Solar Water Heating
Commercial Systems

PG&E
Pacific Energy Center, San Francisco
Energy Training Center, Stockton
Instructor

Pete Shoemaker
PG&E Pacific Energy Center
(415) 973-8850
pjsy@pge.com
Agenda

- Overview and definition of terms
- Unique commercial system issues
- Basic finances
- Site analysis and targeting sites
- Further classes
Overview and Definition of Terms
Overview

Solar is pre-heater

Existing gas or electric system is "backup" or "booster" heater

Courtesy CCSE
Overview

Solar Fraction: Percentage of total water heating provided by solar – the rest is provided by backup heater.
Overview

Two types of systems:

1. Open Loop (Direct)
   - Uses just the water from the main.
   - “Open” to outside elements.

2. Closed Loop (Indirect)
   - Uses heat-transfer fluid in “closed” system.
   - Needs heat exchanger.
Overview

Two types of systems:

1. Open Loop (Direct)
   - Uses just the water from the main.
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   - Uses heat-transfer fluid in “closed” system.
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Overview

Closed loop heat transfer fluid:

Typically water-glycol mix
• Food-grade glycol (non-toxic)
• Percentage depends on climate

Also can be water (drainback system)
Overview

Further categorized by “pumping” source:

1. Passive (natural)
   - Thermosiphon process.
   - Tank must be higher than collector.

2. Active (electric pump)
   - Must have electric source.
   - Tank can be anywhere.
Overview: Schematic Elements

![Schematic Diagram](image)

Courtesy University of Central Florida
Overview: Collector Types

ICS (Batch)  
Flat Plate  
Evacuated Tube

Figures Courtesy of DOE/NREL
Overview: Flat Plate Styles

Harp

Serpentine
Overview: SRCC Ratings

Systems must be SRCC certified: www.solar-rating.org

OG-100
Panel ratings

OG-300
System ratings
Overview: Shade Tools

Courtesy: Solmetric, Corp.
Overview: Shade Tools

- Visually demonstrates seasonal sun path and shading effects of obstructions
- Summary tabular data

Courtesy: Solmetric, Corp.
Unique Commercial System Issues

Courtesy of NASA
Usage Patterns – Draw Profile

Data from CSI Thermal commercial calculator

https://www.csithermal.com/calculator/commercial/
Balancing Flow

Water takes the path of least resistance.

So make sure all water has the same resistance to flow—the same length path.
Reverse Return

Making the return piping the opposite of the supply piping: short supply = long return and vice-versa. Done to balance flow.
Series Flow Path

How many times a molecule is heated in a heat collection loop.

... or another way to put it ...

How many collectors it goes through on its path from the tank (heat exchanger) back to the tank.

One-collector path

Three-collector path
Thermal Expansion

Need to guard against too much pipe expansion due to heat – each collector has limits on the number you can chain together.
Production: Kilowatt Thermal ($kW_{th}$):

Equates electrical energy (kWh) with heat energy:

1 kWh = 3,412 BTU

System capacity measurements based on collector aperture area:

- 4 feet = 32 ft.$^2$  
  (10.8 ft.$^2$ = 1 m$^2$)  
  = 2.97 m$^2$

Conversion factor of 0.7 $kW_{th}$/m$^2$ of collector space:

20 collector system = 20 x 2.97 = 59.4 m$^2$

59.4 x 0.7 = 41.58 kW$_{th}$. 
Rebate Program Metering Size Categories

Because of the metering expense, systems have been given two categories according to size, with the cutoff 30 kWth.

This is defined as 462 ft² of collector area.

<table>
<thead>
<tr>
<th>SMALL</th>
<th>LARGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 30 kWth</td>
<td>30 kWth or greater</td>
</tr>
<tr>
<td>1 to 9 panels (approx.)</td>
<td>Over 9 panels (approx.)</td>
</tr>
<tr>
<td>Residential &amp; small commercial</td>
<td>Large commercial</td>
</tr>
</tbody>
</table>
Recirculation Loop

Circulating flow of hot water, driven by pump.

Can be constant (24/7)
Or keyed by sensors
Or keyed by timer

Extreme potential for heat loss, especially with non-insulated pipes.
Recirculation Loop

To Shower, Tap, Dishwasher, etc.

Domestic Hot Water Supply

Return Water

Hot Water Tank or Tankless

Cold Water In

Check Valve

Pump

Branch

Trunk

http://www.tanklesshotwaterguide.ca
Storage Tank Sizes

Above 119 gallons requires extra engineering and is much more expensive.
Unique Commercial Issues: Summary

- Draw profile
- Balancing flow
- Reverse return
- Series flow path
- Thermal expansion
- Kilowatt thermal
- Recirculation loop
- Tank sizing
Basic Finances
Financial Considerations

Financial return on investment is function of:
• Total project installed cost
• System maintenance cost
• Fuel displaced and at what cost
• CSI thermal program rebate
• Federal Tax Credit
• Depreciation
Economics of Solar
What Fuel is Displaced?

• Current Fuel Costs
  – Natural Gas = @$1.00/therm
  – Propane Gas= @$2.30/therm
  – Electricity= @$5.80/therm
## Utility Rebate

### Natural Gas backup

<table>
<thead>
<tr>
<th>Step</th>
<th>Customer Class</th>
<th>$/ therm displaced</th>
<th>Incentive Cap</th>
<th>Budget Allocation</th>
<th>PG&amp;E Budget Allocation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Residential</td>
<td>$18.59</td>
<td>$2,719</td>
<td>$29 Million</td>
<td>$11.31 Million</td>
</tr>
<tr>
<td></td>
<td>Commercial/Multifamily</td>
<td>$14.53</td>
<td>$500,000</td>
<td>$34 Million</td>
<td>$13.26 Million</td>
</tr>
<tr>
<td>2</td>
<td>Residential</td>
<td>$13.11</td>
<td>$1,919</td>
<td>$23 Million</td>
<td>$8.97 Million</td>
</tr>
<tr>
<td></td>
<td>Commercial/Multifamily</td>
<td>$9.88</td>
<td>$500,000</td>
<td>$26 Million</td>
<td>$10.14 Million</td>
</tr>
<tr>
<td>3</td>
<td>Residential</td>
<td>$7.69</td>
<td>$1,125</td>
<td>$18 Million</td>
<td>$7.02 Million</td>
</tr>
<tr>
<td></td>
<td>Commercial/Multifamily</td>
<td>$6.55</td>
<td>$500,000</td>
<td>$23 Million</td>
<td>$8.97 Million</td>
</tr>
<tr>
<td>4</td>
<td>Residential</td>
<td>$3.23</td>
<td>$475</td>
<td>$11 Million</td>
<td>$4.29 Million</td>
</tr>
<tr>
<td></td>
<td>Commercial/Multifamily</td>
<td>$3.13</td>
<td>$500,000</td>
<td>$16 Million</td>
<td>$6.24 Million</td>
</tr>
</tbody>
</table>
## Utility Rebate

### Electric backup

<table>
<thead>
<tr>
<th>Step</th>
<th>Customer Class</th>
<th>$/kWh displaced</th>
<th>Max Incentive</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Residential</td>
<td>0.54</td>
<td>$1,834</td>
</tr>
<tr>
<td></td>
<td>Comm/Multifamily</td>
<td>0.42</td>
<td>$250,000</td>
</tr>
<tr>
<td>2</td>
<td>Residential</td>
<td>0.38</td>
<td>$1,311</td>
</tr>
<tr>
<td></td>
<td>Commercial/Multifamily</td>
<td>0.29</td>
<td>$250,000</td>
</tr>
<tr>
<td>3</td>
<td>Residential</td>
<td>0.22</td>
<td>$752</td>
</tr>
<tr>
<td></td>
<td>Commercial/Multifamily</td>
<td>0.19</td>
<td>$250,000</td>
</tr>
<tr>
<td>4</td>
<td>Residential</td>
<td>0.10</td>
<td>$329</td>
</tr>
<tr>
<td></td>
<td>Commercial/Multifamily</td>
<td>0.09</td>
<td>$250,000</td>
</tr>
</tbody>
</table>
Financial Terms

- Full Price (installed cost)
- Rebate (from utility), declared as income
- Tax paid on rebate
- Tax credit (federal)
- Depreciation (federal and state)

Declaring the rebate as income allows the owner to use the entire full cost as the tax basis. This large tax basis allows for a higher tax credit and depreciation.

\[
\text{Full Price} = \text{Tax basis} \\
\text{Net Rebate} = \text{Rebate} - \text{Tax on rebate} \\
\text{Full Price} - \text{Net Rebate} - \text{Tax Credit} - \text{Depreciation} = \text{Net Cost}
\]
## Sample Finances

<table>
<thead>
<tr>
<th>Description</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross system cost</td>
<td>$131,000</td>
</tr>
<tr>
<td>Rebate</td>
<td>($34,872)</td>
</tr>
<tr>
<td>Tax on rebate</td>
<td>$12,205</td>
</tr>
<tr>
<td>Federal tax credit</td>
<td>($39,300)</td>
</tr>
<tr>
<td>Federal depreciation</td>
<td>($38,973)</td>
</tr>
<tr>
<td>State depreciation</td>
<td>($5,982)</td>
</tr>
<tr>
<td><strong>Net cost after incentives</strong></td>
<td><strong>$24,078</strong></td>
</tr>
</tbody>
</table>
## Sample Finances

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net cost</td>
<td>$24,078</td>
</tr>
<tr>
<td>Projected yearly production</td>
<td>2400 therms</td>
</tr>
<tr>
<td>Average cost per therm</td>
<td>$1.00</td>
</tr>
<tr>
<td>Average yearly savings</td>
<td>$2,400</td>
</tr>
<tr>
<td>Simple payback with 4% inflation</td>
<td>8.5 years</td>
</tr>
</tbody>
</table>
California Solar Initiative
CSI-Thermal Program

Incentives are now available for Solar Water-Heating Systems!
The CSI-Thermal Program offers cash rebates of up to $1,875 for solar water heating systems on single-family homes. Multifamily and commercial properties qualify for rebates of up to $500,000. Save money on gas or electricity bills by harnessing the heat of the sun!

For More Information

- Contact the Program Administrator in your area for more information on applying for the CSI-Thermal Program.
- Check the availability of solar thermal classes in your area.
- Incentive levels, technical requirements and other program details can be found in the CSI-Thermal Program Handbook.
- To apply for rebates, visit the CSI-Thermal online application site.
- For information about CSI-Thermal program policy developments, including the forthcoming CSI-Thermal program for multifamily and commercial solar hot water systems, see the CSI-Thermal Program page on the CPUC website.
- You may download a file containing information on all projects that have applied for the CSI-Thermal rebate, including project size, type and cost information. Download the Excel CSV file.
CSI Thermal Program Data

Data as of 10/8/12

889 total applications
471 residential
• 187 vs. electric
• 264 vs. gas
• 20 vs. propane
418 commercial, multi-family
• 3 vs. electric
• 415 vs. gas
Of commercial
• 332 retrofits
• 87 new construction
CSI Thermal Program Data

Load Profiles

<table>
<thead>
<tr>
<th>Category</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apartments</td>
<td>307</td>
</tr>
<tr>
<td>Restaurants</td>
<td>15</td>
</tr>
<tr>
<td>Laundromats</td>
<td>13</td>
</tr>
<tr>
<td>Retirement Homes</td>
<td>11</td>
</tr>
<tr>
<td>Other</td>
<td>11</td>
</tr>
<tr>
<td>Dormitories</td>
<td>6</td>
</tr>
<tr>
<td>Offices</td>
<td>4</td>
</tr>
<tr>
<td>Hotels</td>
<td>1</td>
</tr>
</tbody>
</table>
# CSI Thermal Program Data

By Bay Area city

<table>
<thead>
<tr>
<th>City</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>San Francisco</td>
<td>47</td>
</tr>
<tr>
<td>Oakland</td>
<td>40</td>
</tr>
<tr>
<td>Mountain View</td>
<td>10</td>
</tr>
<tr>
<td>Pittsburg</td>
<td>9</td>
</tr>
<tr>
<td>Carmel</td>
<td>8</td>
</tr>
<tr>
<td>Berkeley</td>
<td>8</td>
</tr>
<tr>
<td>San Jose</td>
<td>5</td>
</tr>
<tr>
<td>Fremont</td>
<td>4</td>
</tr>
</tbody>
</table>

![Bar chart showing the number of data points by Bay Area city]
CSI Thermal Program Data

Freeze protection
• Glycol: 310
• Drainback: 66

Configuration
• Separate tanks: 273
• Single tank: 90
• Storage with tankless backup: 14
CSI Thermal Program Data

By size: collector square footage

<table>
<thead>
<tr>
<th>Sq. ft.</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 100</td>
<td>46</td>
</tr>
<tr>
<td>100 - 200</td>
<td>53</td>
</tr>
<tr>
<td>200 - 400</td>
<td>93</td>
</tr>
<tr>
<td>400 - 600</td>
<td>65</td>
</tr>
<tr>
<td>600 - 1000</td>
<td>41</td>
</tr>
<tr>
<td>1000 - 2000</td>
<td>55</td>
</tr>
<tr>
<td>2000 +</td>
<td>21</td>
</tr>
</tbody>
</table>

![Bar chart showing the distribution of collector square footage by size]
### CSI Thermal Program Data

**By cost per size range:**

<table>
<thead>
<tr>
<th>Sq. ft.</th>
<th>Cost/sq.ft.</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 100</td>
<td>$189</td>
</tr>
<tr>
<td>100 - 200</td>
<td>$156</td>
</tr>
<tr>
<td>200 - 400</td>
<td>$151</td>
</tr>
<tr>
<td>400 - 600</td>
<td>$150</td>
</tr>
<tr>
<td>600 - 1000</td>
<td>$136</td>
</tr>
<tr>
<td>1000 - 2000</td>
<td>$142</td>
</tr>
<tr>
<td>2000 +</td>
<td>$117</td>
</tr>
</tbody>
</table>

![Graph showing cost per size range]
Targeting Buildings

What makes a good potential client?

• High water usage
  • The more regular and the more during the day the better

• Adequate roof and solar access

• Good location for storage

• Stable business

• Green clientele
Four Critical Questions

• What is the load and frequency?
• How much room available for collectors?
• How much room available for storage?
• How much room in the budget? $$$

One will usually be a limiting factor.
Space and Access: Storage

- Small doorways, stairwells
- Crowded spaces
- Obstructions

Source: PG&E
Space and Access: Roof

- Standard space / shade analysis with solar tools
- Roof support, mounting beams
- Pipe runs

- Getting panels on roof
- Lift access in street
- Possible roof slope, unevenness

Source: PG&E
Good Candidates

- Building owner usually pays the water bill.
- If owner/entity pays taxes, tax incentives work.
- Low-income programs, grants available.
- Lease financing for SWH is just beginning.

_Multi-unit apartment buildings are a good choice, particularly low-income._
Further Classes

At the PG&E Pacific Energy Center and other locations. Register at www.pge.com/energyclasses.

To learn about the technology, how to design systems:
Solar Water Heating Systems
(basic class -- in February)
Solar Water Heating Advanced Commercial Systems
(11/6 at the Pacific Energy Center)
Inspecting Solar Water Heating Systems
(12/5 at the Pacific Energy Center)

To be eligible to participate in the rebate program:
CSI Thermal Program Workshop
(10/18 at San Jose, 11/8 at the PEC)
For technology questions:

Pete Shoemaker
PG&E Pacific Energy Center
(415) 973-8850
pjsy@pge.com

For rebate / eligibility / program questions:

Nick Stimmel
CSI Thermal Program Manager
(415) 973-2146
njsa@pge.com