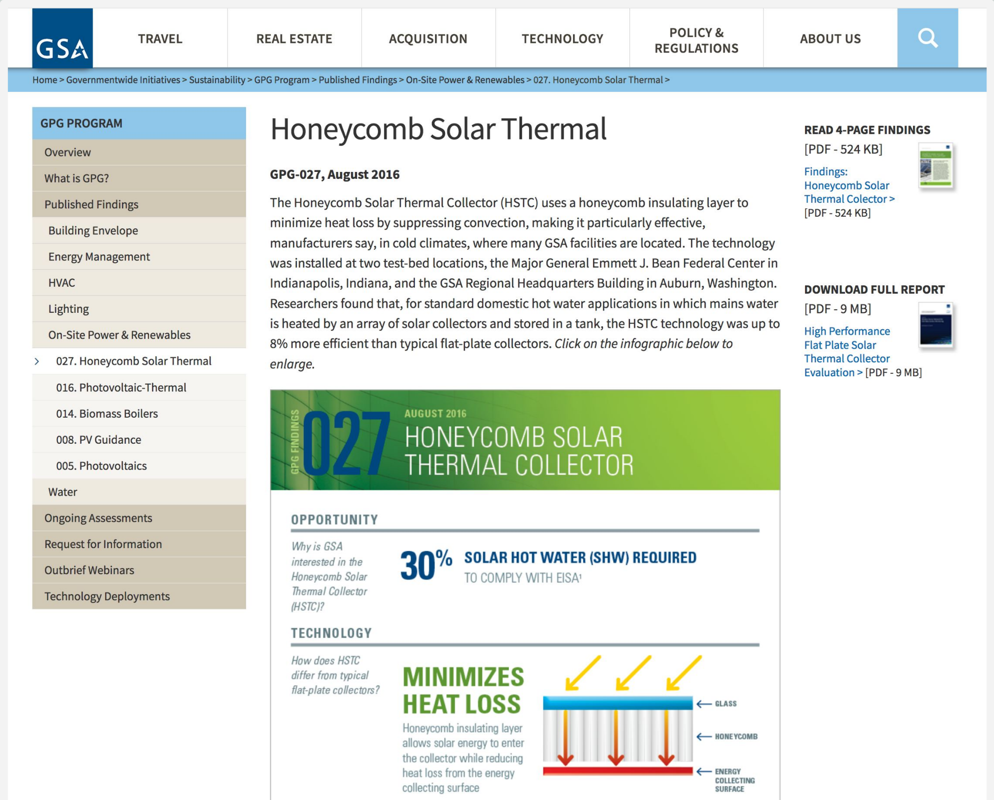
GPG Outbrief 13

Honeycomb Solar Thermal Collector

Emerging Technologies, GPG Program | U.S. General Services Administration | May 24, 2018

GPG-023 Honeycomb Solar Thermal @ gsa.gov

- Infographic
- 4-page Findings
- Full Report
- Additional Resources



Upcoming 2018 GPG Outbriefs - Thursdays, 12 PM ET

June 7	Variable Refrigerant Flow
July 12	LED + Advanced Lighting Controls
Sept 13	High-Performing RTUs

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How to Ask Questions

Please chat your questions during the presentation for the Q&A segment

Introduction

Michael Hobson
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Webinar Agenda

- Introduction (5 minutes)
  Michael Hobson, Project Manager, Emerging Technologies
  Kevin Powell, Program Manager, Emerging Technologies
- Honeycomb Solar Thermal Collector (15 minutes)
  Jesse Dean, National Renewable Energy Laboratory
  Greg Barker, Mountain Energy Partnership
- On-the-ground Feedback (15 minutes)
  Marty Novini, GSA Region 10
  Alan Miller, GSA Region 5
- Q & A (20 minutes)

Introduction

Kevin Powell
Program Manager, Emerging Technologies
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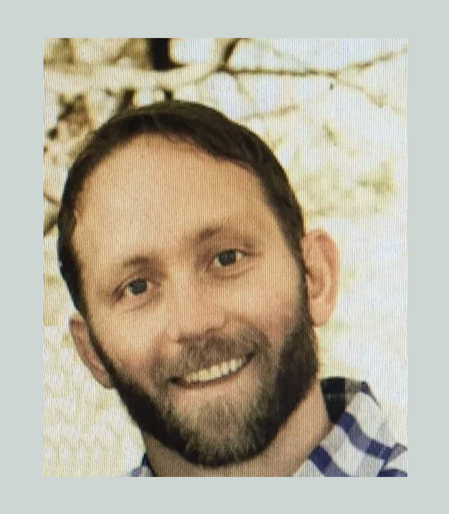
Emerging Technologies’ two programs — GSA Proving Ground (GPG) and Pilot to Portfolio (P2P) — enable GSA to make sound investment decisions in next generation building technologies based on their real world performance

Measurement & Verification



Jesse Dean
Senior Research Engineer, M.S., CEM
National Renewable Energy Laboratory

Greg Barker
Mountain Energy Partnership

GPG-027

Honeycomb Solar Thermal Collector

General Services Administration
Public Buildings Service

GSA

GPG-027 | AUGUST 2016

HONEYCOMB SOLAR THERMAL COLLECTOR

Cost-Effective for Facilities with Electric Water Heaters and Large Consistent Loads

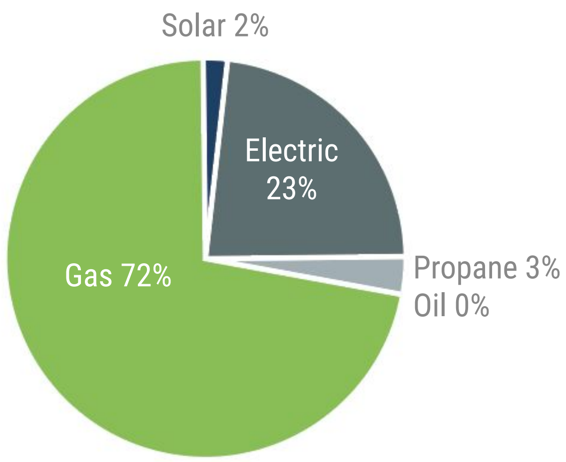
The Energy Independence and Security Act of 2007 (EISA) requires new federal buildings and major renovations to meet 30% of their hot water demand with solar energy, provided it is cost-effective over the life of the system. In response to this mandate, GSA's GPG program commissioned the National Renewable Energy Laboratory (NREL) to assess a unique solar hot water (SHW) collector technology, the Honeycomb Solar Thermal Collector (HSTC). The HSTC uses a honeycomb insulating layer to minimize heat loss, making it particularly effective, manufacturers say, in cold climates, where many GSA facilities are located. The technology was installed at two test-bed locations, the Major General Emmett J. Bean Federal Center in Indianapolis, Indiana, and the GSA Regional Headquarters Building in Auburn, Washington. Researchers found that, for most domestic hot water applications in which mains water is heated by an array of solar collectors and stored in a tank, the HSTC technology was up to 8% more efficient

Requirement for Solar Hot Water

30% of Solar Hot Water Required–EISA 2007

- For new construction and major renovation. Provided it is cost-effective over the lifetime of the equipment. Technology life for SHW systems is typically 25 years.
- When the law was written, SHW was more cost effective than PV. Since then PV has dropped 80% in price and natural gas prices are 48% lower.[1]

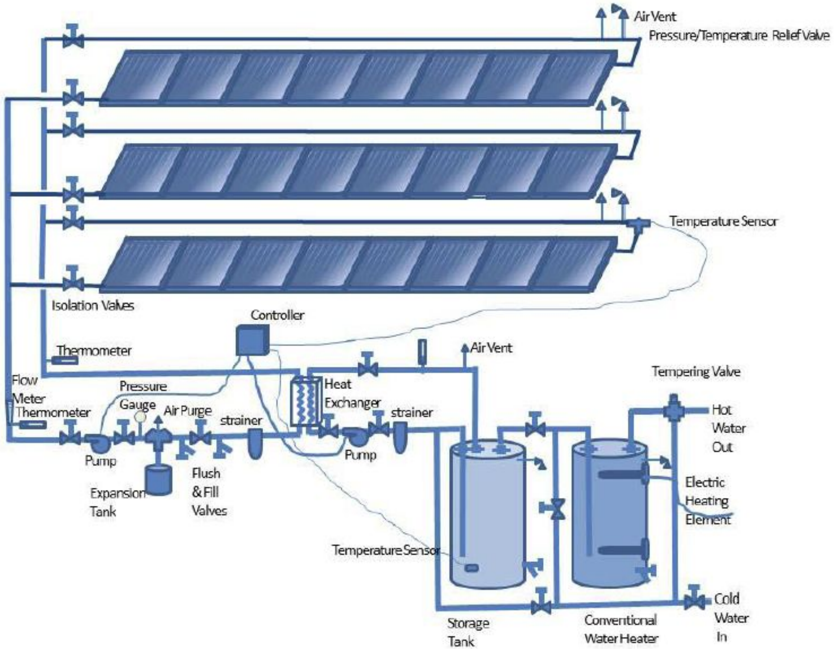
Domestic Hot Water Energy Sources



[1] Natural Gas per 1,000 cubic/ft 2007=$7.31; 2017 $3.52, https://www.eia.gov/dnav/ng/hist/n3045us3a.htm

How It Works

- The collector captures sunlight energy with solar panels and heat a fluid (sometimes but not always water).
- Heated fluid flows from the collector to a storage tank for use in service applications, space heating and cooling, and process heat.

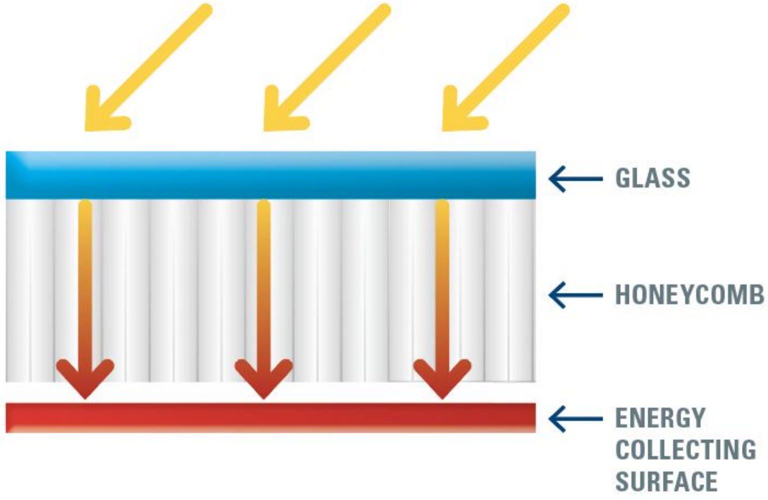


How HSTC Differs from Typical Flat-Plate Collectors

Claim of Higher Operating Efficiency in Cold Climates

MINIMIZES HEAT LOSS

Honeycomb insulating layer allows solar energy to enter the collector while reducing heat loss from the energy collecting surface



Measurement & Verification

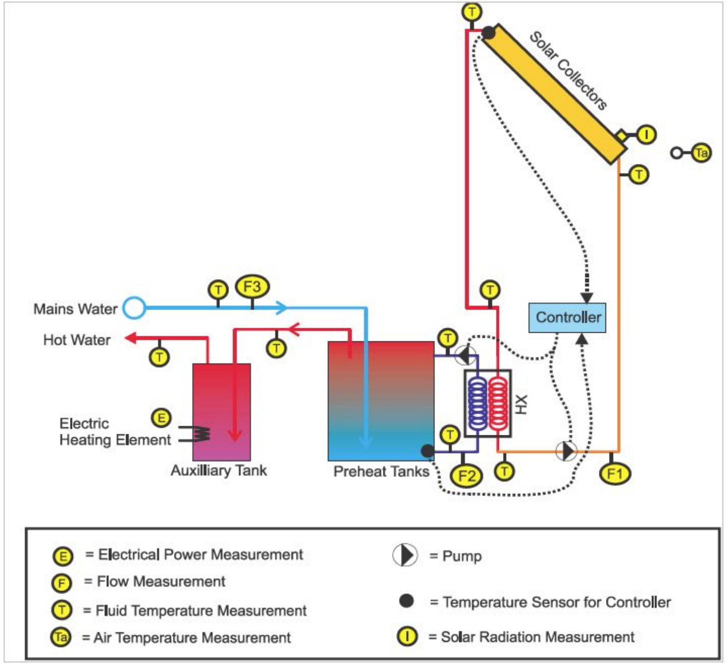
Researchers Monitored Performance at Two Demonstration Sites in Cold Climates

Bean Federal Center, Indianapolis
Cold winters, hot summers, average solar resource

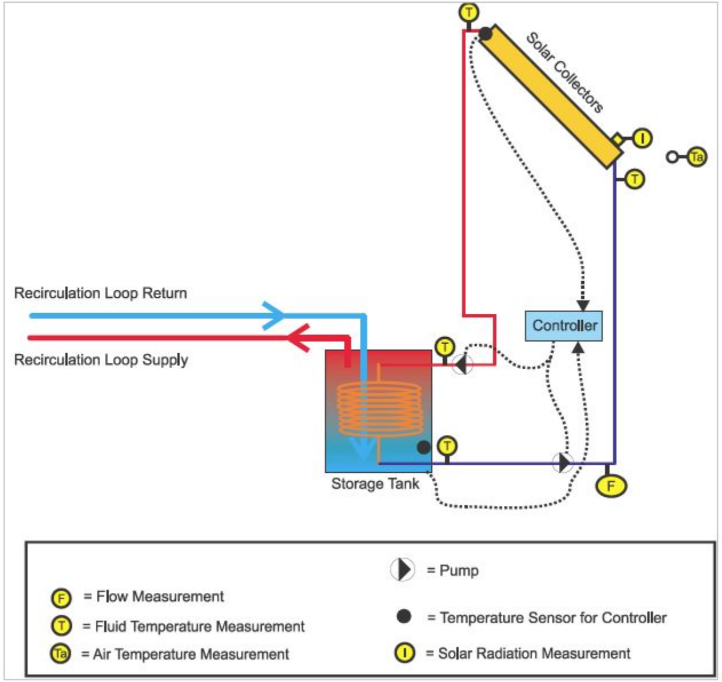
GSA Regional Headquarters, Auburn
Mild winters and summers, low solar solar resource

Technology for test-bed measurement and verification provided by Tigi Solar

System Design



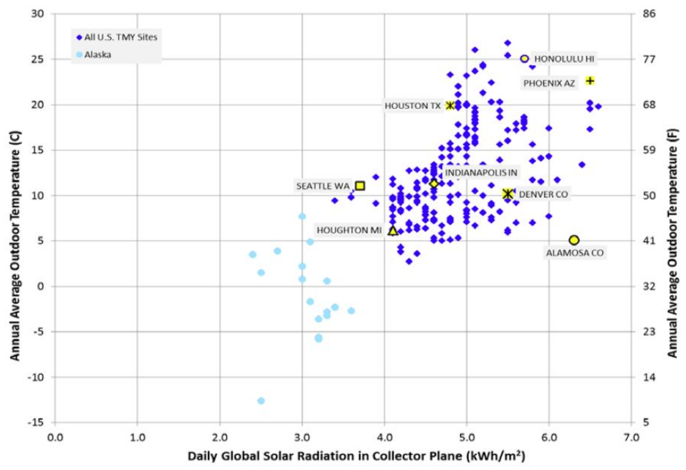
Bean Federal Center



Auburn Regional Headquarters

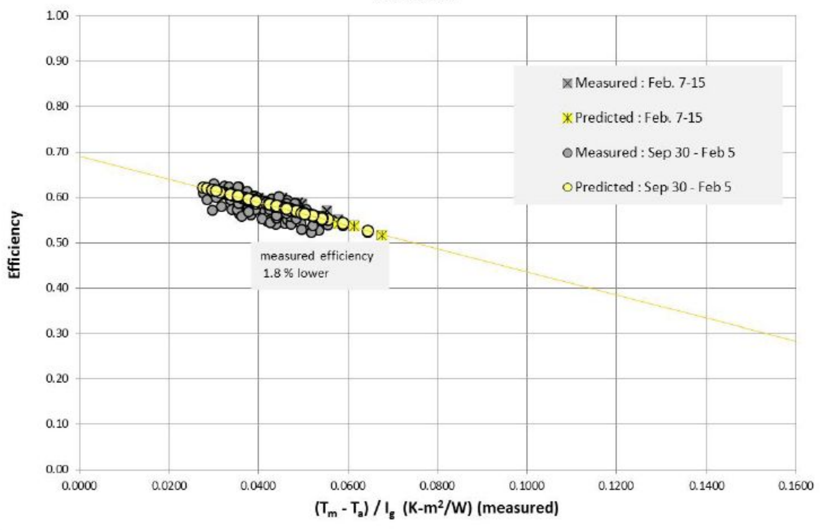
Performance Objectives

- Was collector performance within +/-10% of manufacturer's claims?
- What was efficiency compared to incumbent technologies?
- Did the overheat protection work as expected?
- What is the expected return on investment?

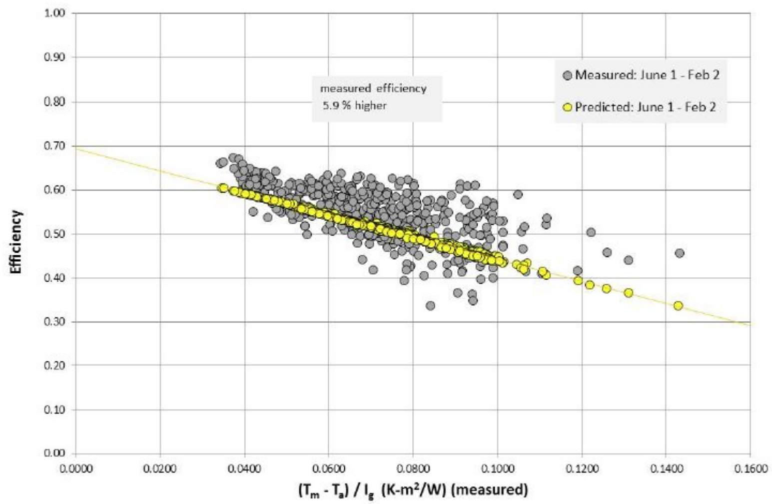


U.S. Locations Used in the Simulation Study

Measured Efficiencies Within 2% of Manufacturer’s Estimate



Bean Federal Center
Comparison of Measured to Predicted Collector Array Efficiency

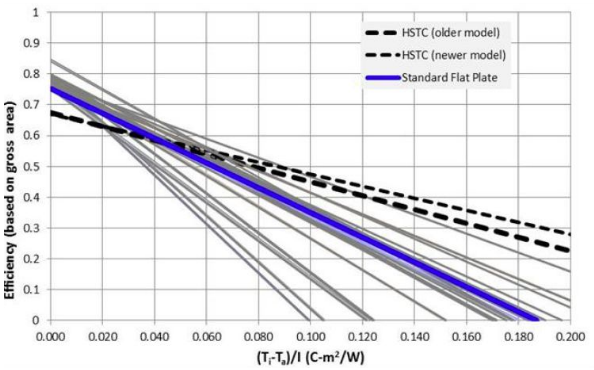


Auburn Regional Headquarters
Comparison of Measured to Predicted Collector Array Efficiency

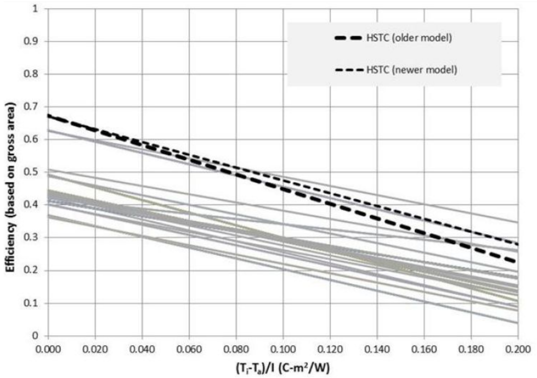
Comparable to Flat-Plate Collectors—Up to 8% Greater Efficiency

Little difference between hot & cold climates when using a temporary storage tank.

Should outperform flat-plate in systems without a storage tank, particularly in cold climates. SHW systems without storage tanks require less infrastructure and can be more cost-effective.



Flat-Plate Collectors



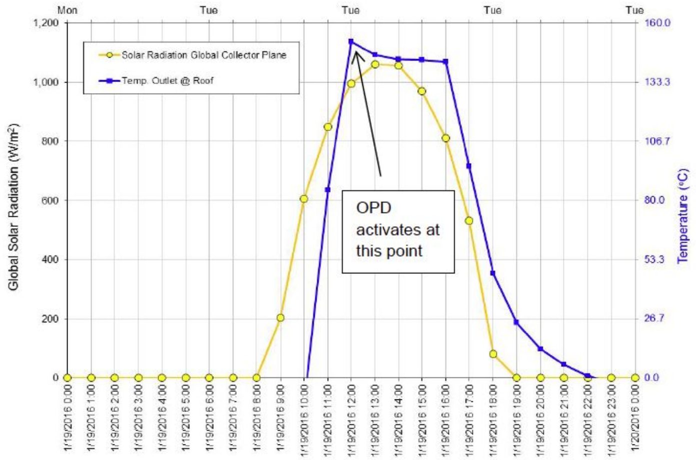
Evacuated Tube Collectors

Sample of Efficiency Curves from the SRCC Database

Overheating Protection Worked

Maximum Stagnation Temperature of 152°C (306°F)

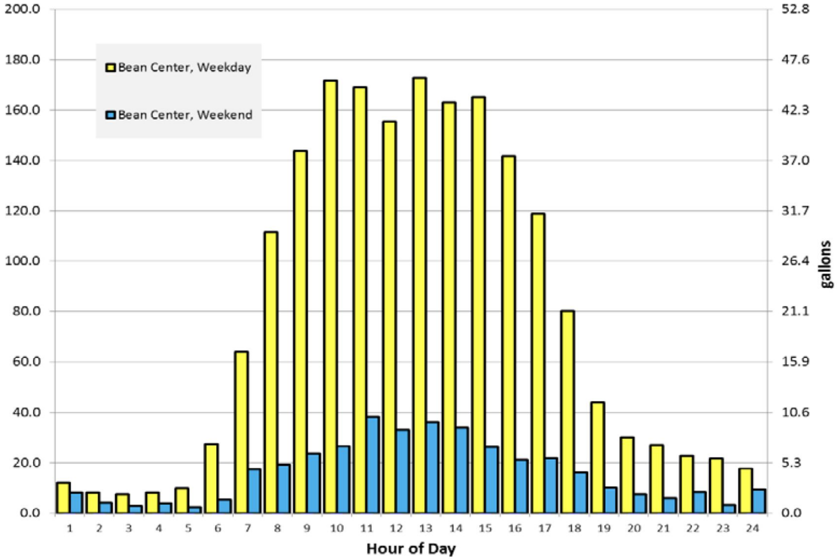
HSTC OPD might decrease SHW maintenance costs over its lifetime.



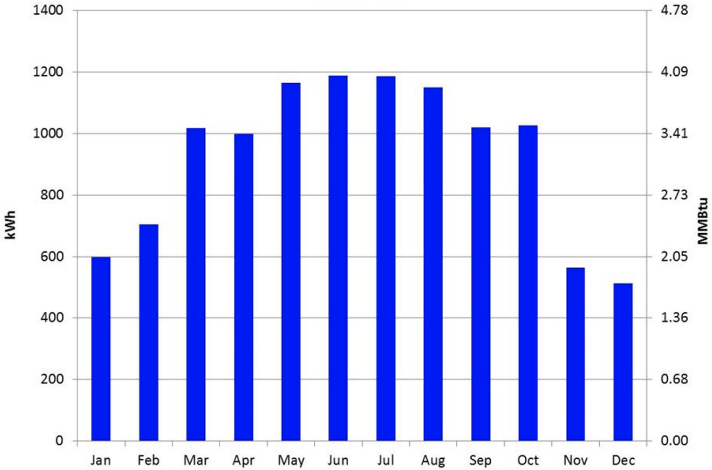
Measured Stagnation Temperature During a Clear Day in January. Outdoor Temperature Was About -9°C (16°F).

Energy Savings—Bean Federal Center

11,100 kWh/year



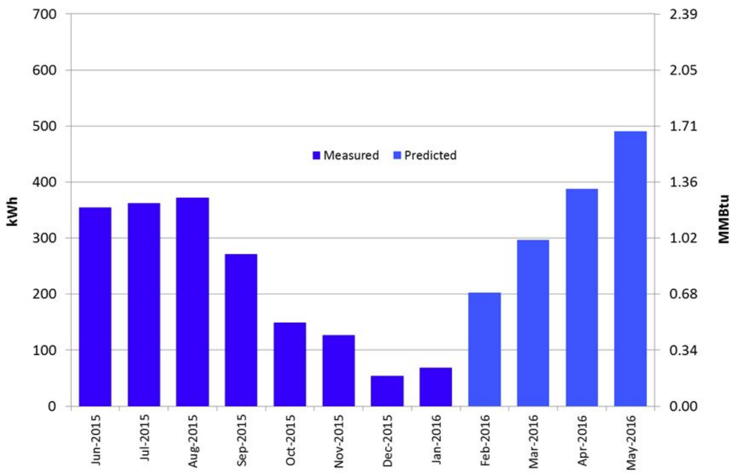
Weekday and Weekend Hot Water Usage



Monthly Electrical Energy Savings

Energy Savings—Auburn Regional Headquarters

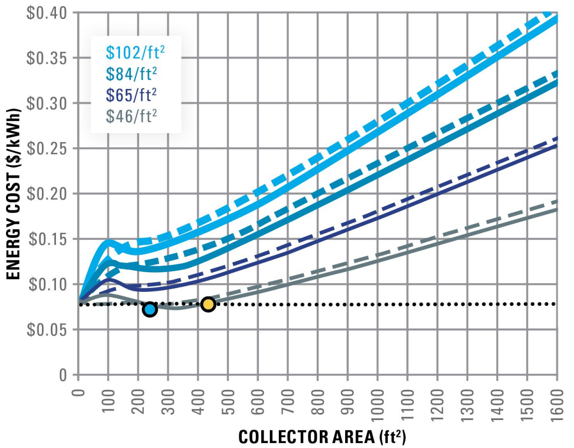
3,155 kWh/year



Monthly Electrical Energy Savings

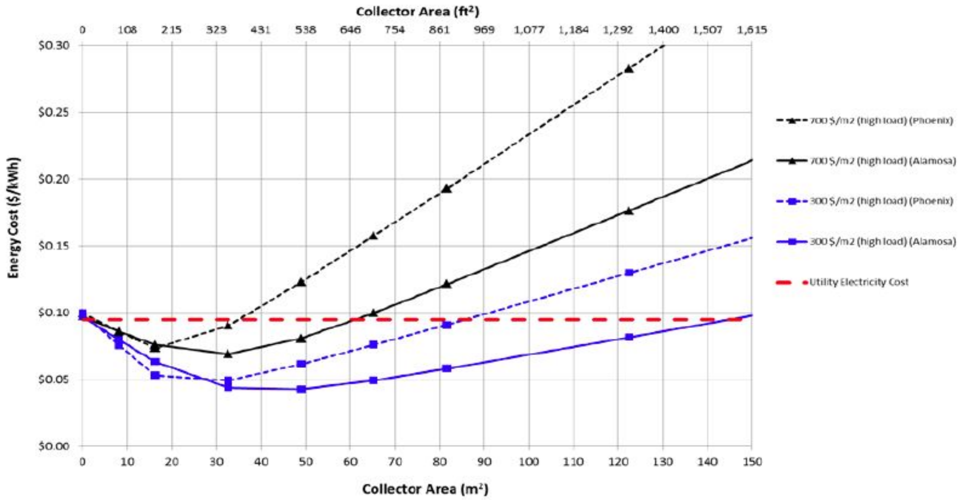
Climate Important to Cost Savings and System Sizing

Optimal System Size for 500-Gallon Load
Seattle, WA (cold/cloudy)



Key

- Honeycomb Solar Thermal
- Standard Flat Plate
- Electricity Cost
- Lowest installed cost
- Highest delivered energy while remaining cost-effective



Delivered Energy Cost for Two Very Sunny Climates, One Very Hot (Phoenix, AZ) and One Very Cold (Alamosa, CO), With Similar Unit Energy Costs

Large Loads are Critical for Positive ROI

Positive ROI With Electric Reheat, 500-Gallon Weekday Load and 46/ft^2 Installed Cost

City	Hot Water Load (gal/day)	System Unit Cost ($/ft²)	Collector Area (ft²)	Solar Fraction*	Annual Energy Savings (kWh/yr)	Payback (years)	SIR
Seattle, WA cold/cloudy annual solar radiation 5.0 gigajoule/m²/yr	125	$102	88	0.44	3,154	40.0	0.26
	500	$102	175	0.32	8,937	26.8	0.56
	500	$46	175	0.32	8,937	13.0	1.15
Indianapolis, IN cold/partly cloudy annual solar radiation 5.9 gigajoule/m²/yr	125	$102	88	0.51	3,638	29.0	0.42
	500	$102	175	0.38	10,448	19.2	0.81
	500	$46	175	0.38	10,448	9.3	1.68
Denver, CO cold/sunny annual solar radiation 6.8 gigajoule/m²/yr	125	$102	88	0.60	4,291	24.5	0.54
	500	$102	175	0.44	12,343	16.2	0.98
	500	$46	175	0.44	12,343	7.8	2.03
Phoenix, AZ warm/sunny annual solar radiation 8.5 gigajoule/m²/yr	125	$102	88	0.54	2,757	21.4	0.50
	500	$102	175	0.71	13,556	15.0	1.06
	500	$46	175	0.71	13,556	7.3	2.20

Collector cost is only 20% of installed system cost, a more expensive collector has a relatively small impact on overall costs.

Guidelines for Deployment

- **Implement Efficiency First** Applicable water conservation and energy efficiency opportunities should be implemented before sizing a solar thermal system.
- **Use Accurate System Design Tools to Optimize Cost Effectiveness** Using the approach outlined in NREL's report to determine system design, a detailed sub-hourly simulation program should be used and the system should be modeled accurately with SRCC-rated solar thermal panel performance data. Life-cycle cost, rather than efficiency, should drive system selection.
- **Use a Trained Solar Hot Water Installer** There are several unique features of SHW systems with which experienced plumbers may not be familiar, such as calculating the required pressure of collector fluid to avoid boiling under stagnation conditions.
- **Require a Backup System** SHW systems almost always require a backup system for cloudy days and times of increased demand.

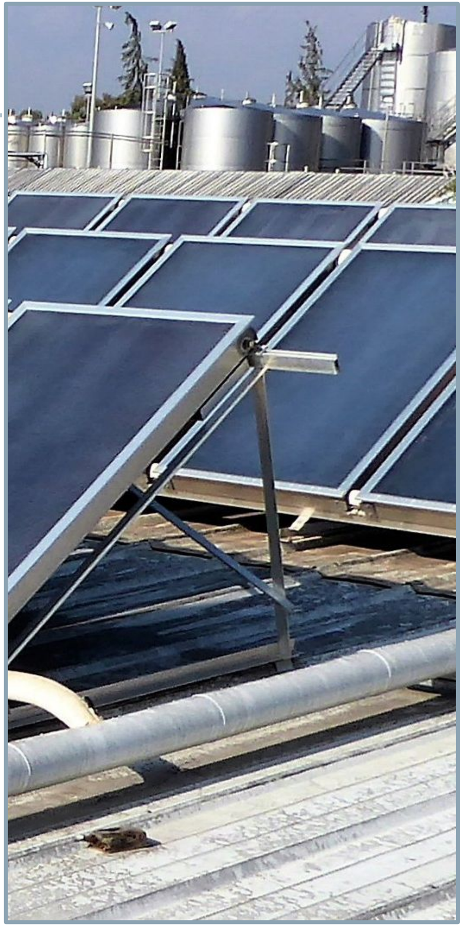
Target Locations

- **Large, Consistent Weekday Hot Water Loads** The larger the load being offset, the more cost-effective the system (facilities with workout facilities, kitchens, laundry).
- **Central Hot Water Systems** Facilities with centralized domestic hot water systems should be targeted for SHW. Facilities with small de-centralized point-of use domestic hot water systems are not suitable for solar thermal installations.
- **Roof Availability** Facilities with roofs that won’t need to be replaced for 20 to 25 years, have sufficient space available to accommodate an SHW system, and won’t need expensive structural modifications to carry the increased load.
- **High Solar Resource** Sunny locations are more cost-effective.
- **High Energy Costs** The unit cost of electricity ($/kWh) is seven times higher than natural gas in many locations.

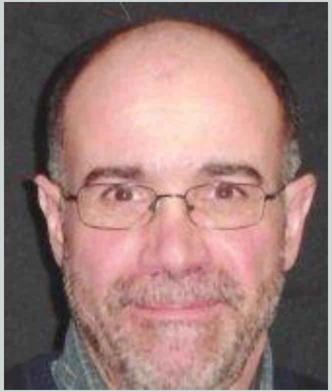
Deployment

Consider for Facilities with Electric Water Heaters and Large, Consistent Loads

- Natural gas prices in the U.S. are generally too low to make SHW cost-effective.
- Life-cycle cost, rather than efficiency, should drive system selection.



GSA Feedback—GSA Regional Headquarters, Auburn



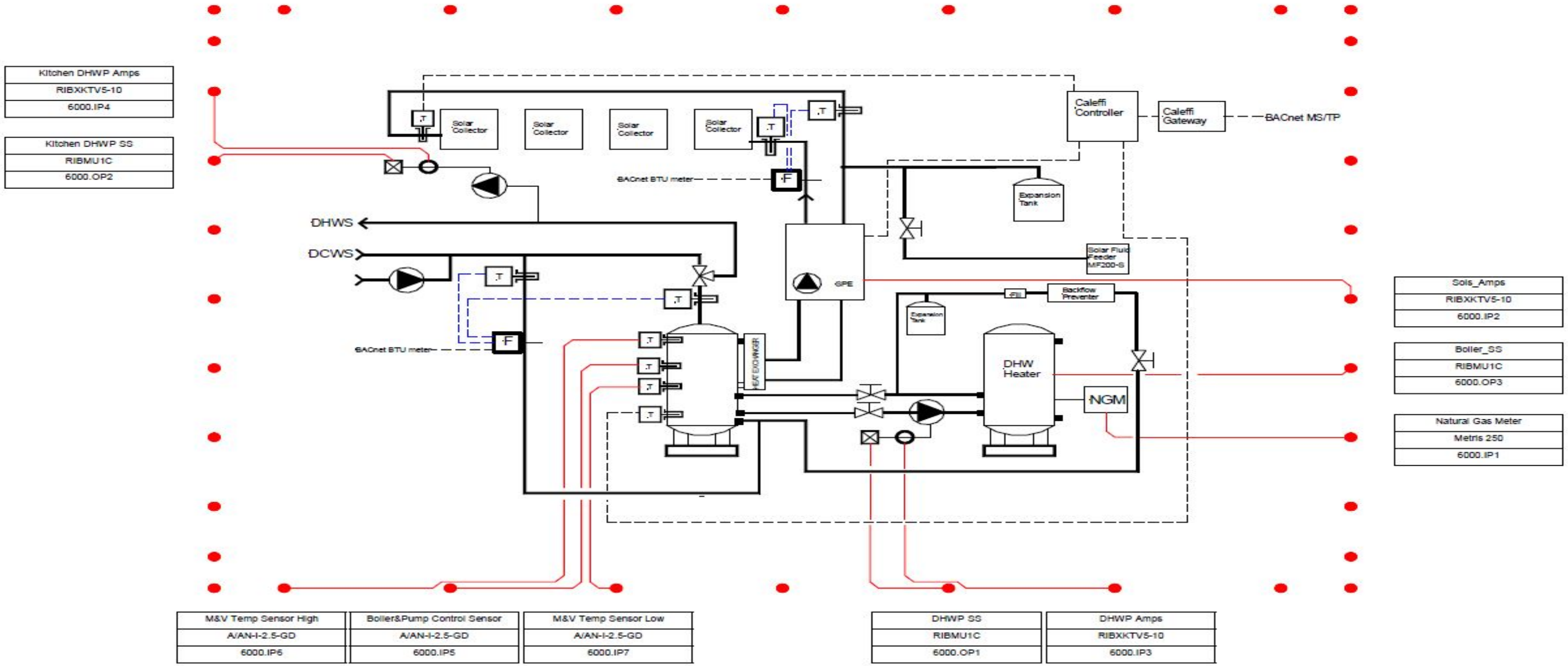
Marty Novini
Energy Program Manager
Northwest Arctic Region 10

GSA Regional Headquarters, Auburn

- Installed as design build
- The mechanical system installer engaged a solar expert for this installation
- A year after the installation was completed, our cafe was closed, which impacted the payback
- Works well in summer, but has limited application in winter

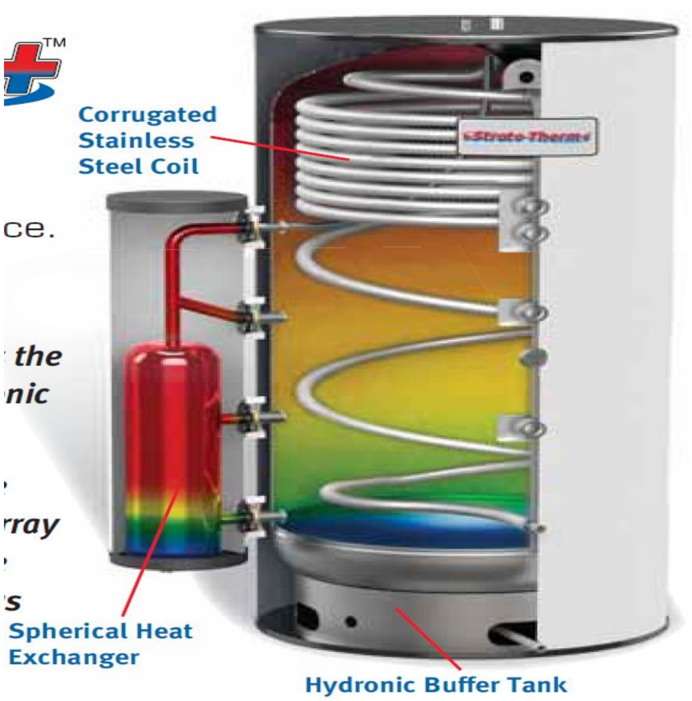
Process and Instrumentation Drawing

System Drawings Report



Solar Controller

Thermal Storage Tank



GSA Feedback—Bean Center, Indianapolis

Alan Miller
Project Manager
Southern Service Center
Indianapolis, IN 46249

Bean Federal Center

Not currently operating, need to consult with a local solar thermal system installer and re-examine:

1. Concentration of glycol (antifreeze)
2. Set point of pressure relief valve
3. Pressure of fluid in system

Bean Federal Center—Preliminary Recommendations

- Change from 30% to 50% antifreeze
- Increase system pressure from 15 psi to 78 psi in the mechanical room (70 psi at the roof)

Note: desired pressure estimate is on the roof but pressure is being measured in the mechanical room, 2 floors down, pressure change is 0.4 psi per foot.

Assigning Pressure

Concentration Propylene Glycol (%)	Gauge Pressure (psi)	Boiling Temperature (deg F)	Freezing Temperature (deg F)
50%	34.8	292.0°	-23.2°
50%	39.2	297.3°	-23.2°
50%	43.5	302.2°	-23.2°
50%	47.9	306.7°	-23.2° min. pressure = 47.9 psi
50%	52.2	311.0°	-23.2°
50%	56.6	315.0°	-23.2°
50%	60.9	318.8°	-23.2°
50%	65.3	322.4°	-23.2°
50%	69.6	325.8°	-23.2° recommended = 69.6 psi
50%	74.0	329.0°	-23.2°
50%	78.3	332.1°	-23.2°
50%	82.7	335.0°	-23.2°
50%	87.0	337.8°	-23.2°

Going Forward

- AE firm to talk with report authors.
- Emerging Technologies to provide support for operations.

GPG FINDINGS 027

AUGUST 2016

HONEYCOMB SOLAR THERMAL COLLECTOR

OPPORTUNITY

Why is GSA interested in the Honeycomb Solar Thermal Collector (HSTC)?

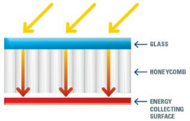
30% **SOLAR HOT WATER (SHW) REQUIRED**
TO COMPLY WITH EISA[1]

TECHNOLOGY

How does HSTC differ from typical flat-plate collectors?

MINIMIZES HEAT LOSS

Honeycomb insulating layer allows solar energy to enter the collector while reducing heat loss from the energy collecting surface



M&V

Where did Measurement and Verification occur?

NATIONAL RENEWABLE ENERGY LABORATORY measured performance of an HSTC system provided by Tigi Solar at two demonstration sites: the Major General Emmett J. Bean Federal Center in Indianapolis; and the GSA Regional Headquarters Building in Auburn, Washington

RESULTS

How did HSTC perform in M&V?

COMPARABLE
TO OTHER FLAT PLATES FOR STANDARD DHW
In SHW systems without a storage tank, HSTC should outperform other flat plates, particularly in cold climates[2]

TRAINED
SHW INSTALLER IS CRITICAL
To address unique features of SHW systems[3]

OVERHEATING PROTECTION WORKED
May decrease maintenance costs over time[4]

Modeled Energy Savings for HSTC in Locations with Different Solar Resources
Large loads are critical for positive ROI

City	Hot Water Load (gal/day)	System Unit Cost ($/ft²)	Collector Area (ft²)	Solar Fraction*	Annual Energy Savings (kWh/yr)	Payback (years)	SIR
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	500	$102	175	0.71	13,556	15.0	1.06
	500	$46	175	0.71	13,556	7.3	2.20

* The solar fraction represents the fraction of the total hot water energy load that is displaced by the solar hot water system

DEPLOYMENT

Where does M&V recommend deploying SHW?

ELECTRIC WATER HEATERS LARGE CONSISTENT LOADS

Natural gas prices in the U.S. are generally too low to make SHW cost-effective. Life-cycle cost, rather than efficiency, should drive system selection.

[1] High Performance Flat Plate Solar Thermal Collector Evaluation. Caleb Rockenbaugh, Jesse Dean, David Lovullo, Lars Lisell, Greg Barker, Ed Hanckock, Paul Norton (NREL), July 2016 p.8 [2] Ibid, p.7 [3] Ibid, p.11 [4] Ibid, p.8

Q & A

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Your answer

First and Last Name

Your answer

The information presented in the Outbrief webinar was helpful.

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

I am interested in installing the honeycomb solar thermal collector.

- ○ Yes, in the next 2 years.
- ○ Yes, in the next 5 years.
- ○ Maybe
- ○ No

Thank you

For more information: gsa.gov/GPG

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Kevin Powell, Program Manager kevin.powell@gsa.gov 510.423.3384