitored as part of this report.

3.4 Solar Resource

- TMY3 historical data is used for energy model calculations and SRCC estimations.
- Weather conditions produce a high degree of variability in short term measurement sets; over a 12-month data set the variability impact of climate conditions may decrease.
- Monitored energy production will be normalized to actual monthly irradiation data for project location sites and included in the final report.

3.5 Determining and Validating Energy Savings

Solar hot water systems have approximately 10-15 critical variables and up to 50 secondary variables that can impact performance. There are multiple methods to aggregate variables to understand expected energy production. Simulation-based methods include energy modeling or SRCC performance benchmarks. Field measurement-based methods include short-term or continuous monitoring of system data points. Whole facility-based methods include a comparison of utility metered usage both pre-installation and post-installation of the solar thermal system.

There are pros and cons to each of these approaches relating to time, cost, accuracy, and complexity. A goal of this analysis is to determine the applicability of these methods based upon system and customer type.

The framework of this analysis will draw off the International Performance Measurement & Verification Protocol (IPMVP). The IPMVP defines approved general procedures to achieve reliable and cost-effective determination of savings in energy and water efficiency or conservation projects. This method is the accepted and practiced protocol in the ESCO and performance contracting fields.

Table: IPMVP Energy Saving Measurements Options

Method	Description	Example
A. Partially Measured Retrofit Isolation	Savings are determined by partial field measurement of the energy use of the system(s) to which an ECM was applied, separate from the energy use of the rest of the facility. Measurements may be either short-term or continuous. Partial measurement means that some but not all parameter(s) may be stipulated, if the total impact of possible stipulation error(s) is not significant to the resultant savings. Careful review of ECM design and installation will ensure that stipulated values fairly represent the probable actual value. Stipulations should be shown in the M&V Plan along with analysis of the significance of the error they may introduce.	Continuous Performance Monitoring, Indirect with Assumed Variables i.e. Energy Input to Storage Tank, with assumed standby, heat exchanger, and balance of system losses.
B. Retrofit Isolation	Savings are determined by field measurement of the energy use of the systems to which the ECM was applied, separate from the energy use of the rest of the facility. Short-term or continuous measurements are taken throughout the post-retrofit period.	Continuous Performance Monitoring, Direct i.e. Energy Directly Input to Hot Water Load
C. Whole Facility	Analysis of whole facility utility meter or sub-meter data using techniques from simple comparison to regression analysis.	Utility Bills i.e. Comparing summertime fuel usage year over year
D. Calibrated Simulation	Energy use simulation, calibrated with hourly or monthly utility billing data and/or end use metering and/or operational conditions	TSOL, or similar Energy Model i.e. Input

The options, as applied to solar hot water, are described below. This includes the pros and cons of each measurement metric.

Performance Monitoring - Indirect Measurement with Assumed Variables (Option A) - This method measures the amount of energy entering the storage tank put in by the solar collectors. It makes assumptions on tank losses, pipe losses, and heat exchanger losses in order to calculate backup fuel displacement. By monitoring the solar hot water system operation, the contractor or system owner can be alerted if the system is not operating correctly, increasing energy savings and improving uptime.

Performance Monitoring - Direct Measurement (Option B) - This method measures the amount of energy directly entering the target hot water stream. While a more accurate measurement of fossil fuel being displaced, it cannot directly provide data on solar hot water system operation itself.

Utility Bill Comparison (Option C) - Looks at year over year backup fossil fuel energy consumption as indicated by the utility bills. For DHW systems this is typically done by comparing summertime usage before and after installation, with the reduction in energy usage being attributed to the solar hot water system. A drawback of this method is that it does not account for occupant usage within the building varying between comparison points.

SRCC OG-100 Ratings (Option D) - is used as a measure to compare performance of collectors across a set of defined operating conditions. OG-100 ratings are not meant for project-specific design purposes, and therefore cannot generally include variations relating to seasons, loading, or installation parameters. In this context, the field calibration assumes that the system specified was installed and that the system is functioning, unless stated otherwise.[1]

Energy Model (Option D) - An energy model can calculate expected energy production for a solar hot water system. In this approach, field calibration assumes that the system was installed as specified and that the system is functioning, unless stated otherwise. Energy models were created for each of the 40 participating systems. When building an energy model, the following project specific parameters were taken into account:

- Collector Manufacturer
- Collector Model
- Collector Quantity
- Collector Tilt
- Solar Water Tank Size (gallons) - Normalized to 20 GPD per person
- Solar Water Tank Quantity

[1] The Solar Rating & Certification Corporation (SRCC) is an independent third-party certification organization that administers national certification and rating programs for solar energy equipment. The SRCC generates relative performance ratings of different solar water heating collectors given a standard set of laboratory conditions. These performance ratings are not meant to generate actual expectations as they do not account for other important factors such as the quality of installation or unexpected weather conditions. The SRCC solar collector thermal performance ratings are valid only for the fluid and flow rate used to generate the ASHRAE test data, as stated on their website. A more complete description of their methodology can be found at www.solar-rating.org.

- Collector Azimuth
- System Type
- Total Collector Area (Sq ft)
- Water Heating System Fuel Type
- Water Heating System Tank Type
- Water Tank Manufacturer (if available on T*SOL)
- Water Tank Model (if available on T*SOL; most not available)
- Use Type (DHW, Space Heating, Combination)
- Hot Water Consumption (Gallons / day)
- Collector Type (Evacuated Tube vs. Flat Plate)
- Project Location and Climate Data

4. Interim Results

4.1 Monitoring Installation Issues

There are a number of observed issues that may adversely affect the reliability of energy production data being reported through the monitoring system. These issues must be resolved, validated, and standardized in order to establish confidence in the accuracy of the reported performance. The following issues have been identified in the subset of projects that have been reviewed.

Online Setup Issues

- Sensors are incorrectly labeled on the online setup
- Incorrect VFS, or flowmeter, is installed or indicated
- Default flowrate of 1 GPM when using current transformer is not changed
- Basic alarms and alerts are not being configured

Flow Sensor (VFS) Issues

- Insufficient grounding of the sensor to controller or to the system
- Wrong selection of flow sensor for actual flow
- Air in the System
- Glycol % in water is too high which impacts the threshold accuracy of the sensor
- Electromagnetic interference (EMI)
- Low velocity creates laminar flow around vortex sensor
- Splicing any cable above recommended length can weaken or distort signal
- When measuring two flow rates, VFS may be plugged into wrong port (CT1 vs CT2)

Temperature Sensor Issues

- Temperature sensor is missing insulation wrap (allows for ambient air interference)
- Do not have the sensor flat surface facing down and flush on the pipe
- Sensors poorly secured to pipe and may fall off
- Incorrect placement

Connectivity Issues

- Internet connection is unplugged or disconnected
- Monitoring system is unplugged
- Internet service disruption

*4.2 Project Performance & Interim Conclusions**

The table below compares the stated energy production between our baseline TSOL energy model generated for each project, and SRCC estimations, contractor estimations submitted to MassCEC with the rebate application, and the monitored performance. A positive percentage in the table represents a higher than expected number as compared to our TSOL model, and likewise, a negative percentage represents an underestimation or underperformance as compared to our TSOL model. One standard deviation represents 68% of the total sample size, and two standard deviations represent 95% of the total projects. This means that for this sample size, one standard deviation (shown in table below) represents the range of values found in 27 of the 40 projects (68% of projects).

***Note: Performance monitoring numbers are subject to common identified issues discussed above, and a consistent methodology for validating installation practices has not yet been established.**

Baseline TSOL Energy Model versus:	**All Projects** (Sample Size: 40)	**DHW Projects** (Sample Size: 29)	**Combination Systems** (Sample Size: 11)
SRCC Category C, Mildly Cloudy**	*Mean: +63.4%* *St. Dev: 44%*	*Mean: +50.1%* *St. Dev: 38.8%*	*Mean:+106.1%* *St. Dev: 40.4%*
Contractor Estimation	*Mean:+3.8%* *St. Dev: 54%*	*Mean:-5.6%* *St. Dev: 51%*	*Mean: +30.9%* *St. Dev: 56.9%*
Performance Monitoring*	*TBD*	*TBD*	*TBD*

** The Commonwealth Solar Hot Water Incentive Program currently uses the SRCC OG-100 Category C, Mildly Cloudy rating to calculate rebates, however alternate SRCC category ratings may be more appropriate and will be explored in future solar hot water incentives.

Interpretation of table data:

- As indicated by the large standard deviation range, project results have varied widely from the baseline TSOL energy model.
- The implications from the initial data analysis show that current calculation or estimation methods do not represent savings in a consistent or predictable manner:

  - The SRCC OG-100 rating for Category C, Mildly Cloudy overestimates expected production by 63.4% with a standard deviation of 44%.
  - Contractor estimations on average slightly overestimate production by 3.8%, and have varied greatly with a standard deviation of 54%.
  - Performance monitoring results have a standard deviation of 53%, but at this time we are not confident in the accuracy of the data on how actual performance varies from the baseline TSOL energy model, due to the monitoring installation issues identified in section 4.1. While early performance monitoring data has a high level of variability, it is believed that once installation procedures become more standardized, this range will tighten substantially.
- Evaluation of outlying project data is ongoing. Outlying projects are ones that deviate substantially from other projects, and are typically due to measurement error or a substantial change in operating conditions from baseline. Additional data must be collected and evaluated before the criteria for establishing outliers can be correctly defined.

Interim Conclusions:

- Program is a necessary stepping stone towards generating valid, quantifiable data relating to solar thermal energy production and system operation.
- Program has identified the frequency and severity of issues seen to date. These weaknesses have largely been seen on the installation and setup side, with some equipment issues being noted as well.
- Available monitoring solutions do not appear to have any major technical issues relating to equipment used, though thermal monitoring is currently a rapidly developing sector and may benefit from the addition of stronger product instructional resources to reduce installation errors.
- There is wide variability of contractor / installer estimations and calculations provided to the MassCEC, therefore an effort should be made to identify current estimation methodologies and subsequently train contractors on reasonable energy estimation methods.
- The SRCC OG-100 rating for Category C, Mildly Cloudy overestimates expected production by 63.4%. Alternate SRCC category ratings may be more appropriate and will be explored in future solar hot water incentives.
- Preliminary data may show that monitored performance is lower than expected production determined in the benchmark energy model. However, at this time due to the large percentage of total performance data that has been identified as inaccurate (due to a number of field factors relating to equipment installation, including sensors not installed optimally as well as periodic internet connection reporting issues), no significant conclusions can be drawn until a solution is properly determined.

***It is important to note that the projects participating in this program have not been field verified by a third party for consistency of monitoring installation practices.**