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The Global Energy Challenge:
Reviewing the Strategies
for Natural Gas

Maximising the Efficiency of Natural Gas Use: The Case for Solar Water Heating

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Expert Forum A.B: The Post-Kyoto Challenges of the Natural Gas Industry
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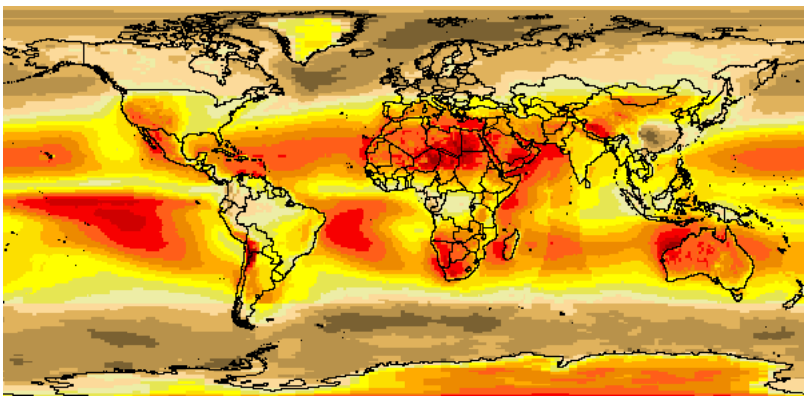
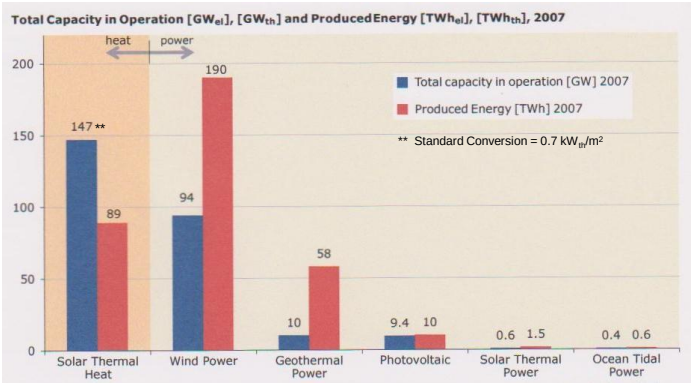
70 Minutes of Sunlight = 1 year of Global Energy Consumption



Source: *United Nations Environment Programme, Solar and Wind Resource Assessment,* http://na.unep.net/swera_ims/map/.

Global Solar Thermal Heat *Capacity* Exceeds All Other Renewable Energy Sources; *Output* Less than Wind



Source: International Energy Agency, Solar Heating and Cooling Program, "Solar Heat Worldwide: Markets and Contribution to the Energy Supply 2007, EDITION 2009," p. 6.

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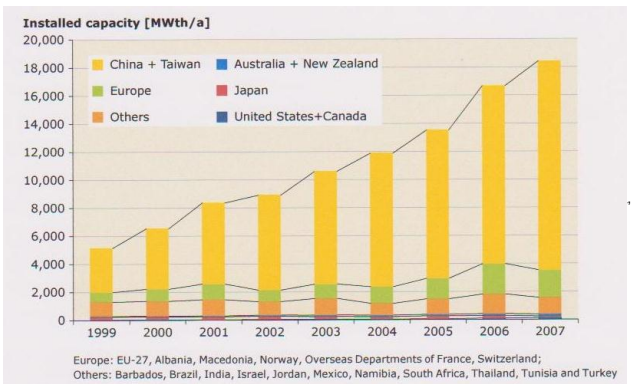
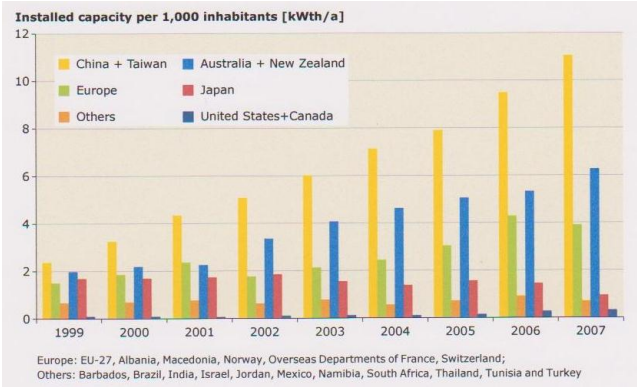
China Installs More Solar Thermal Capacity Per Year than the Rest of the Globe Combined



Source: International Energy Agency, Solar Heating and Cooling Program, "Solar Heat Worldwide: Markets and Contribution to the Energy Supply 2007, EDITION 2009," p. 16.

Per Capita Installed Capacity: China Leads, but.. Australia + New Zealand ~60% and Europe ~35% of China



Source: International Energy Agency, Solar Heating and Cooling Program, "Solar Heat Worldwide: Markets and Contribution to the Energy Supply 2007, EDITION 2009," p. 17.

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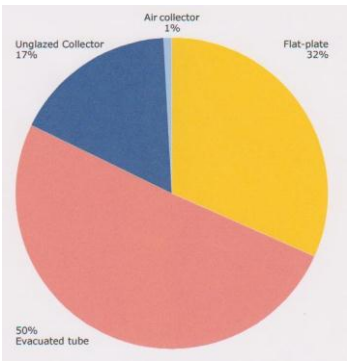
Evacuated Tube and Flat Plate Technologies Dominate; Unglazed Collectors Provide Lower Temperature Heat



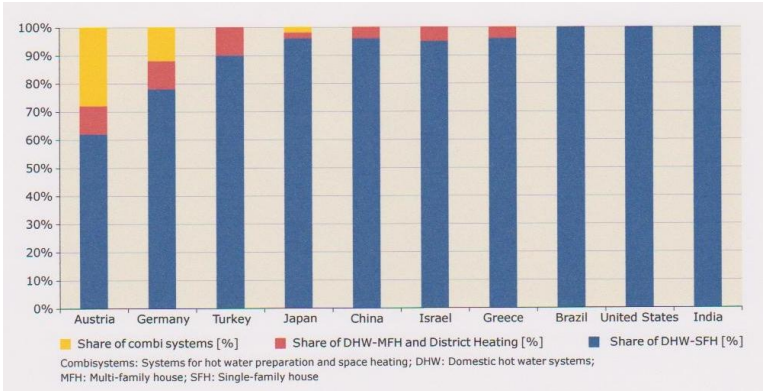
Evacuated Tube Collector
Vermont, U.S.A.

Flat Plate Collectors
Texas, U.S.A.

Source: International Energy Agency, Solar Heating and Cooling Program, "Solar Heat Worldwide: Markets and Contribution to the Energy Supply 2007, EDITION 2009," p. 9.

Photos: Courtesy of National Renewable Energy Laboratory, U.S. Department of Energy.

Most Solar Thermal Heat Used for Domestic Hot Water; Space Heating Use Varies by Country



Source: International Energy Agency, Solar Heating and Cooling Program, "Solar Heat Worldwide: Markets and Contribution to the Energy Supply 2007, EDITION 2009," p. 30.

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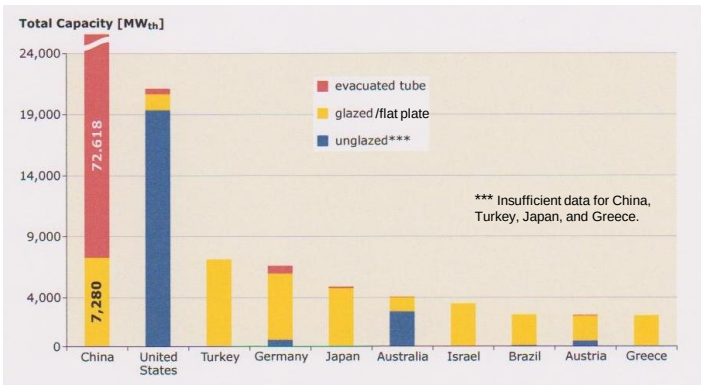
China Has 4x More Installed Capacity Than U.S. - Most U.S. Capacity for Swimming Pool Use



Source: International Energy Agency, Solar Heating and Cooling Program, "Solar Heat Worldwide: Markets and Contribution to the Energy Supply 2007, EDITION 2009," p. 9.

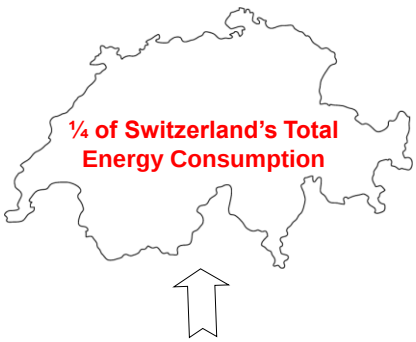
State of California, U.S.A., Case Study: Value of Residential Solar Water Heating ("SWH")

2005 US Total Energy Consumption

100.48 Quadrillion Btu = 2532 Mtoe

Residential Energy Consumption
10.55 Quadrillion Btu = 266 Mtoe

Water Heating Energy Consumption
2.11 Quadrillion Btu = 53 Mtoe



California NG for Water Heating
0.25 Quadrillion Btu = 6.3 Mtoe

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What Can SWH Do to Maximise Efficient Use of Natural Gas in California?

- 85% of California's natural gas ("NG") is from out-of-state
  - 22% of California's NG is for residential use
    - ~40% of residential NG use is for water heating
      - 89% of water heating is natural gas-fired
        - 7% liquefied petroleum gases; 4% electric
        - SWH primarily for swimming pool heating
    - Hot water usage = 41,045 Btu/day = 43,275 kJ/day

Assumptions Used in Quantifying Residential SWH Value in California

- Displaced hot water would be from NG-fired water heaters
- Residential SWH collector in California:
  - 40 square feet ("ft^2") = 3.7 square meters ("m^2")
  - 1,000 Btu/ft^2-day = 1,054 kJ/m^2-day
    - 40,000 Btu/day => SWH needs auxiliary NG-fired tank
    - SWH does not completely displace need for NG
  - Yearly hot water from SWH = 146 therms = 15.4 GJ

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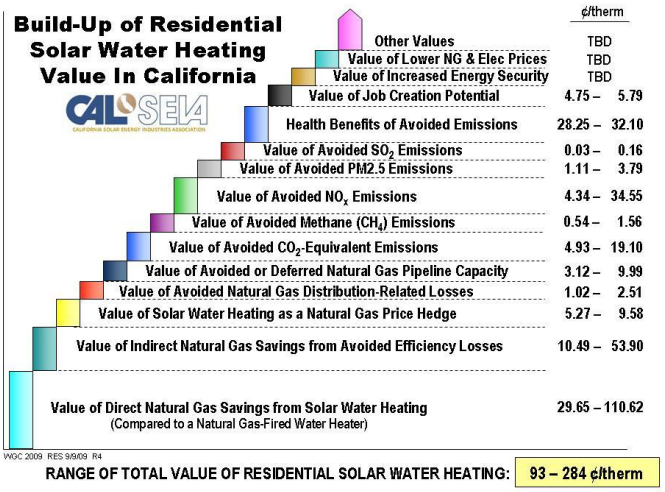

Greatest Value of SWH = Natural Gas Savings

- Direct:
  - Displacement of NG Otherwise Combusted to Generate Hot Water
  - Value = 29.65-110.62¢/therm SWH
- Indirect:
  - Avoided Efficiency Losses from Displaced NG-Fired Water Heater
  - Value = 10.49-53.90¢/therm SWH
- Solar Energy Factor ("SEF") = Energy Output of SWH System ÷ (Auxiliary Water Heater Energy Use + SWH System Energy Use)

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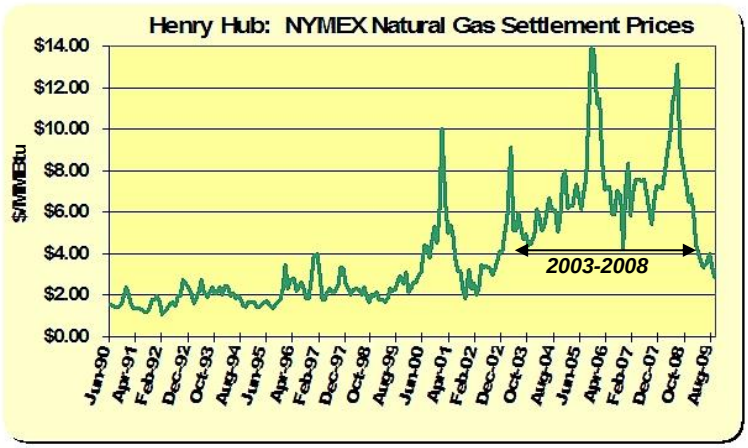
Table 1. Examples of Natural Gas Savings from Residential SWH[1]

	Case 1	Case 2
Natural Gas-Fired Water Heater Efficiency	0.60	0.67
Solar Energy Factor	2.00	2.15
Total Natural Gas Savings (therms/year)	175	154
Direct Natural Gas Savings (therms/year)	105	103
Indirect Natural Gas Savings (therms/year)	70	51
Natural Gas Therms Saved per Therm SWH	1.20	1.05

[1] The 67% efficiency used in Case 2 became the federal standard in the United States for small natural gas-fired storage-type water heaters effective January 20, 2004.

Natural Gas Hedge Value = 5.27-9.58¢/therm SWH



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2017 SWH Projections: California Solar Hot Water and Efficiency Act of 2007

- Goal: 200,000 SWH installations x 130 therms/year avoided NG use/SWH installation = 26 million therms/year avoided NG use
  - < 2% of California's residential + commercial SWH "technical potential" (i.e., engineering-based)
- 0.14 million metric tonnes of CO_2-equivalent ("MMtCO2e") emissions avoided per year
- 0.3 tons/day of nitrous oxides ("NO_x") emissions avoided
- 0.03 tons/day of particulate matter <2.5μ ("PM2.5") emissions avoided

Avoided CO_2 Emissions Are Significant Policy Driver

- California Global Warming Solutions Act of 2006
  - 2020 GHG emissions = 1990 levels = 427 MMtCO2e
  - Reduction of 169 MMtCO2e per year by 2020
- CO_2 emissions rate = 11.7 lb/therm of NG combusted
- 1 therm SWH avoids 1.20-1.05 therms of NG combustion, depending on efficiency (60-67%) of NG-fired water heater
- CO_2 emissions price range: $8.00-$27.27/ton CO_2
- Value of Avoided CO_2 Emissions = 4.93-19.10¢/therm SWH

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Other SWH Avoided Emissions Add Significant Value

	NG-Fired Water Heater Emissions (lb/MMBtu)	Emissions Allowances Price ($/lb/day)	SWH Value (¢/therm SWH)
NO_x	0.08420 (SHW output)	$47,000-$374,384	4.34-34.55
PM2.5	0.00842 (SWH output)	$120,000-$410,959	1.10-3.79
SO_2	0.00059 (NG input)	$40,275-$244,751	0.03-0.16

+

Value of Related In-State Health Benefits = 28.25-32.10¢/therm SWH

Value of Avoided Distribution Losses & Fugitive Methane

- Avoided Distribution Losses
  - 1.76% Average Lost and Unaccounted For; wt. avg. for California's 3 investor-owned NG distribution companies
  - Valued at daily NG price range of $4.20-$15.40/MMBtu
  - Value = 1.02-2.51¢/therm SWH
- Avoided Fugitive Methane ("CH_4") Emissions
  - CH_4 Global Warming Potential ("GWP") = 21
  - 1.4% systemic NG losses (wellhead to burner tip) x 75-95% CH_4 content x 21 x NG price range = 0.54-1.56¢/therm SWH

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Value of Avoided (or Deferred) NG Pipeline Capacity

- Based on avoided cost analysis for California investor-owned utilities used in regulatory proceedings
- 2008 Gas Transportation Avoided Costs discounted by 50% to reflect statistical capacity value of the NG savings attributable to SWH
- Value of residential SWH = 3.12-9.99¢/therm SWH

Value of Job Creation Potential

- Value of 4.75-5.79¢/therm SWH based solely on cost of installing and maintaining medium-temperature SWH systems in California, based on 2020 penetration assumptions
- No increase in manufacturing capacity *within* California
- 8 million ft^2 of SWH collector area by 2017 = 200,000 SWH systems x 40 ft^2 per SWH system
- 32 hours of labor per installation x $86.77/hour + ongoing annual maintenance @ $1/10^{th}$ the number of installation hours

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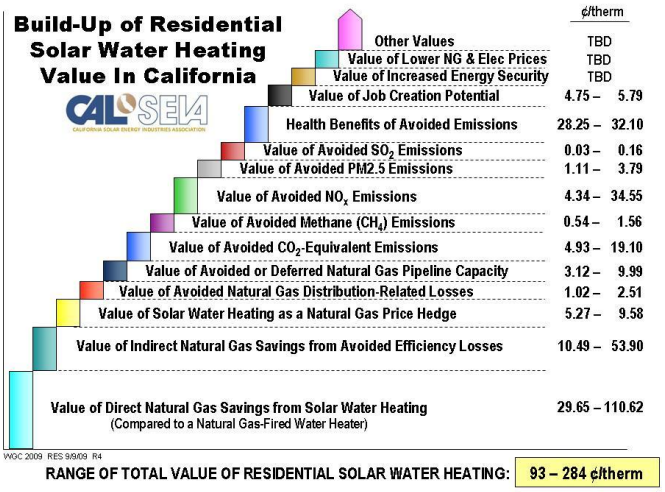
Additional SWH Attributes Not Yet Quantified

- Value of lower natural gas and electric prices
- Value of reduced reliance on imported natural gas
- Value of increased energy security
- Value of meeting other policy objectives:
  - By 2020, 100% of new homes built in California should achieve a statewide standard of zero net energy ("ZNE") => No net purchases of energy from the electrical or NG distribution grid



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Conclusions

- SWH provides significant value to California in displacing hot water otherwise provided by NG-fired water heaters
- Ratepayer incentives for SWH between 93-284¢/therm SWH would fall within quantified range of value of residential SWH
- Quantification of additional components will increase value of SWH even more…
- Use of SWH can maximise the efficient use of NG not only in California, but around the globe.