Solar Thermal Energy Technology and Market Trends

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Topics

- Discussion of current market shaping trends affecting solar thermal industry: energy prices, environmental concerns, public awareness, incentives and information on where to find them, certification issues

- Types of solar thermal collectors and systems now used, pros/cons of evacuated tubes and flat plate collectors

- Examples of various residential and commercial system designs
Market Transformation

Primary Drivers for Change

- Increase in conventional energy costs as global demand for resources heats up
  - U.S. desire for energy independence
- Need for U.S. job creation
  - Great Recession of 2009
- Global Pressure to reduce carbon emissions
  - Global Warming
  - Green Initiative
Market Transformation

1970’s vs. Today
- In the 1970’s prices spiked due to geo-political pressures…The Arab Oil embargo.

- Today, Supply & Demand Pressures are driving prices…Growth of Emerging Markets (China, India, Brazil) and Global Warming Concerns
Market Transformation

Incentives for Change

- State Renewable & Alternative Energy Portfolio Standards
- DOE Standards and New Construction Requirements
- Federal & State Government incentive programs for the end-user
Market Transformation

Renewable Portfolio Standards

<table>
<thead>
<tr>
<th>State</th>
<th>Target</th>
<th>Year</th>
<th>Legislation</th>
</tr>
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<tbody>
<tr>
<td>Arizona</td>
<td>15%</td>
<td>2025</td>
<td>RPS</td>
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<tr>
<td>California</td>
<td>20%</td>
<td>2010</td>
<td>SB 107</td>
</tr>
<tr>
<td>Colorado</td>
<td>20%</td>
<td>2020</td>
<td>HB 1281</td>
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<tr>
<td>Connecticut</td>
<td>27%</td>
<td>2020</td>
<td>HB 7432</td>
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<tr>
<td><strong>Delaware</strong></td>
<td>20%</td>
<td>2019</td>
<td>SB 19</td>
</tr>
<tr>
<td>Florida</td>
<td>20%</td>
<td>?</td>
<td>HB 7135 &amp; EO 07-127</td>
</tr>
<tr>
<td>Hawaii</td>
<td>40%</td>
<td>2030</td>
<td>HB 1464</td>
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<tr>
<td>Illinois</td>
<td>25%</td>
<td>2025</td>
<td>Public Act 095-0481</td>
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<tr>
<td><strong>Iowa</strong></td>
<td>105MW from Renewable</td>
<td></td>
<td></td>
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<tr>
<td>Kansas</td>
<td>20%</td>
<td>2020</td>
<td>HB 2369</td>
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<tr>
<td>Maine</td>
<td>10%</td>
<td>2017</td>
<td>1999 RPS2007 Law</td>
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<tr>
<td><strong>Maryland</strong></td>
<td>20%</td>
<td>2022</td>
<td>SB 209 &amp; SB 595</td>
</tr>
<tr>
<td>Massachusetts</td>
<td>25%</td>
<td>2020</td>
<td>SB 2768</td>
</tr>
<tr>
<td><strong>Michigan</strong></td>
<td>10%</td>
<td>2015</td>
<td>SB 213</td>
</tr>
<tr>
<td><strong>Minnesota</strong></td>
<td>25%</td>
<td>2025</td>
<td>SB 4</td>
</tr>
<tr>
<td>Missouri</td>
<td>15%</td>
<td>2021</td>
<td>SB 54</td>
</tr>
<tr>
<td>Montana</td>
<td>15%</td>
<td>2015</td>
<td>SB 415</td>
</tr>
</tbody>
</table>

* At least 4% Solar, Large investor owned 20%, municipal and Rural utilities 10% by 2020
** At least 2% Solar PV....Thermal Solar not mentioned
*** Alternative Energy Production Law,...does not mention Thermal Solar
**** Solar carve out of 2%...not clear if Thermal Solar qualifies or if only Solar PV
***** Up to 10% of the RPS can be met with advanced clean energy technologies
****** Ecel Energy must reach 30% by 2020...currently product 1/1 of the states energy
******* 2% must come from Solar energy

<table>
<thead>
<tr>
<th>State</th>
<th>Target</th>
<th>Year</th>
<th>Legislation</th>
</tr>
</thead>
<tbody>
<tr>
<td>*Nevada</td>
<td>25.0%</td>
<td>2025</td>
<td>AB 3 &amp; SB 395</td>
</tr>
<tr>
<td>New Hampshire</td>
<td>25.0%</td>
<td>2025</td>
<td>HB 873</td>
</tr>
<tr>
<td>New Jersey</td>
<td>22.5%</td>
<td>2025</td>
<td>14 N.J.A.C. 8-2</td>
</tr>
<tr>
<td>New Mexico</td>
<td>20.0%</td>
<td>2020</td>
<td>SB 418</td>
</tr>
<tr>
<td><strong>New York</strong></td>
<td>25.0%</td>
<td>2013</td>
<td>NY Public Service Comm.</td>
</tr>
<tr>
<td>North Carolina</td>
<td>12.5%</td>
<td>2021</td>
<td>SL 2007-397</td>
</tr>
<tr>
<td>Ohio</td>
<td>12.5%</td>
<td>2025</td>
<td>SB 221</td>
</tr>
<tr>
<td>***Oregan</td>
<td>25.0%</td>
<td>2025</td>
<td>SB 838 &amp; HB 3039</td>
</tr>
<tr>
<td>Pennsylvania</td>
<td>18.0%</td>
<td>2020</td>
<td>Alternative Energy Portfolio</td>
</tr>
<tr>
<td>Rhode Island</td>
<td>16.0%</td>
<td>2020</td>
<td>Clean Energy Act</td>
</tr>
<tr>
<td>Texas</td>
<td>5,880 MW</td>
<td>2015</td>
<td></td>
</tr>
<tr>
<td>Vermont</td>
<td>25.0%</td>
<td>2025</td>
<td>Energy Eff. &amp; Affordability Act</td>
</tr>
<tr>
<td>Washington</td>
<td>15.0%</td>
<td>2020</td>
<td>Ballot Initiative 937</td>
</tr>
<tr>
<td>West Virginia</td>
<td>25.0%</td>
<td>2025</td>
<td>HB 103</td>
</tr>
</tbody>
</table>

* At least 6% from Solar
** Main Tier must account for 24% and the Customer-Sited Tier 1%
**** HB 3039 is a Bill for Solar PV only

Electric utilities generate a certain amount of electricity from renewable or alternative energy sources
Market Transformation

DOE NAECA III – Final

Condensing & Thermal Solar

Heat Pump & Thermal Solar

2009: Units over 55 gal. 145,000

2009: Units over 55 gal. 355,000

Gas tankless heater minimum set at 0.82 EF

Effective date will be in April, 2015
Federal Incentives
- Energy-Efficient Mortgages (FHA or VA)
- Residential Renewable Energy Tax Credit 30%

State Incentives
- Personal Tax Credit, State Rebate Programs, Utility Programs, Sales Tax exemption, Property Tax Incentives, Grant Programs, Loan Programs, Public Benefit Funds

www.dsireusa.org
Federal Tax rebate – equal to 30% of the systems cost, provided that installation is by Dec 31st 2017.

State incentives – over half of states provide an additional incentive of 500$ and more.

Ohio: Green Energy Ohio - GEO Solar Thermal Rebate Program Amount: $30 per kBtu/day, Maximum Incentive: $2,400
Solar Rating and Certification Corporation

- The corporation is an independent third-party certification entity. It is unique in that it is the only national certification program established solely for solar thermal energy collectors and systems.

- It is also the **only** national certification organization whose programs are the direct result of combined efforts of state organizations involved in the administration of standards and an industry association.

- Six to Eight months required for **system certification** and confirmation of the Solar Energy Factor (SEF)
### Sample SRCC OG100 Certificate

**SOLAR COLLECTOR CERTIFICATION AND RATING**

**CERTIFIED SOLAR COLLECTOR**

**SUPPLIER:**

**MODEL:**

**COLLECTOR TYPE:**

**CERTIFICATION #:**

---

### COLLECTOR THERMAL PERFORMANCE RATING

<table>
<thead>
<tr>
<th>CATEGORY (Tt-Ta)</th>
<th>CLEAR DAY</th>
<th>MILDLY CLOUDY</th>
<th>CLOUDY DAY</th>
<th>CATEGORY (Tt-Ta)</th>
<th>CLEAR DAY</th>
<th>MILDLY CLOUDY</th>
<th>CLOUDY DAY</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (-5 °C)</td>
<td>54.9</td>
<td>41.6</td>
<td>28.4</td>
<td>A (-9 °F)</td>
<td>52.0</td>
<td>39.4</td>
<td>26.9</td>
</tr>
<tr>
<td>B (5 °C)</td>
<td>49.2</td>
<td>35.9</td>
<td>22.7</td>
<td>B (9 °F)</td>
<td>46.6</td>
<td>34.0</td>
<td>21.5</td>
</tr>
<tr>
<td>C (20 °C)</td>
<td>40.8</td>
<td>27.8</td>
<td>15.0</td>
<td>C (36 °F)</td>
<td>38.7</td>
<td>26.4</td>
<td>14.2</td>
</tr>
<tr>
<td>D (50 °C)</td>
<td>25.4</td>
<td>13.7</td>
<td>3.1</td>
<td>D (90 °F)</td>
<td>24.0</td>
<td>13.0</td>
<td>2.9</td>
</tr>
<tr>
<td>E (80 °C)</td>
<td>11.8</td>
<td>2.4</td>
<td>0.0</td>
<td>E (144 °F)</td>
<td>11.2</td>
<td>2.2</td>
<td>0.0</td>
</tr>
</tbody>
</table>

- A- Pool Heating (Warm Climate)  
- B- Pool Heating (Cool Climate)  
- C- Water Heating (Warm Climate)  
- D- Water Heating (Cool Climate)  
- E- Air Conditioning

**Original Certification Date:** 24-APR-09

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### COLLECTOR SPECIFICATIONS

- **Gross Area:** 3.710 m² 39.93 ft²  
- **Net Aperature Area:** 3.44 m² 37.03 ft²  
- **Dry Weight:** 67.0 kg 148. lb  
- **Fluid Capacity:** 6.3 liter 1.7 gal  
- **Test Pressure:** 551. KPa 80. psg
Market Transformation

- Arizona (**OG-300**)  
  - Tucson Electric Power (**OG-300**)  

- Georgia (**OG-300**)  

- California  
  - Sacramento Municipal Utility District (**OG-300**)  
  - City of Thousand Oaks (OG-300)  
  - California Energy Commission (OG-100 and OG-300)  
  - Title 24  

- Colorado (OG-300)  

- Delaware (OG100 and OG300)  

- Guam  

- Hawaii  
  - Hawaiian Electric (OG-100)  
  - Hawaii Electric Light (OG-100)  
  - Kauai Island Utility Cooperative (OG 100)  
  - Maui Electric (OG-100)  

- HUD (OG-300)  

- Illinois (OG-300)  

- Louisiana (OG-100 and OG-300 recommended)  

- Maryland (OG-100 and OG-300)  

- Minnesota (OG-100 and OG-300)  

- Montana  
  - National Center for Appropriate Technology  

- Nevada  
  - Public Utilities Commission (OG-300)  

- New Mexico (OG-100 and OG-300)  

- North Carolina (OG-100 and OG-300 highly recommended)  

- Oregon (OG-300)  
  - Eugene Water and Electric Board (OG-300)  

- Pennsylvania  
  - Allegheny Power (OG-100)  
  - GPU (OG-100)  
  - PECO Energy (OG-100)  

- Texas  
  - Oncor (OG-300)  

- Utah  
  - Questar Gas (OG-100)  

- Vermont (OG-100)  

- Wisconsin (OG-100 and OG-300)  

- Washington, D.C. (OG-100 and OG-300)  

- Wyoming  
  - Questar Gas (OG-100)
Market Transformation

What is SEF and how do I calculate Pay Back?

"Solar Energy Factor" defined as the energy delivered by the system divided by the electrical or gas energy put into the system.

The higher the number, the more energy efficient the system is. Solar energy factors range from 1.0 to 11. Systems with solar energy factors of 2 or 3 are the most common.
Solar Gas Value Proposition – Payback?

Examples: (Assume that gas costs $1.60/therm)

1. TYPICAL GAS WATER HEATER (EF = 0.6)
   Annual Operating Costs = 365*0.4105/0.6*1.60 = $399.55

2. TYPICAL SOLAR SYSTEM (SEF = 1.7)
   Annual Operating Costs = 365*0.4105/1.7*1.60 = $141.02
   - Solar system saves $258.53 per year.
   - Payback (SEF 1.7 System):
     - Gas Solar system installed $6,000
     - 40 Gallon Gas installed price $800
     - Payback is with in 16 to 33 years

Note: Does not account for escalation of energy cost or Incentives
Solar Electric Value Proposition – Payback?

Examples: (Assume that electricity costs $0.12/kWh)

1. TYPICAL ELECTRIC WATER HEATER (EF = 0.90)
   Annual Operating Costs = \(365 \times 12.03 / 0.90 \times 0.12 = 585.46\)

2. TYPICAL SOLAR SYSTEM (SEF = 2.5)
   Annual Operating Costs = \(365 \times 12.03 / 2.0 \times 0.12 = 210.77\)

- Solar system saves $374.69 per year.
- Payback (SEF 2.5):
  - Electric Solar System install $5,500
  - 52 Electric installed cost $700
  - Hawaii 7 years…Idaho 21 years

Note: Does not account for escalation of energy cost or Incentives
## Solar Electric Value Payback with Incentives

<table>
<thead>
<tr>
<th>State</th>
<th>Cost Std. Solar System Installed</th>
<th>Federal Tax Credit</th>
<th>State personal Tax Credit</th>
<th>State Rebate</th>
<th>Sales Tax</th>
<th>Utility Rebate</th>
<th>Net Cost Solar System</th>
<th>Cost Std Electric 52 + $400 Install</th>
<th>Diff</th>
<th>Pay Back Years</th>
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</thead>
<tbody>
<tr>
<td>New York</td>
<td>$8,000</td>
<td>$1,650</td>
<td>$2,000</td>
<td>$0</td>
<td>$1,200</td>
<td>$3,150</td>
<td>$700</td>
<td>$2,450</td>
<td>4.5</td>
<td></td>
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<tr>
<td>Rhode Island</td>
<td>$8,000</td>
<td>$1,650</td>
<td>$2,000</td>
<td>$560</td>
<td>$1,200</td>
<td>$2,590</td>
<td>$700</td>
<td>$1,890</td>
<td>4.1</td>
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<tr>
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<td>$8,000</td>
<td>$1,650</td>
<td>$2,800</td>
<td>$2,800</td>
<td>$0</td>
<td>$3,550</td>
<td>$700</td>
<td>$2,850</td>
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<td>$1,650</td>
<td></td>
<td>$2,800</td>
<td>$0</td>
<td>$3,550</td>
<td>$700</td>
<td>$3,250</td>
<td>6.0</td>
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<tr>
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<td>$8,000</td>
<td>$1,650</td>
<td>$1,200</td>
<td>$0</td>
<td>$1,200</td>
<td>$3,950</td>
<td>$700</td>
<td>$3,250</td>
<td>6.0</td>
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<td>$1,200</td>
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<td>$1</td>
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<td>$700</td>
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<td>$5,950</td>
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<td>$4,050</td>
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<td>$4,849</td>
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<td>$4,149</td>
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<td>$700</td>
<td>$2,849</td>
<td>9.2</td>
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<td>*Oregon</td>
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<td>$1,500</td>
<td>$1,500</td>
<td>$1</td>
<td>$3,349</td>
<td>$700</td>
<td>$2,649</td>
<td>9.7</td>
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</tr>
</tbody>
</table>

Note: Includes annual solar savings…does not include escalation of energy costs
Market Transformation

- Solar water heating installations grew by approximately 10%
- Pool Heating installations declined by 10% over 2008
- Annual electric installations grew by approximately 37%

Source: Solar Energy Industries Association
Solar Solutions and Collectors/Panels
THE SOLAR CONSTANT

- 440 BTUH/FT²
- 1.4 kW/m²

- 30 - 60% is absorbed and scattered
- 170 – 315 Btuh/ft² reaches surface
Energy

Energy is measured in many ways.

• One of the basic measuring blocks is called a Btu. This stands for British thermal unit and was invented by, of course, the English.

• Btu is the amount of heat energy it takes to raise the temperature of one pound of water by one degree Fahrenheit, at sea level. **8.34 BTU's are required to raise 1 gallon of water 1 degree F.**

• One Btu equals about one blue-tip kitchen match.

• One thousand Btus roughly equals: One average candy bar or 4/5 of a peanut butter and jelly sandwich.

• It takes about 2,000 Btus to make a pot of coffee.
Not all solar is created equal.

SOLAR PHOTOVOLTAICS (PV)
- Converts radiant solar energy into DC electricity.
- Efficiencies: 16% for mono-crystalline silicon, 12% for polycrystalline, 4-7% for amorphous silicon cells.

SOLAR WATER HEATING
- Converts radiant solar energy into heat energy for fluid heating applications. Efficiencies range from 50% to 80%
- Advantages of Solar Water Heating:
  - More efficient than solar PV
  - Less costly to install
  - Faster payback period (ROI) than PV
Solar Electric or PV?

- Most expensive entry into residential solar energy without significant government incentive programs.

Source: *Home Power*, Oct/Nov 2008 issue

<table>
<thead>
<tr>
<th>Technology</th>
<th>Collector or Module Efficiency</th>
<th>System Efficiency</th>
<th>Cost</th>
<th>System Cost Per KWH*</th>
</tr>
</thead>
<tbody>
<tr>
<td>SHW: 64 sq. ft. of collectors + 80 gal. water heater</td>
<td>50%–70%</td>
<td>35%–50%</td>
<td>$8,000</td>
<td>$0.09</td>
</tr>
<tr>
<td>Grid-tied PV: 2 KW</td>
<td>5%–19%</td>
<td>4%–13%</td>
<td>20,000</td>
<td>0.27</td>
</tr>
</tbody>
</table>

*Over 30 yrs. in Richmond, Virginia; maintenance costs not included*
What is the difference between Solar Hot Water and “standard” gas or electric hot water system?

**The Basics:**
Solar Hot Water Heating uses simple principles and components to capture incoming solar radiation (sunlight) and transform it heat energy – providing the hot water needed for domestic, commercial, industrial, and other uses. Solar Hot Water Heating Systems have been around decades.
Water Heating Facts

- The average household with an electric water heater spends about 25% of its home energy costs on heating water
  [Source: Florida Solar Energy Center].

- Solar can save as much as 50-85% annually on the water heating portion of your utility bill (compared to electric water heaters).
  [Source: US Dept. of Energy]
Americans Want Solar!

- 79% feel that homebuilders should offer solar power as an option for all new homes.
- 64% are willing to pay more for a home with solar. For every utility-bill dollar saved annually, property value can increase $10 - $20. Reducing an annual electric bill by $1,000 through a solar power investment, can result in $10,000 to $20,000 rise in home value. [Source: CNNMoney.com October 2006]
- 73% believe that solar energy technology is more important today than ever.
- 42% say that saving money on monthly utility bills is the most compelling argument for installing solar power. Others indicated it was to decrease the nation's dependence on oil (31%) or reduce environmental pollution (18%).

source: Roper survey commissioned by Sharp Electronics Corporation 2006
Does solar make sense?

**YES** if you want to…

- Save money on energy from day 1

- Add re-sale value to your home/business: a home’s value is increased by $20,000 for every $1,000 reduction in annual operating costs from energy efficiency.”

- Be more independent

- Protect our environment

- and can accept longer-term ROI’s
Solar Thermal Applications

Solar DHW Solution

Simplest, least expensive entry into solar energy for the home
Residential Solar – Packaged Systems

Closed-Loop Pressurized System

1 Solar collectors
2 Solar storage tank
3 Heat exchanger
4 Expansion tank
5 Temperature and Pressure relief valve
6 Air vent
7 Drain valve
8 Mixing valve
9 Solar pump station
10 Temperature sensor Tank and collector sensor
Drain Back Systems

What is the advantage of Drain Back?

- Better thermal efficiency since you can run just water through the panels (or a lower concentration of glycol)

- Allows the system to shut down at any time the tank temperature reaches set point, avoiding the "boiling" or "frying" of a glycol water solution.
Drain Back Systems

What are the disadvantages of Drain Back?

- Disadvantages include increased installation costs and difficulties installing properly pitched supply/return lines.

- Drainage and filling cycles are typically noisy and pump needs to be sized for lifting.
Solar Thermal Applications

Solar Pool Heating Applications

Solar Hydronic Systems

- Indoor / Outdoor pools
- Combi-Systems
- Space Heating Support
Solar Thermal Applications

Solar Cooling Applications

- LiBr single effect absorption chillers

Concentrating solar arrays

Solar Electric Power Plants
SOLAR THERMAL SYSTEMS

Closed loop system

Glycol / water heat transfer fluid

Closed loop system
SOLAR DHW HEATING SYSTEM
Retrofit / Preheat system

Existing gas/oil or electric tank
SOLAR DHW HEATING SYSTEM
Retrofit / Preheat system

- SOLAR DHW HEATING SYSTEM
- Retrofit / Preheat system
- Overflow Container
- DHW Tank
- Expansion Tank
- Solar Pump Station
- System Fill
- FAST AIR VENT C/W SHUT OFF
- Solar Collectors
- Solar Control
- 120V
- Existing gas/oil or electric tank

Existing gas/oil or electric tank
SOLAR DHW - POOL HEATING SYSTEM
DHW + Pool heating supplement

FAST AIR VENT C/W SHUT OFF

SOLAR COLLECTORS

EXPANSION TANK

OVERFLOW CONTAINER

P1 P2

S1

120V

CONTROL

P2

P1

S1 S2 S3

DHW

TEMPERING VALVE

OVERFLOW CONTAINER

S2

DCW

DHW TANKS

HEAT EXCHANGER 1

S3

S3

120V

P3

120V
Collectors/panels

There are (4) proven commercially available technologies for solar water heating. Which one is right depends on the application and the location and climate.

– Flat Plate Collectors
– Plastic, Non-Insulated Collectors
– Evacuated Tube Collectors
– Concentrating Collectors
Concentrating Collectors

Much higher temperatures than flat-plate collectors or evacuated tubes (steam generation possible)

Focuses direct solar radiation, hence poor performance on hazy or cloudy days

Most practical in areas with high insolation (exposure to the sun's rays), such as those close to the equator and in the desert southwest United States

Systems may use tracking mechanisms to move the collectors during the day to keep them focused on the sun

High installation and maintenance costs

Used primarily for large-scale electric power generation using steam powered turbines
Pool Heating Only

**collector area = 75% to 100% of the exposed pool area**

Seasonal use

**Low cost – not for DHW**

Typical solar pool heating system with automatic control

[Source: Florida Solar Energy Center]
Flat Plate Collectors

Residential & Commercial water heating applications

Medium Cost, robust proven performance, all climates, tempered glass

Common Sizes:
3’x7’, 4’x8’, and 4’x10’

Rule of thumb for sizing (DHW):

20 ft² (2 m²) of collector area for each of the first two family members
8 square feet (0.7 square meter) for each additional family member in the Sun Belt.
12 - 14 additional square feet (1.1-1.3 m²) per person in the northern US [US DEPT OF ENERGY]
Evacuated Tube Collectors

Residential & commercial water heating applications
Medium to High Cost (16, 20, and 30 tube collectors common), all climates, non-tempered glass, snow melt problems with shallow incline angle

Rule of thumb for sizing (DHW):
4-10 tubes per person depending on tube diameters and lengths, or 7.5 square feet (0.7 square meter) per person. Typical family of 4 DHW system would use 16 to 30 tubes and an 80 gal storage tank.
Flat-plate collectors are the most cost effective technology for applications where the temperature rise above ambient is less than about 50°C (90°F)
Flat Plate vs. Evacuated Tube

- Flat plates use tempered safety glass while evacuated tubes use borosilicate or soda-lime glass, which breaks into shards.
- Evacuated tubes are only efficient as long as the vacuum seals are in-tact. No vacuum loss issues with flat plates.
- Flat plates are able to shed snow more easily compared to tubes, resulting in possibly more heat production in the winter.
- Flat plates can be used to regulate excessive tank temperatures by emitting heat in reverse control cycle – not possible with tubes.
Solutions for any application

Typical Applications

- Single homes
- Apartment buildings
- Industrial / Commercial
Single homes

Individual Home Systems

From left to right - North Carolina, Florida and Maine
Apartment buildings

Central Systems
Industrial/Commercial

Mega solutions
Industrial / Commercial

Mega Systems
Commercial Project Sequence

- Complete questionnaire or review RFP
- Analyze questionnaire or RFP and climate data
- System design, performance modeling and ROI – PolySun, T-SOL, F-Chart, RET Screen simulation software
- Quotation
- Purchase Order
- Detailed system design
- System delivery
- Installation and supervision
- After sale support
Swimming Pools

- Exposed surface area?
- Average depth of water?
- Desired pool water temperature?
- Indoor or outdoor pool?
- If indoor – what is the room ambient temperature and relative humidity?
- Hours of use per day?
- Seasonal use? If yes, auxiliary heat dumps available?
- Cover used?
- Back-up heating system information?
- Yearly energy needed and cost of back-up energy?
- Solar panel installation location specifics – orientation to South, type of mounting proposed, distance from panels to pool mechanical equipment?
Sport Facilities

Spain

Chile

Mexico
Apartment Buildings

Cuba

Spain

Israel
Hospitals

Jamaica

Mexico

Chile
Factories

Spain

Brazil

Chile
Schools

Spain

Chile
Solar in USA?

- Ideal climate for Solar in the sun belt as well as most areas of the country using the right panel and design
- “Green” awareness
- Volatile Energy prices
- 30% Federal tax rebate & local, state, utility incentives
- Feasible Return On Investment
- Accessible room for large arrays of collectors
Can solar work in New England?

Examples of Insolation Data (kWh/m^2)

The following is a table of insolation data for Boston, Massachusetts:

<table>
<thead>
<tr>
<th>Month</th>
<th>Insolation (kWh/m^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan</td>
<td>1.66</td>
</tr>
<tr>
<td>Feb</td>
<td>2.50</td>
</tr>
<tr>
<td>Mar</td>
<td>3.51</td>
</tr>
<tr>
<td>April</td>
<td>4.13</td>
</tr>
<tr>
<td>May</td>
<td>5.11</td>
</tr>
<tr>
<td>June</td>
<td>5.47</td>
</tr>
<tr>
<td>July</td>
<td>5.44</td>
</tr>
<tr>
<td>Aug</td>
<td>5.05</td>
</tr>
<tr>
<td>Sept</td>
<td>4.12</td>
</tr>
<tr>
<td>Oct</td>
<td>2.84</td>
</tr>
<tr>
<td>Nov</td>
<td>1.74</td>
</tr>
<tr>
<td>Dec</td>
<td>1.40</td>
</tr>
</tbody>
</table>

Daily Average: 3.58 kWh/m^2 (1135 Btu/ft^2)
Total for year: 1,307 kWh/m^2 (414,317 Btu/ft^2)

Munich, Germany ... which has a higher latitude than Boston has a level of 1,088. In other words Boston gets about 20% more sunlight than Munich.
SOLAR INSTALLATION

- SITE SELECTION
- PANEL INSTALLATION
- TANK INSTALLATION & PUMP STATION INSTALLATION
- CHARGING WITH HEAT TRANSFER FLUID
SITE SELECTION IS VERY IMPORTANT!!!

Software Programs Available:
SOLAR PATHFINDER, Bing™ Map
RETScreen & POLYSUN
SOLAR PATHFINDER™
Solar Site Analysis
6209 Lampkins Bridge Rd
College Grove, TN 37046

Aerial View
Notice the South Facing Direction
Summary:
Excellent Solar Site! Very few solar obstructions as indicated by Solar Pathfinder analysis of 97.87%.

CHROMAGEN CR 110
Solar Collectors to be installed here.
### SOLAR PATHFINDER™

<table>
<thead>
<tr>
<th>Field</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Report Name</td>
<td>6209 Lampkins Bridge Rd.</td>
</tr>
<tr>
<td>Report Date</td>
<td>3/26/2010 11:15:42 AM</td>
</tr>
<tr>
<td>Declination</td>
<td>-3d 04m</td>
</tr>
<tr>
<td>Location</td>
<td>COLLEGE GROVE, TN 37046</td>
</tr>
<tr>
<td>Lat/Long</td>
<td>35.791 / -86.726</td>
</tr>
<tr>
<td>Weather Station</td>
<td>Nashville Intl AP, TN, Elevation: 581 Feet, (36.117/-86.683)</td>
</tr>
<tr>
<td>Site distance</td>
<td>23 Miles</td>
</tr>
<tr>
<td>Report Type</td>
<td>Thermal</td>
</tr>
<tr>
<td>Array Type</td>
<td>Fixed</td>
</tr>
<tr>
<td>Tilt Angle</td>
<td>35.79 deg</td>
</tr>
<tr>
<td>Ideal Tilt Angle</td>
<td>35.79 deg</td>
</tr>
<tr>
<td>Azimuth</td>
<td>180.00 deg</td>
</tr>
<tr>
<td>Ideal Azimuth</td>
<td>180.00 deg</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>---------------</td>
<td>--------------------------------------</td>
</tr>
<tr>
<td>Collector Make</td>
<td></td>
</tr>
<tr>
<td>Collector Model</td>
<td></td>
</tr>
<tr>
<td>Collector Area</td>
<td>23.1 Sq. Feet</td>
</tr>
<tr>
<td>Collector Count</td>
<td>3</td>
</tr>
<tr>
<td>Total Collector Area</td>
<td>69.4 Sq. Feet</td>
</tr>
<tr>
<td>Solar Fraction</td>
<td>0.74</td>
</tr>
<tr>
<td>Annual Production</td>
<td>10.10 Million BTU</td>
</tr>
<tr>
<td>Electricity Saved</td>
<td>3,218.0 KWH</td>
</tr>
<tr>
<td>Annual Savings</td>
<td>$321.80</td>
</tr>
<tr>
<td>Collector Fluid</td>
<td>Glycol</td>
</tr>
<tr>
<td>Layout Configuration</td>
<td>SinglePicture</td>
</tr>
<tr>
<td>Layout Point Count</td>
<td>1</td>
</tr>
</tbody>
</table>
Energy Source Used to Heat Water

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy Source</td>
<td>Electricity</td>
</tr>
<tr>
<td>Energy Efficiency</td>
<td>100.0 %</td>
</tr>
<tr>
<td>Energy Cost</td>
<td>$0.10 per KWH</td>
</tr>
<tr>
<td>Total Electricity Saved</td>
<td>3,218.0 KWH</td>
</tr>
</tbody>
</table>
### Estimated Average Daily Hot Water Usage

<table>
<thead>
<tr>
<th>Month</th>
<th>Usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>60.0</td>
</tr>
<tr>
<td>February</td>
<td>60.0</td>
</tr>
<tr>
<td>March</td>
<td>60.0</td>
</tr>
<tr>
<td>April</td>
<td>60.0</td>
</tr>
<tr>
<td>May</td>
<td>60.0</td>
</tr>
<tr>
<td>June</td>
<td>60.0</td>
</tr>
<tr>
<td>July</td>
<td>60.0</td>
</tr>
<tr>
<td>August</td>
<td>60.0</td>
</tr>
<tr>
<td>September</td>
<td>60.0</td>
</tr>
<tr>
<td>October</td>
<td>60.0</td>
</tr>
<tr>
<td>November</td>
<td>60.0</td>
</tr>
<tr>
<td>December</td>
<td>60.0</td>
</tr>
</tbody>
</table>

### Other Assumptions

- **Tank Temperature**: 120.0 °F
- **Water Supply Temperature**: 55.0 °F
- **Main Tank Volume**: 120.0 Gallons
- **Secondary Tank Volume**: 0.0 Gallons
- **Heat Exchanger Efficiency**: 70.00 %
## Estimated Monthly Savings

<table>
<thead>
<tr>
<th>Month</th>
<th>Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>$16.08</td>
</tr>
<tr>
<td>February</td>
<td>$21.23</td>
</tr>
<tr>
<td>March</td>
<td>$27.92</td>
</tr>
<tr>
<td>April</td>
<td>$30.19</td>
</tr>
<tr>
<td>May</td>
<td>$31.06</td>
</tr>
<tr>
<td>June</td>
<td>$32.87</td>
</tr>
<tr>
<td>July</td>
<td>$33.03</td>
</tr>
<tr>
<td>August</td>
<td>$33.50</td>
</tr>
<tr>
<td>September</td>
<td>$28.63</td>
</tr>
<tr>
<td>October</td>
<td>$29.18</td>
</tr>
<tr>
<td>November</td>
<td>$20.78</td>
</tr>
<tr>
<td>December</td>
<td>$17.33</td>
</tr>
</tbody>
</table>

### Annual Savings

$321.80
### Solar Obstruction Data

<table>
<thead>
<tr>
<th>Month</th>
<th>Unshaded % of Ideal Site Azimuth=180 Tilt=35.79</th>
<th>Actual Solar Rad w/ Shading Azimuth=180.0 Tilt=35.79 KWH/m²/day</th>
<th>Solar Hot Water Actual Cost Savings Electricity $0.10/KWH</th>
<th>Solar Hot Water Solar Fraction Azimuth=180.0 Tilt=35.79</th>
<th>Solar Hot Water Produced Azimuth=180.0 Tilt=35.79 MMBTU</th>
<th>Solar Hot Water Demand Azimuth=180.0 Tilt=35.79 MMBTU</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>94.84%</td>
<td>2.95</td>
<td>$16.08</td>
<td>0.44</td>
<td>0.50</td>
<td>1.16</td>
</tr>
<tr>
<td>February</td>
<td>97.65%</td>
<td>4.15</td>
<td>$21.23</td>
<td>0.64</td>
<td>0.67</td>
<td>1.05</td>
</tr>
<tr>
<td>March</td>
<td>98.78%</td>
<td>4.82</td>
<td>$27.92</td>
<td>0.76</td>
<td>0.88</td>
<td>1.16</td>
</tr>
<tr>
<td>April</td>
<td>98.89%</td>
<td>5.45</td>
<td>$30.19</td>
<td>0.84</td>
<td>0.95</td>
<td>1.12</td>
</tr>
<tr>
<td>May</td>
<td>98.38%</td>
<td>5.32</td>
<td>$31.06</td>
<td>0.84</td>
<td>0.98</td>
<td>1.16</td>
</tr>
<tr>
<td>June</td>
<td>98.89%</td>
<td>5.90</td>
<td>$32.87</td>
<td>0.92</td>
<td>1.03</td>
<td>1.12</td>
</tr>
<tr>
<td>July</td>
<td>98.88%</td>
<td>5.64</td>
<td>$33.03</td>
<td>0.89</td>
<td>1.04</td>
<td>1.16</td>
</tr>
<tr>
<td>August</td>
<td>99.15%</td>
<td>5.76</td>
<td>$33.50</td>
<td>0.91</td>
<td>1.05</td>
<td>1.16</td>
</tr>
<tr>
<td>September</td>
<td>98.32%</td>
<td>4.97</td>
<td>$28.63</td>
<td>0.80</td>
<td>0.90</td>
<td>1.12</td>
</tr>
<tr>
<td>October</td>
<td>97.19%</td>
<td>5.00</td>
<td>$29.18</td>
<td>0.79</td>
<td>0.92</td>
<td>1.16</td>
</tr>
<tr>
<td>November</td>
<td>96.56%</td>
<td>3.66</td>
<td>$20.78</td>
<td>0.58</td>
<td>0.65</td>
<td>1.12</td>
</tr>
<tr>
<td>December</td>
<td>95.16%</td>
<td>3.09</td>
<td>$17.33</td>
<td>0.47</td>
<td>0.54</td>
<td>1.16</td>
</tr>
<tr>
<td>Totals</td>
<td>97.72%</td>
<td>56.70</td>
<td>$321.80</td>
<td>0.74</td>
<td>10.10</td>
<td>13.65</td>
</tr>
</tbody>
</table>

Unweighted Effect: 97.66%
Yearly Avg Sun Hrs: 4.73
The best orientation is achieved when the collectors are facing due south +/- 45°. Should be tilted at an angle from the horizontal equal to the latitude of the location + 10°. The + 10° tilt gives better winter performance.
PANEL INSTALLATION

UNDER ROOF
PANEL INSTALLATION

APPLY SEALANT
MARKING FOR MOUNTING
PANEL INSTALLATION

FIRST PANEL
PANEL INSTALLATION

MOUNTING CLIP DETAIL
PANEL INSTALLATION

MOUNTING CLIP DETAIL
PANEL INSTALLATION

PANEL SUPPORTS

Blocking
All Thread Rod
Spanner
LAG BOLTS GONE WRONG!

PANEL INSTALLATION
PANEL INSTALLATION

UNION INSTALLED
PANEL INSTALLATION

Panels Installed
Can collectors be placed horizontally on the roof?

- On closed loop pressurized systems yes, but it complicates the plumbing and raises installation costs.
- Also, panels will not drain well during servicing in this configuration when the risers are running the long axis of the panel.
- Panel vents will trap moisture unless they are plugged.
Install at the highest point in the system
Leave vent cap open for 5 days
Close cap to prevent loss of heat transfer liquid
PIPE INSULATION

¾” MIN. WALL THICKNESS
Tank & Pump Station Installation

Mixing Valve

Pump and Control Station

Connection to Heat Exchanger
Relieve pressure if more than 25 PSI.

If it is lower than 25 PSI use a bicycle pump or air compressor to set the charge pressure to 25 PSI.
The use of regular tap water as a mixing agent is prohibited.

Distilled, de-ionized, or de-mineralized water is often available from grocery stores and drugstores.

This solution provides freeze protection down to -30°C F and burst protection down to -60°C F.
GLYCOL CHARGE

CHARGING HOSES
GLYCOL FILL PORT

Pressure Gauge
Fill Port
FLOW ADJUSTMENT

Flow Adjustment Valve

Meter
GLYCOL CHARGING PUMP

Transfer Pump
PUMP SPEED ADJUSTMENT

3 SPEED ADJUSTMENT BUTTON
FINISHED TANK INSTALL

External Plate Heat Exchanger Version
MAINTENANCE

- Check the system pressure every 6 months.
- Pressure loss might indicate the existence of a leak. The pressure should remain above 30 PSI. If necessary, pressurize the system again and check for leaks.
- Flush a bit of water through the pressure relief valve on the tank every 6 months to ensure proper operation.
- Wash the glass on the collectors once a year; more often if dirty.
How often should the glycol be replaced in the system?

- Every three years or -
- When the results of a pH and refractometer tests indicate it is necessary - check annually
- The pH should be 8.0+. At 7.0 and below, replace fluid.
- Refractometer (calibrated for propylene glycol) shows frost protection level of the solution. If it drops below that level re-charge the loop.
MAINTENANCE

Digital Refractometer
• $300+
• Show glycol %
• Analog version $60
MAINTENANCE

Analog Refractometer
• $60+
• Automotive for glycol

Automotive Glycol Tester
$13.99

Pool pH Test Kit
$8.99
Questions