Low-cost Solar Water Heaters

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Presentation Outline

• Background
  • Solar water heater (SWH) markets and economics

• Low-cost SWH: present and future
  • U.S. DOE: two polymer systems
  • International polymer systems
  • Evacuated tubes?

• Conclusions
  • Low-cost systems will be a market player
Residential Energy and Water Heating

Source energy basis

Water Heating = 13%
Costs: $100 (NG) - $700 (Elec)

~ 200 GJ/year$_{source}$
$/year_{tot,avg}$ ~ $1500

National Averages
Solar H/C World Market: Huge

Solar Heating: More installed capacity than ALL other renewables combined; **production** ~1/3 all renewable energy

**Figure 2:** Total capacity in operation [GW_{el}] [GW_{th}] 2006 and annually energy generated [TWh_{el}] [TWh_{th}]

Sources: Fawer M : Sarasin Sustainability Report 2006 and IEA SHC 2007
US SWH Market: ~ Zero

Country Share of the SWH World Market

- China: 76%
- Europe: 12%
- Turkey/Israel: 6%
- Japan: 4%
- United States: 2%
- RestOfWorld: 0%

United States
Market Penetration in U.S.

Maximum Market Penetration vs. Payback (avg of 3)

Payback = (First cost)/(\$ saved/yr)

Currently in the U.S.:
vs. elec.: 5-20 years
vs. gas: 10-50 years

Target: 3 yrs to 7 yrs
Solar Water Heating
Payback vs. Electricity

Assumed cost: $84/ft^2: low/new-construction cost; retrofit = ~ X2

Some market penetration

Assume no incentives
Solar Water Heating
Payback vs. Natural Gas

No chance for market anywhere!

Assumed cost: $84/ft²: low/new-construction cost; retrofit = ~ X2

Assume no incentives
Cost Goals for SDHW System

Desired market penetration ⇒ payback time ⇒ payback line

For site cost of fuel, project up to payback line, over to system cost
Cost Goals for SDWH

Cost of 40 ft² System vs Cost-of-elec (vs simple payback)
(Incidence = 5.4 kWh/m²/day; Denver)

Target costs @ 7-10 yr Payback

Current costs

Simple Payback:
- Gas: $12.5/0.8 $/MMBtu
- Elec: 9.5 c/kWh

Elec.: $2000-$3000
Gas: $1000-$1500
Current Costs Before Rebates

- **Goals**: $1000 - $3000 (vs. gas to vs. electricity), ~$25-$60/ft²
- **Current costs**:
  - **New Construction**:
    » Efficient, no marketing
    » $4000-$6000, ~ $100/ft²
  - **Retrofit**
    » High installation and marketing cost
    » $5000 - $10000, ~ $125/ft² - $250/ft²
    » Industry inefficiencies: consequence of low volume
  - Rebates/incentives change the picture for the buyer (but not society)
Market Needs:

- **SDWH Cost Reduction**
  - From $4k - $10k to ~ $1.5k - $3k

- **External Factors:**
  - Subsidies?
  - Increased energy cost?
    - China, India demands?
    - US gas supply? Crisis?
  - Renewable Energy Credits?

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*EIA, Electricity Review 2003*
DOE Residential Goal/Strategy

• Reduce levelized cost of energy by > 50%
  • Target market to date: mild climates
  • Cold climate development starting FY09 (?)
    – Warm-climate systems only to date
    – Need for focus: R&D budget ~ $1.3M/year

• Technical strategy: polymers
  • Low-cost materials and processing
  • System re-design and simplification
Unpressurized ICS

Simplest possible, lowest-cost system

Immersed heat exchanger

Glazing(s)

Insulation

Supply/Return Piping

Thin-walled polymer vessel of water
Unpressurized ICS: DEG/SE

Thermoformed acrylic glazing

PE tank

Cu Load-side Hx
DEG/SunEarth ICS

Glazed version

Unglazed version
Field Installations

Migrant housing camp in CA

Glazed units

Unglazed units
SunCache Cost Estimates

• Production cost in volume with profit:
  
  < $1000

• Installation cost in new construction:
  
  $1200-$1600

• Installation cost in retrofit:
  
  $2000-$2500

Note: Costs can exceed $5K in inefficient distribution channels

NOTE: not currently available in volume
Unglazed SDWH

\[ Q_{\text{ungl}} \approx \frac{1}{2} Q_{\text{glz,selective}} \]
\[ Q_{\text{ungl}} \approx \frac{2}{3} Q_{\text{glz,non-selective}} \]

\[ \eta_{\text{sys,ungl}} / \eta_{\text{sys,glaz,non-selective}} \]
FAFCO SDHW System
Installations

- Over 1000 installations across North America since release in 2007
FAFCO Unglazed Active Indirect Systems

- Lightweight flexible solar collectors
- Freeze tolerant drainback design
- Simple user interface
- Cannot overheat
- Easy to install
- Everything is provided in one box
FAFCO Cost Estimation

- Production cost in volume with profit:
  < $1000
- Installation cost in new construction:
  $1300-$1800
- Installation cost in retrofit:
  $2000-$3000
- Current distribution chain cost/retrofit:
  $3000-$5000
Cold Climate Systems: Cost Reduction Potential

Film-lined storage
- Heat exchanger
- Retainer ring
- Submersible pump
- Polymer film liner
- Insulation
- Sheet metal cylinder
- Rigid foam base

Integrated valve pkg

Integrated piping

Cost & Cost-of-Savings/Drainback

- First Cost
- COSE [c/kWh]

Low-cost SDWH: ASES 2005

Polymer Collector

Polymer tank + hx
Integrated piping
Valve package
Polymer selective
Polymer non-selective
Polymer unglazed

Cost ~$12
Low-cost Systems Internationally

The systems to follow are not certified by SRCC or are available in the US

(But they soon may be)

Some evacuated tube systems becoming available

System assemblers using imported tubes and/or systems
Not low-cost yet
Some European Systems

http://www.solarpower-gmbh.de

http://www.solarnor.no


Commercial?
More Commercial Systems

www.okuonline.com

http://soletrol.com.br

ACEEE Water Heating Forum 6-2-08
Polymer ThermoSiphon

Cost ~ $400 US in 2001: 65% reduction

Rotomolded PE Body
PMMA glazing
Unpressurized tank

Evacuated Tube Collector

Fin-tube absorber

Dewar design

Evacuated space

Selective coating

In/out tubes

Heat pipes often used in this tube type

Glass tube

Out

In

Historically expensive; dewar design is cheap today in China

ACEEE Water Heating Forum 6-2-08
Variations with Evacuated Tubes

• **Passive thermosiphons**
  • Tubes directly enter storage tank, thermosiphon loop each tube

• **Active systems**
  • Fin-tube heat pipe transfers heat to condensor in manifold
Conclusions

• Solar water heaters
  • Currently $5K-$10K before rebates
  • Incentives or lower-cost systems needed

• Low-cost SWH development
  • Two US system entering the US market
  • European low-cost systems: several years away?
  • Low-cost evacuated tube systems: maybe?
Thank You

• Questions?