Solar Heating & Lighting:
Solar Water Heating R&D

DOE Solar Energy Technologies Program Peer Review

Denver, Colorado

April 17-19, 2007

Relevance/Objective

- Describe the overall research objective or purpose of the work as it relates to the DOE SETP Multi-year Program Plan and the program's mission.

Solar Heating Goals

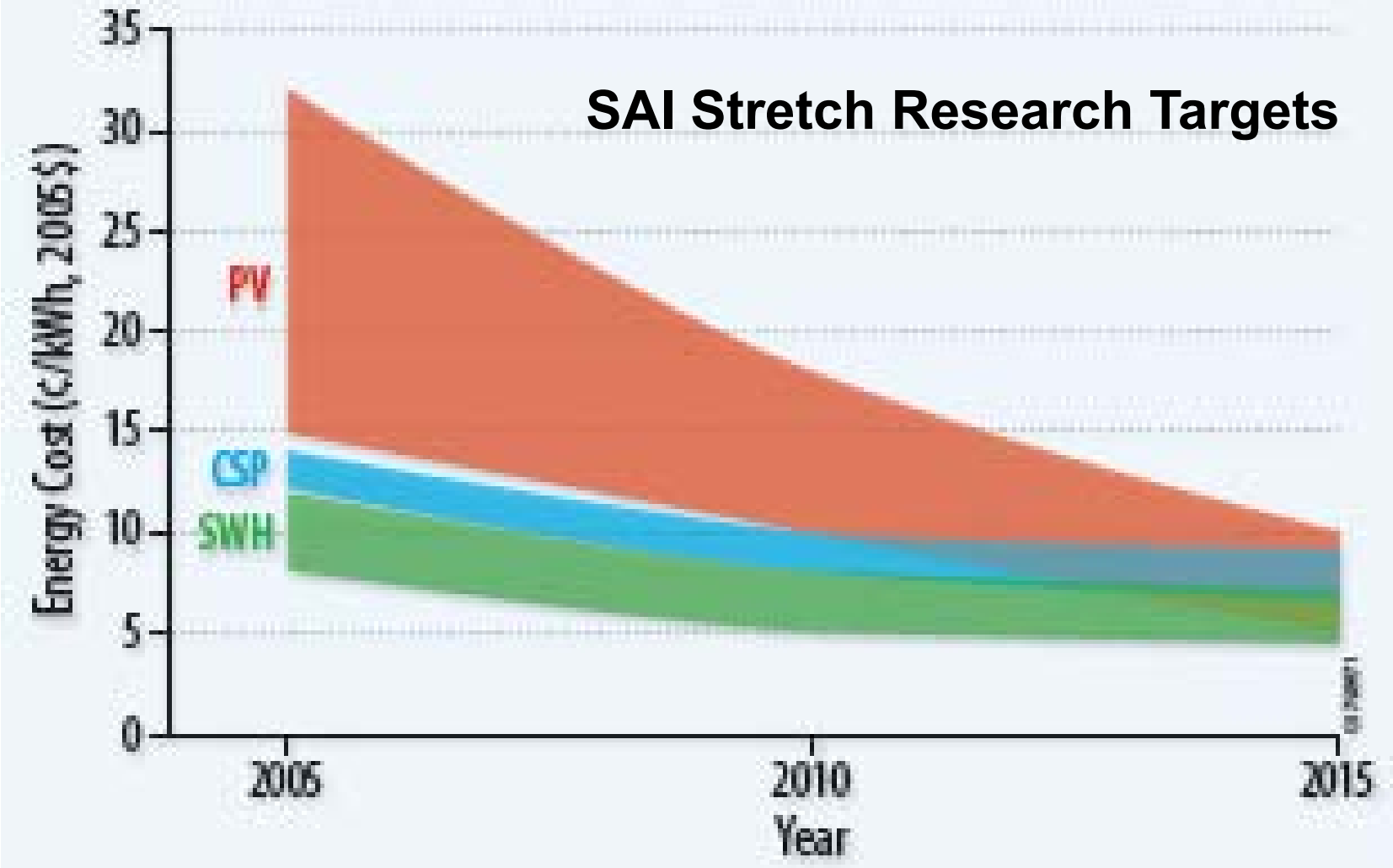
MYPP Strategic Goals

• Develop low-cost solar water heaters for zero energy homes (ZEH) in mild climates that will be cost-competitive with conventional technologies, with levelized cost of energy (LCOE) of 4-6¢/kWh. This represents a ~50% reduction in LCOE.

• Develop low-cost solar water heaters for zero energy homes in freezing climates that have LCOE of 6¢/kWh. This represents a 40-50% cost reduction from conventional technologies.

• Develop low-cost heating and cooling systems for zero energy homes that have LCOE of 6¢/kWh. This represents a 50-70% cost reduction from conventional technologies.

Solar America Initiative



Summary of Activities

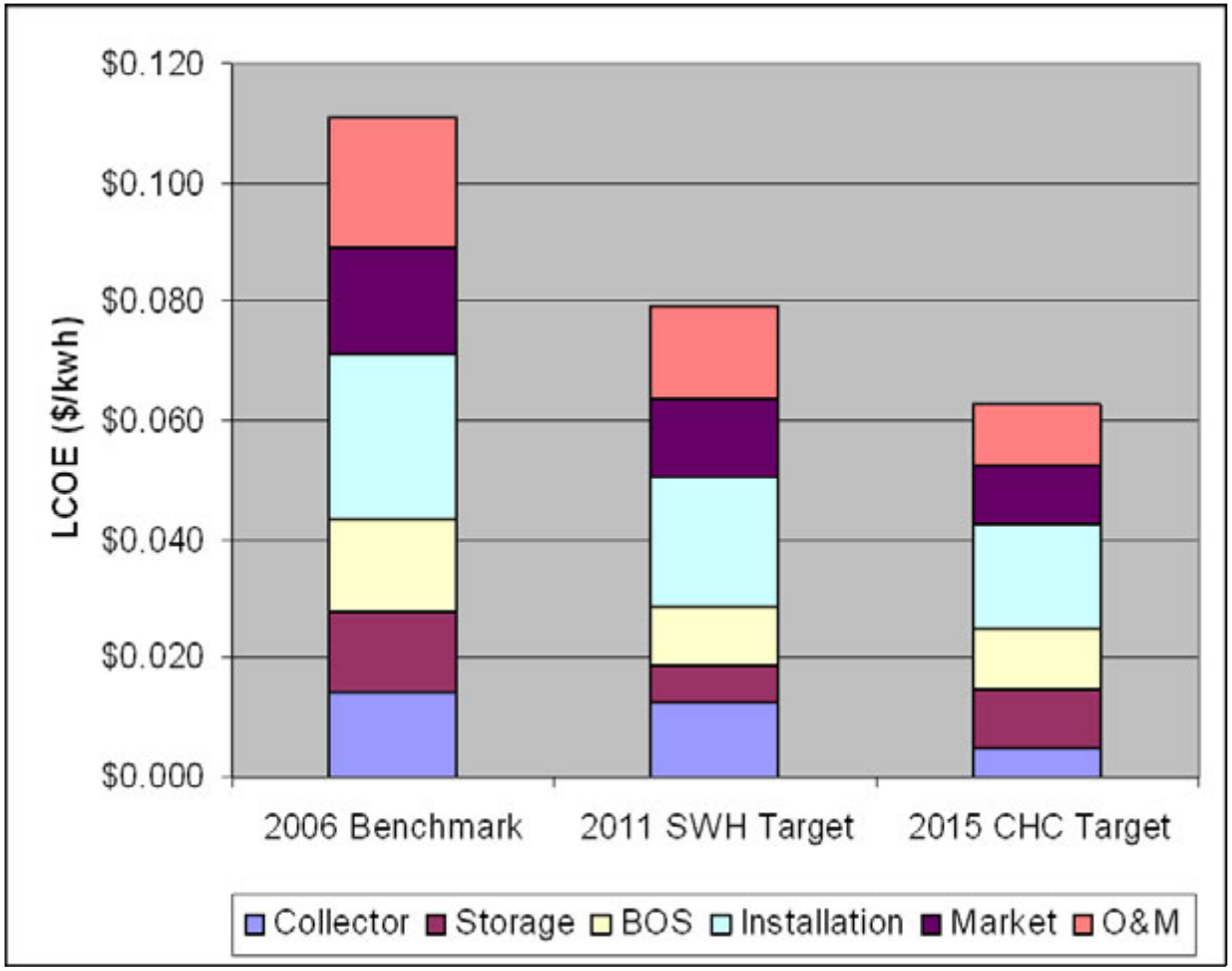
- Summarize the main activities in terms of technical focus, participants, methods, outcomes, etc.

Solar Heating R&D Pathways

Material-focused R&D:

- Reduce the hardware cost of SWH systems through the use of polymer materials and parts integration
- Reduce the installation cost of SWH systems through the use of lightweight polymer materials and flexible, bundled piping
- Test and demonstrate the performance and durability of polymer materials in solar water heating environments
- Integrate and reduce the cost of the balance of system (BOS) components, e.g., valves, tank, HX
- Integrate the SWH components with conventional building equipment and materials

Technology Improvement Opportunities -- Impact on LCOE



Materials Durability Testing (NREL)

Outdoor (1X)

Accelerated Laboratory Chambers (6X)

Ultra-Accelerated, Natural Sunlight (50X)

R&D Participants

- **National Laboratories**
  - National Renewable Energy Laboratory
  - Sandia National Laboratories
- **Industry**
  - FAFCO (California)
  - Davis Energy Group / SunEarth (California)
  - SRP (Arizona)
  - Energy Laboratories Inc. (Florida)
- **Universities**
  - University of Minnesota
  - University of Colorado
  - University of Central Florida (Florida Solar Energy Center)

Stage-Gate Process

R&D Phases:

- **Concept Generation / Exploratory Research**
  - Identification of general system configurations which could conceivably reach the project's cost goal
- **Concept Development / Prototype Test**
  - Development of detailed designs for promising concepts and construction and evaluation of prototypes
- **Advanced Development / Field Test**
  - Development of second-generation prototypes and conducting limited field testing and evaluation
- **Engineering / Manufacturing Development**
  - Construction of third-generation units and evaluation of "near-final" systems in "real-world" applications

FY06 Budget

Project Task(s)	Total Value ($K)
Low-cost Polymer SWH Systems (NREL)	$357
Materials Durability (NREL)	$150
SHL Systems Analysis, Program Management, Communications (NREL)	$242
Industry Assistance (Sandia)	$90
Solar Rating & Certification Corp. (DOE-GO)	$318
Grand Total	**$1157**

Solar Heating Responsibilities

Project	Project Leader
Low-cost Polymer SWH Systems	Jay Burch - NREL
Materials Durability	Gary Jorgensen - NREL
Industry Assistance	Greg Kolb - Sandia
Systems Analysis	Craig Christensen - NREL
Program Management	Tim Merrigan - NREL Roland Hulstrom - NREL

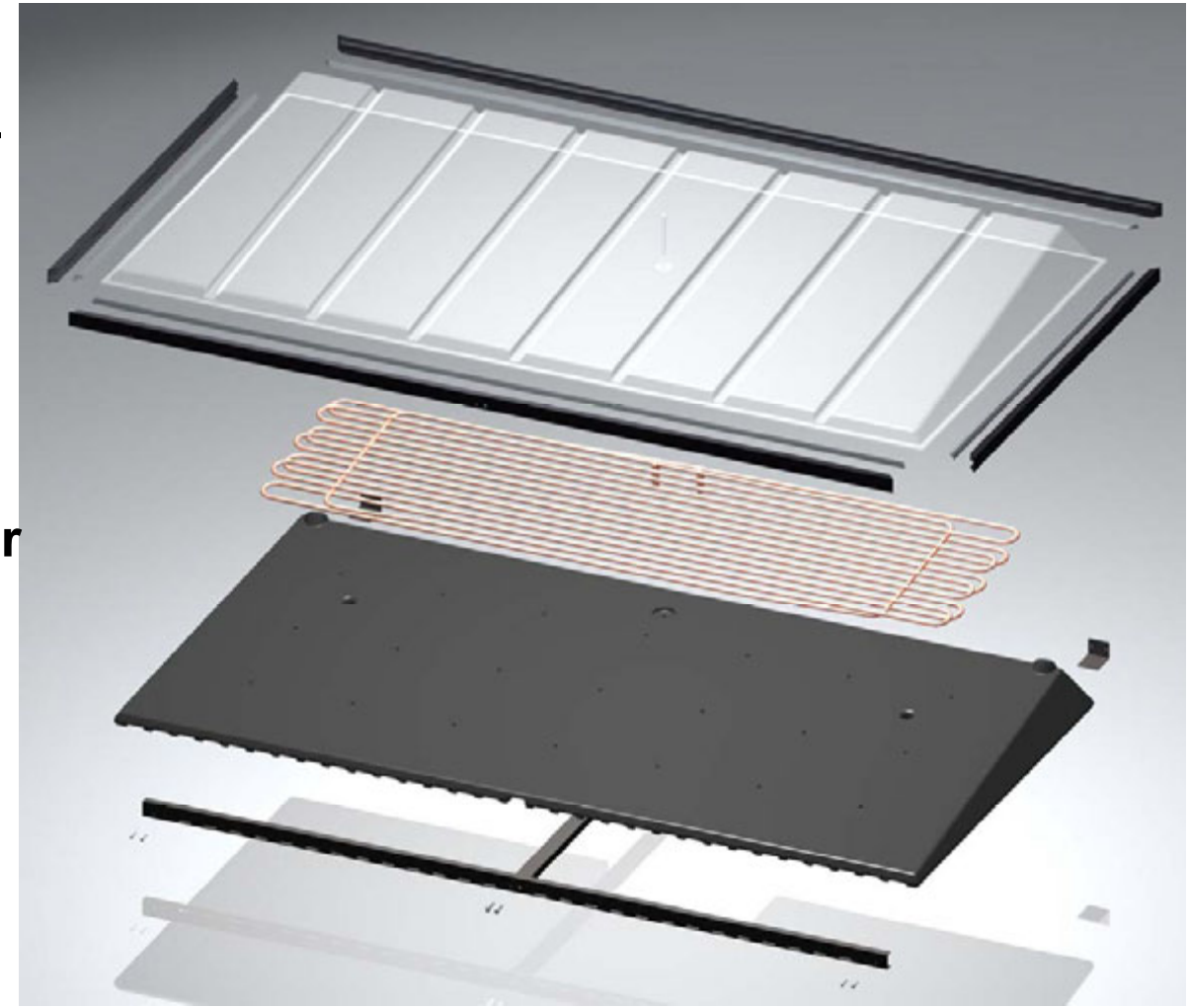
Accomplishments

- Summarize the major accomplishments of this project. What major developments have resulted from this research.

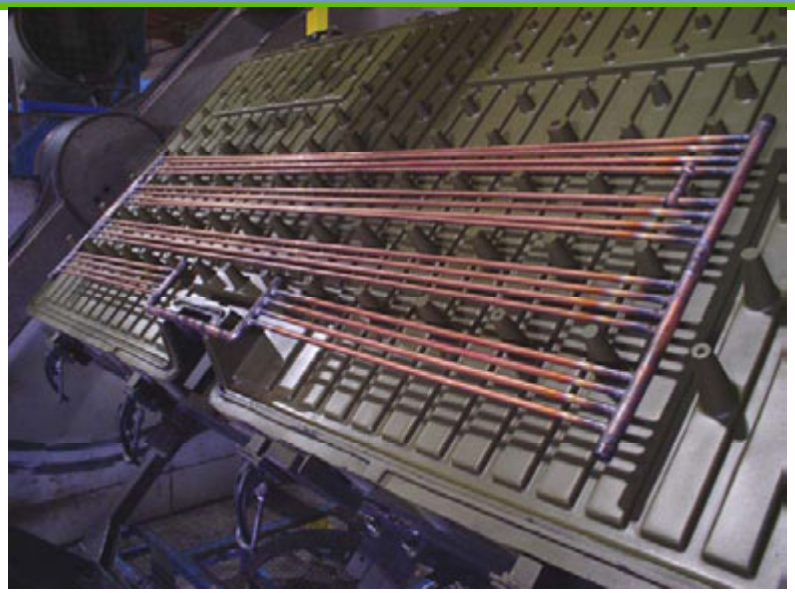
Davis Energy Group / SunEarth Polymer SWH

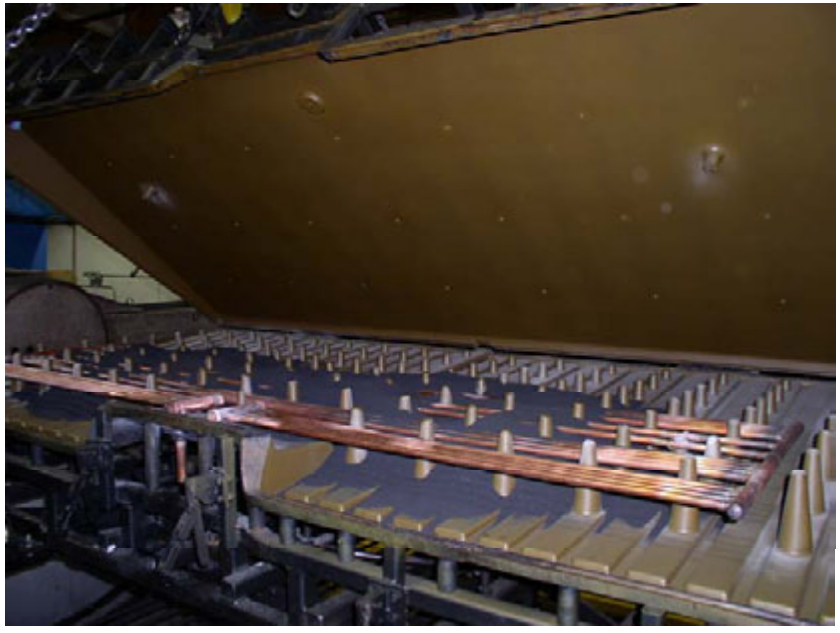
Davis Energy Group / SunEarth Polymer SWH:

- **Rotomolded PE tank**
- **Single, thermoformed PC "cap" glazing**
- **No back or side insulation**
- **Dual-serpentine copper heat exchanger**
- **Single rafter or truss mounting penetration**
- **Easy installation**
- **Sealed tank with no makeup water**



Davis Energy Group / SunEarth Polymer SWH

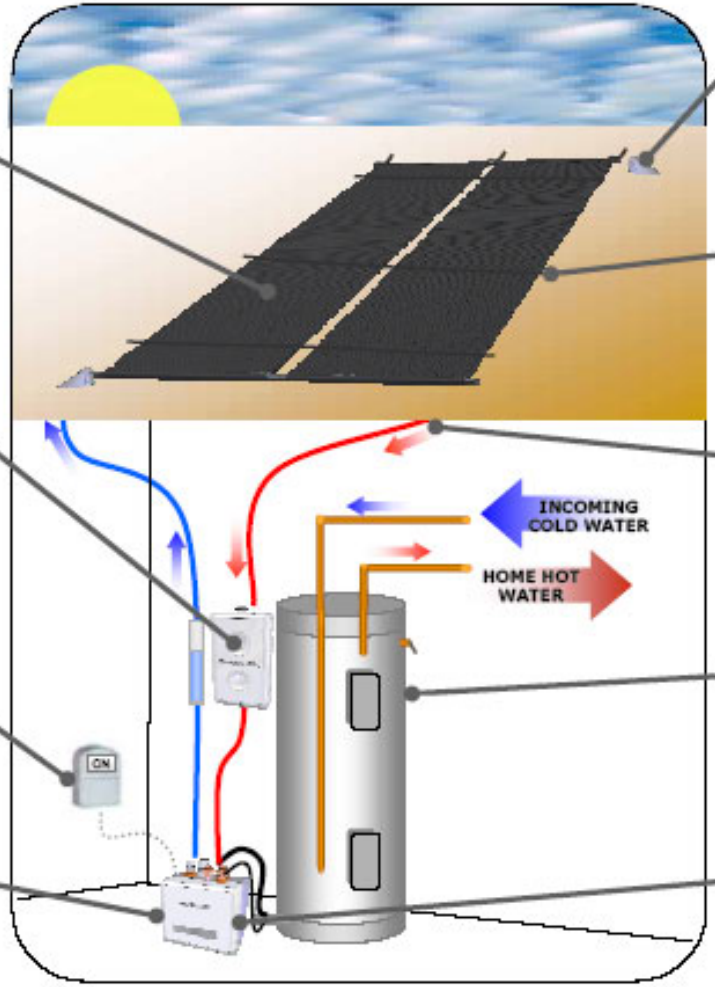




Davis Energy Group / SunEarth SRCC Testing

FAFCO Polymer SWH System

FAFCO Drainback System



Unglazed Collectors
1-1/2" headers, Solid body ¼" or 3/16" OD tubing, PEX push connections.

Vented Drainback Tank
Polypropylene, 10 gallons, two mounting holes, PEX dip tube, adjacent level indicator

Controller
Astronomic timer, battery backup, auto daylights savings adjustment

Pump/HX Enclosure
Grundfos Riton low and high head pumps. St/st brazed heat exchanger

Roof Jacks
Low profile, EPDM grommet seal, horizontal port

Mounting Hardware
UV resistant straps, St/st lag screws

PEX Plumbing
½" standard, Red and Blue, Seatech push connections

Auxilliary or Storage Tank
System adapts to existing electric water heater or a preheating solar storage tank.

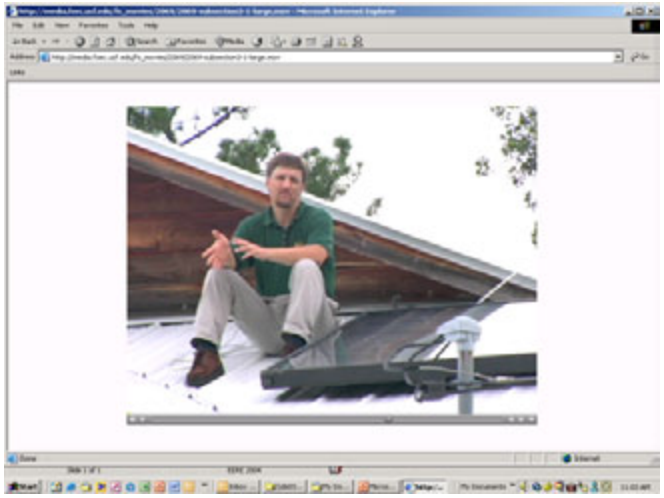
One Piece Coaxial Tank Adapter
Inj. Molded Riton fittings with polymer dip tube. Adapts hose bibb and two flex connections into one port .

FAFCO Polymer SWH System

Introduced at National Association of Homebuilders (NAHB) International Builders Show, Orlando, Florida, Feb. 7-10, 2007 (SRCC OG-300)

Industry Assistance Activities at Sandia

- Worked with ELI to resolve RITH leakage problem. RITH resubmitted to SRCC for certification, December 2005
- With SRCC and FSEC, completed SDHW inspector training video
  - Can be viewed online at SRCC website
- Completed commercial solar-pool website
  - Calculates energy saved and economics
  - Linked to FindSolar.com



Industry Assistance (Sandia)

Sandia activities (cont.)

- Helped University of New Mexico establish a solar energy program
  - UNM recently received an education grant from the State of NM
  - UNM will build and operate a 10-ton solar air conditioning system

• Advanced *freeze-protected* and roof-integrated SDHW system installed in a Building America home in Albuquerque

Building America
U.S. Department of Energy

Artistic HOMES

Solar Rating & Certification Corp.

Solar Rating & Certification Corporation (SRCC)

http://www.solar-rating.org/

- Administers a U.S. certification, rating, and labeling program for solar collectors and solar water heating systems
- Over 300 solar water heating system models have been approved for SRCC certification
- SRCC certification referenced in the *Energy Policy Act of 2005* for residential solar energy tax credit

Schedule of Major Events/Milestones

- Summarize major events/milestones, for instance major stage-gates, the beginning of new solicitation cycles, major overall milestones planned for the future.

Stage-Gate Process

R&D Phases:

- **Concept Generation / Exploratory Research**
  - Identification of general system configurations which could conceivably reach the project's cost goal
- **Concept Development / Prototype Test**
  - Development of detailed designs for promising concepts and construction and evaluation of prototypes
- **Advanced Development / Field Test**
  - Development of second-generation prototypes and conducting limited field testing and evaluation
- **Engineering / Manufacturing Development**
  - Construction of third-generation units and evaluation of "near-final" systems in "real-world" applications

Low-cost Solar Water Heating for Warm Climates

Major Events/Decision Points	Year
Issue RFPs for low-cost warm climate SWH concept development	1999
Evaluate and select "best" Phase I concepts for further development	2000
Testing of small-scale prototypes / redesign	2001-02
Fabrication / field testing of full-scale prototypes	2003-04
Exposure / torture tests of full-scale prototypes	2004-06
Large-scale field tests of low-cost warm climate solar water heating systems	2007-08

Low-cost Solar Water Heating for ZEHs in Cold Climates

Major Events/Milestones	Year
Conduct workshop; solicit low-cost cold climate SWH concepts from industry; evaluate/select potential systems	2007
Evaluate and select "best" Phase I concepts for further development	2008
Testing of small-scale prototypes / redesign	2008-09
Fabrication / field testing of collector and/or system full-scale prototypes	2009-10
Exposure / torture tests of full-scale prototypes	2010-11
Field testing and documentation for code approval of cold climate SWH systems	2011-12

Future Directions

- Outline broad future plans. If appropriate, provide some context for this research. Discuss whether follow on research is expected.

Zero Energy Buildings: Platform for Integration

EERE Programs Contributing to Zero Energy Buildings Goal

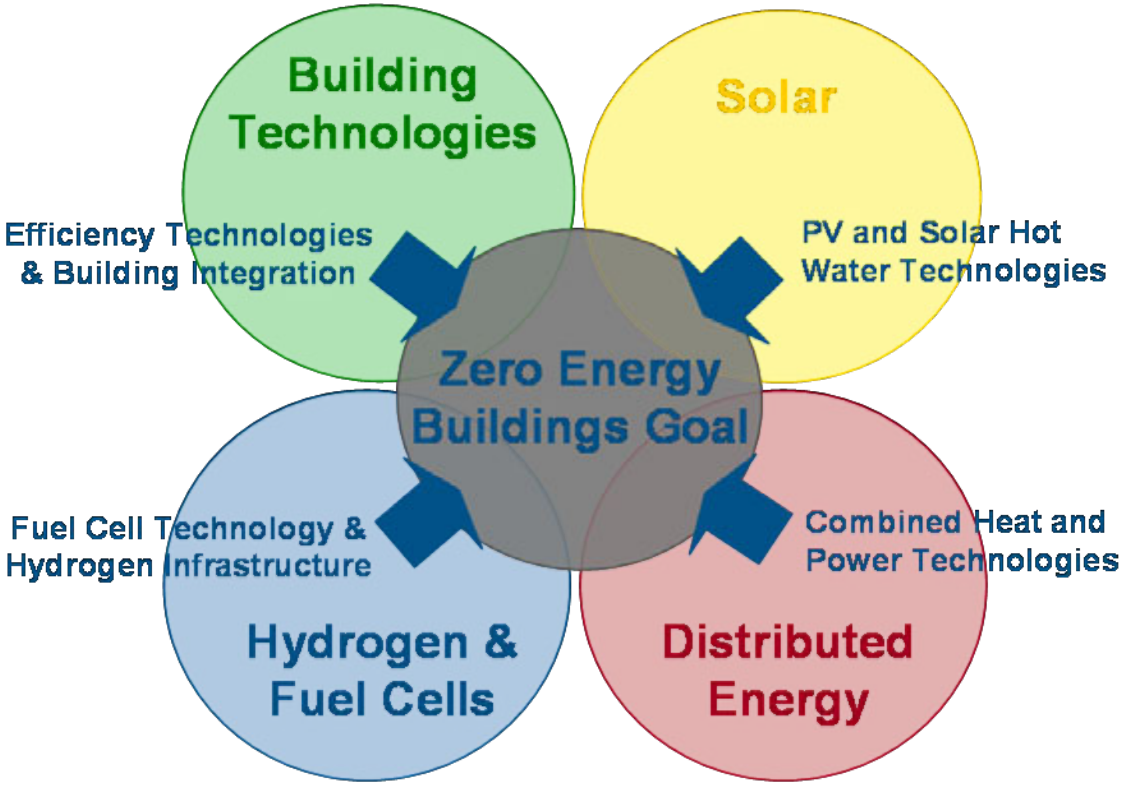
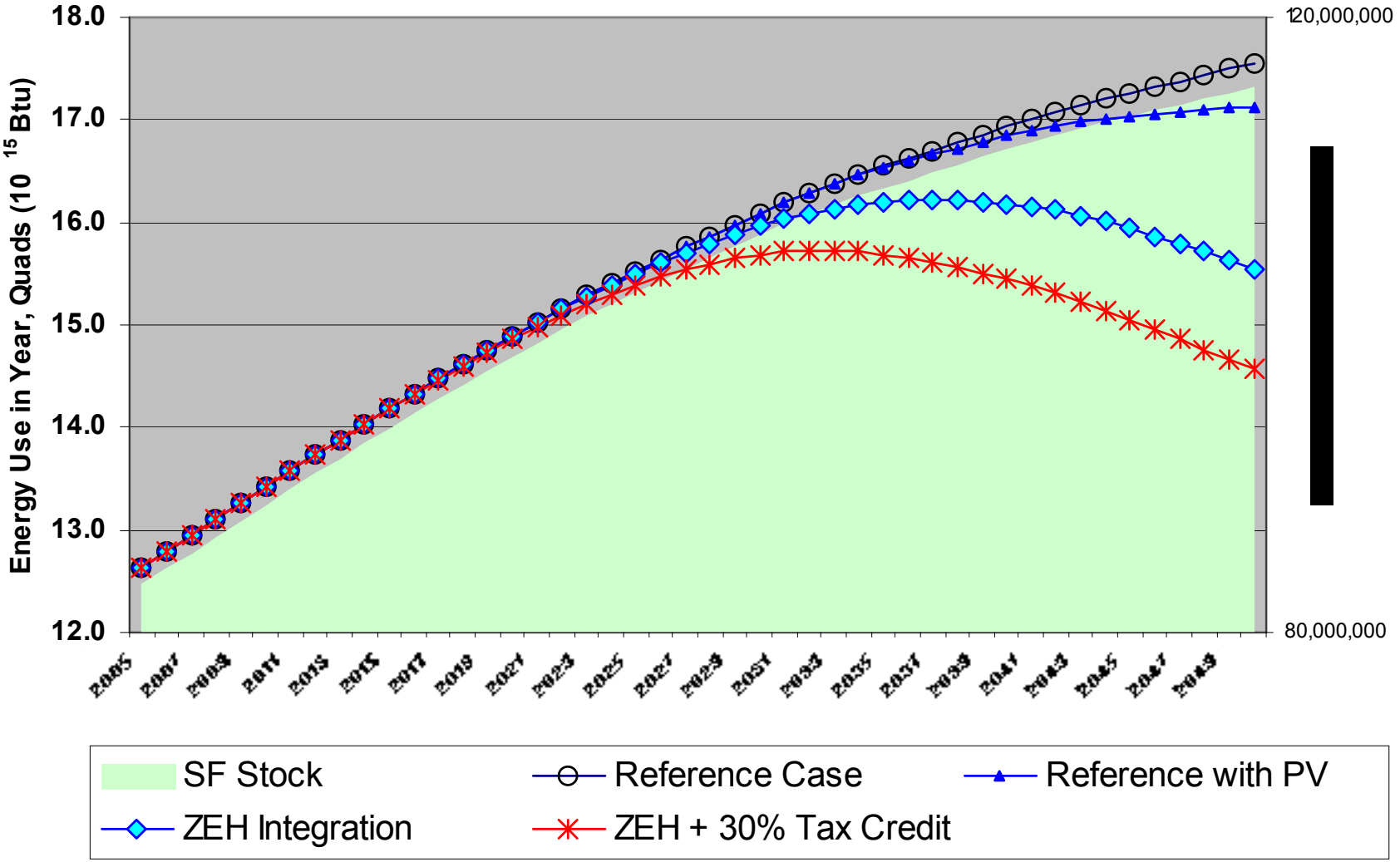


Figure 2-3 of Building Technologies Program Multi-Year Program Plan

Impact of Zero Energy Homes on Residential Energy Consumption*



*National Association of Home Builders- Research Center, Sept 2005

Stage-Gate Process

-
  - Identification of general system configurations which could conceivably reach the project's cost goal
-
  - Development of detailed designs for promising concepts and construction and evaluation of prototypes
-
  - Development of second-generation prototypes and conducting limited field testing and evaluation
-
  - Construction of third-generation units and evaluation of "near-final" systems in "real-world" applications

Low-cost Solar Water Heating for ZEHs in Cold Climates

Conduct workshop; solicit low-cost cold climate SWH concepts from industry; evaluate/select potential systems	2007
Evaluate and select "best" Phase I concepts for further development	2008
Testing of small-scale prototypes / redesign	2008-09
Fabrication / field testing of collector and/or system full-scale prototypes	2009-10
Exposure / torture tests of full-scale prototypes	2010-11
Field testing and documentation for code approval of cold climate SWH systems	2011-12

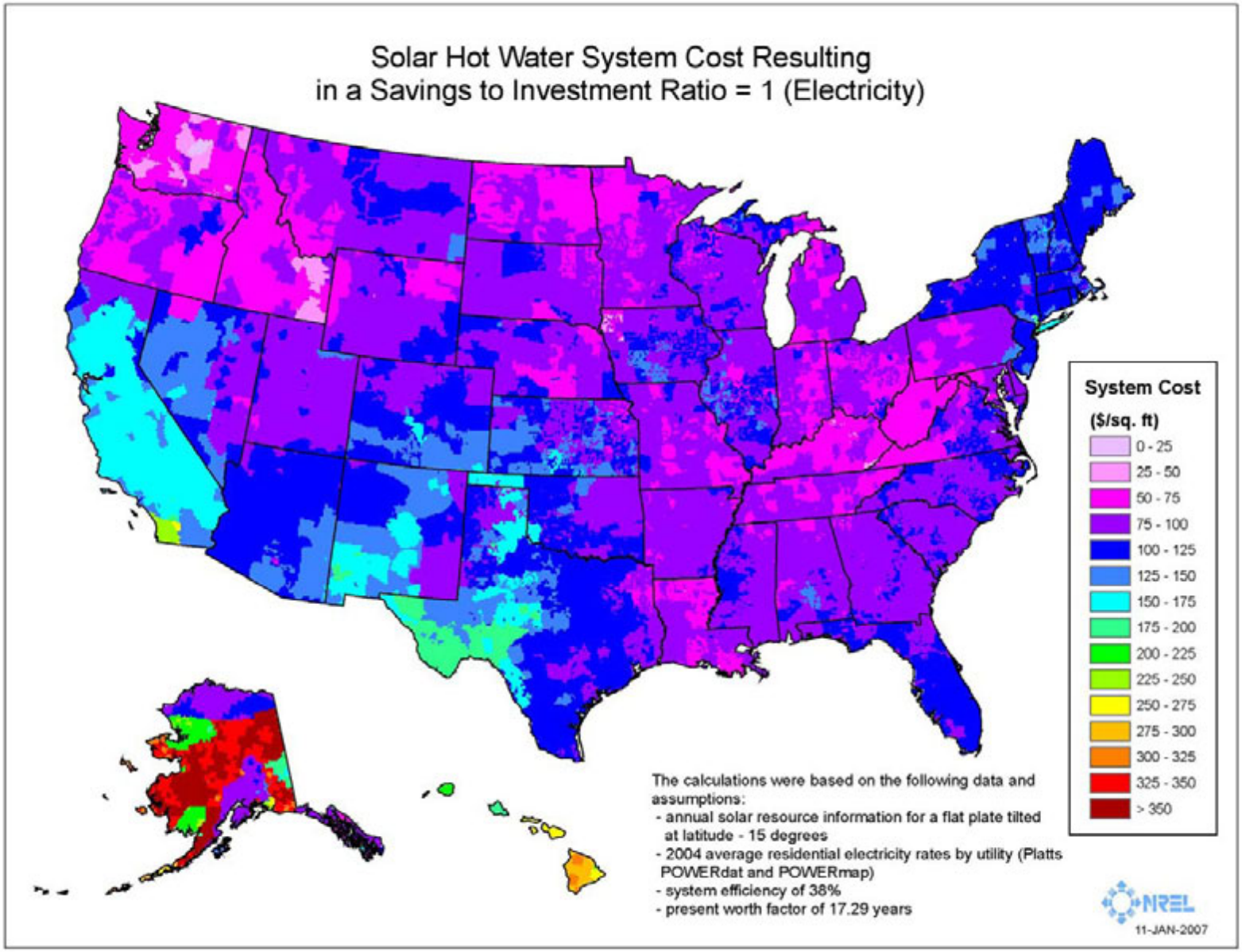
FY07 Activities

- Solar Water Heating Market Expansion Workshop, San Diego, CA (January 18-19, 2007) http://www.swhmarketexpansion.com

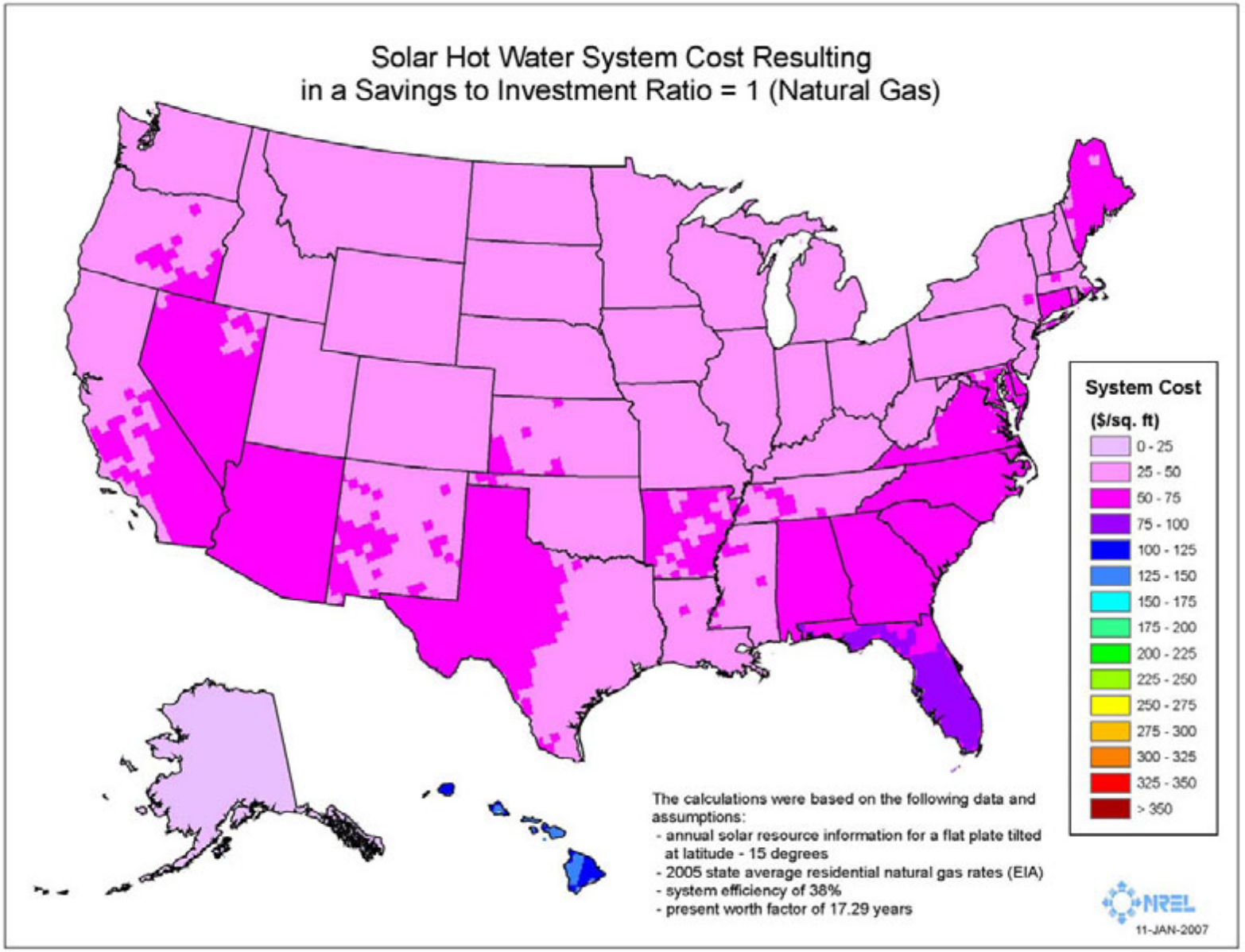
- NREL report on "*The Technical Potential of Solar Water Heating to Reduce Fossil Fuel Use and Greenhouse Gas Emissions in the U.S*"

- SWH system economic analysis using GIS software

SWH Economic Analysis



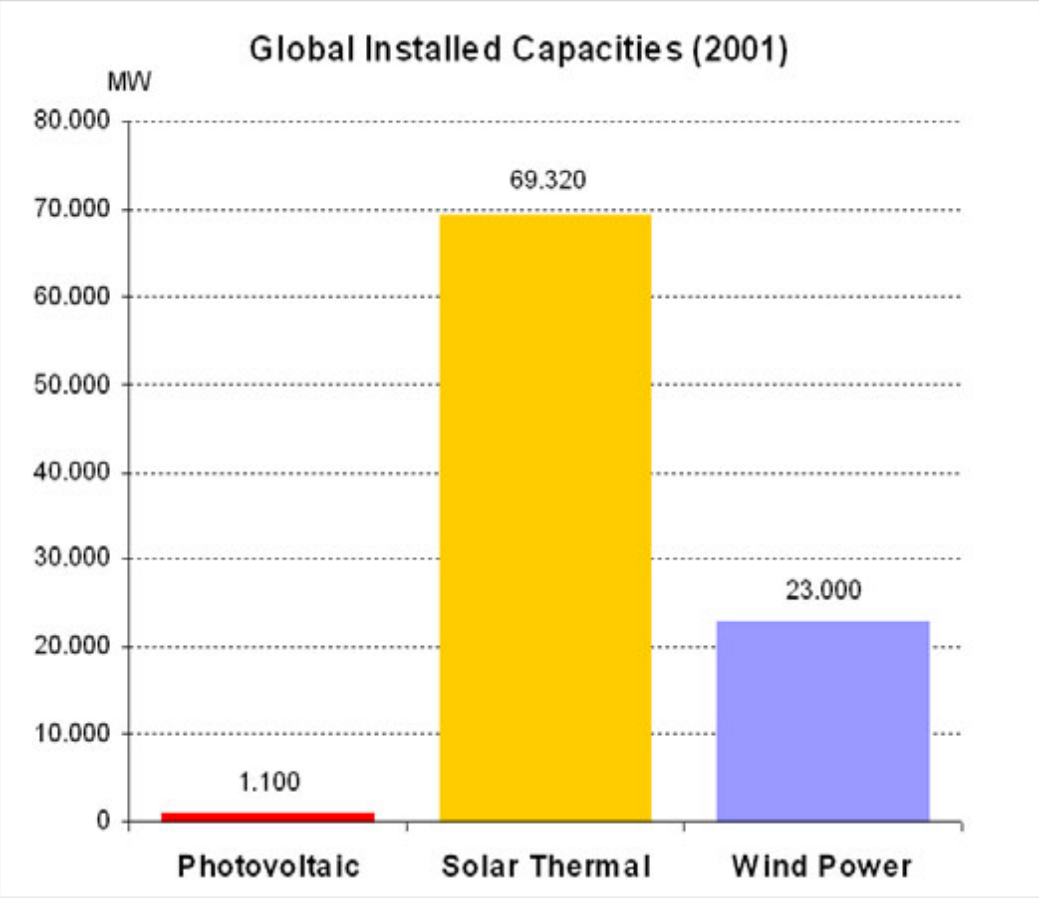
SWH Economic Analysis



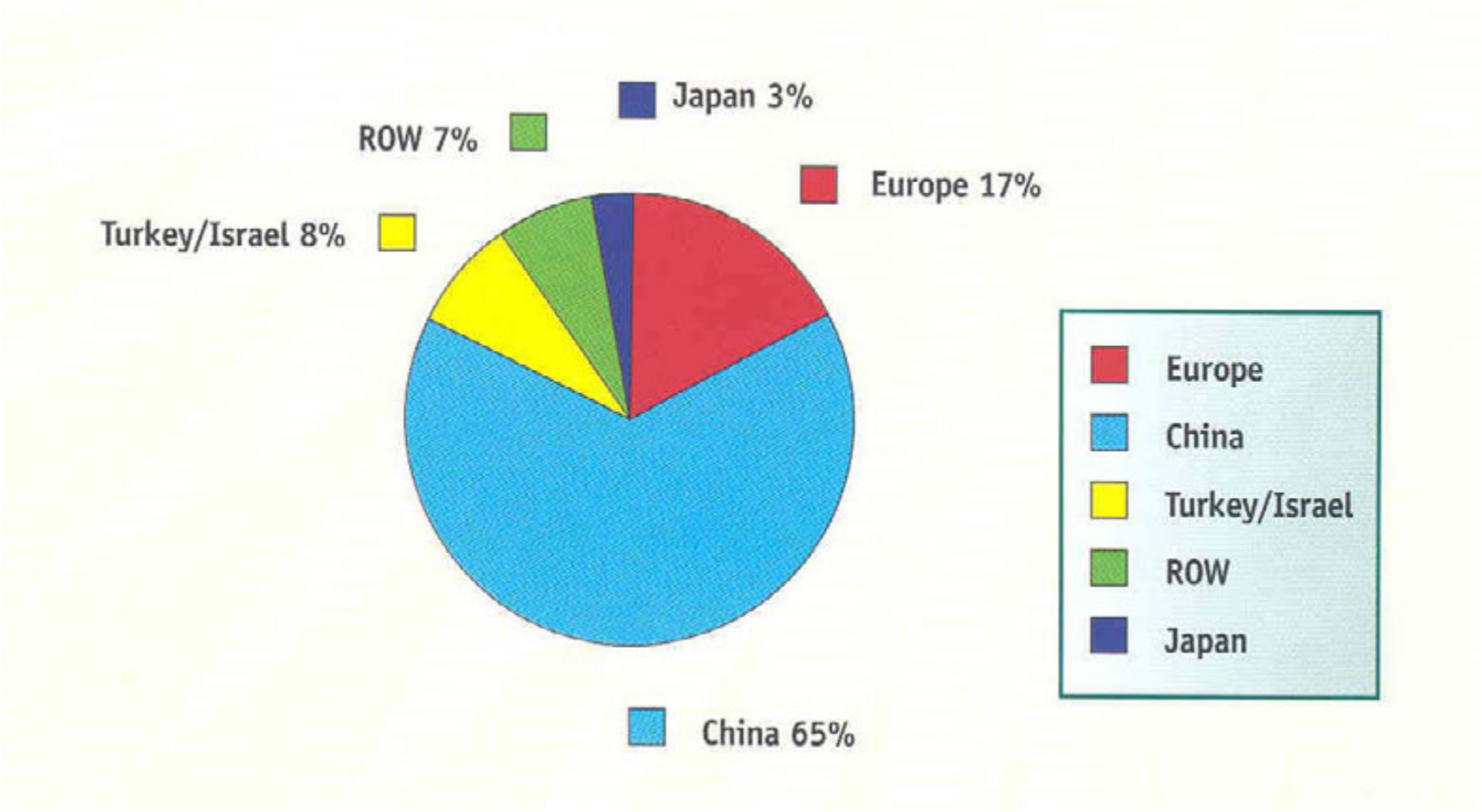
Solar Water & Space Heating Capacity - Worldwide

Global Installed Capacities of 3 Types of Renewable Energy in 2001

Source: http://www.iea-shc.org/

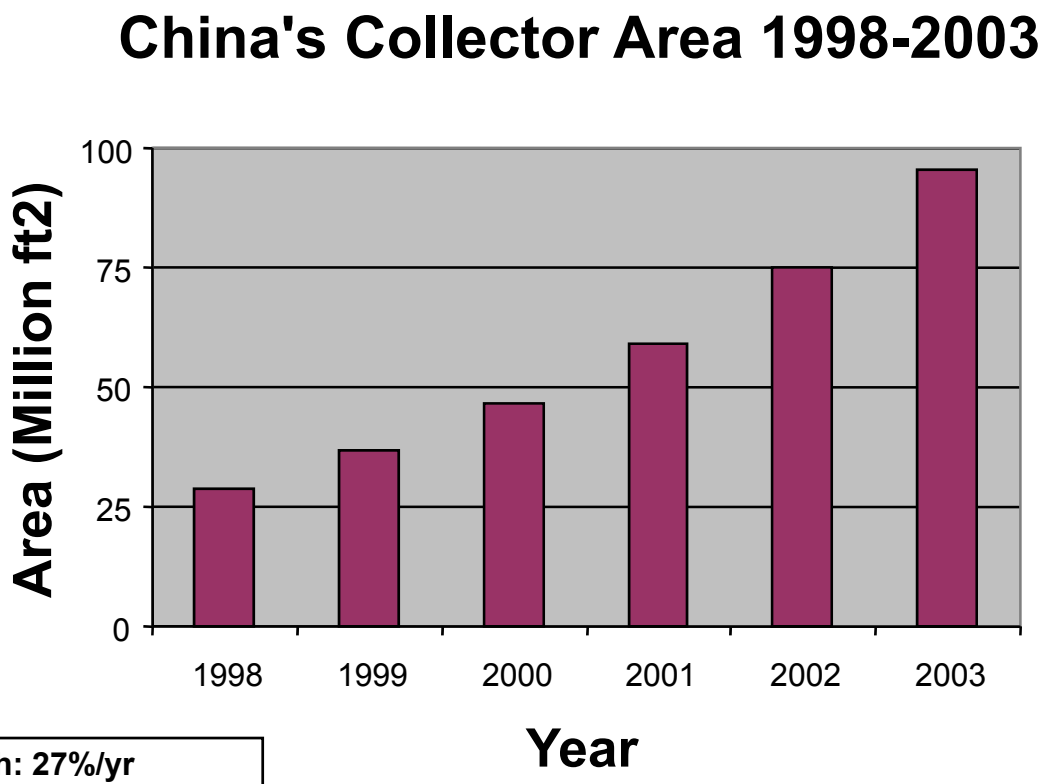


Solar Water Heating Market - Worldwide

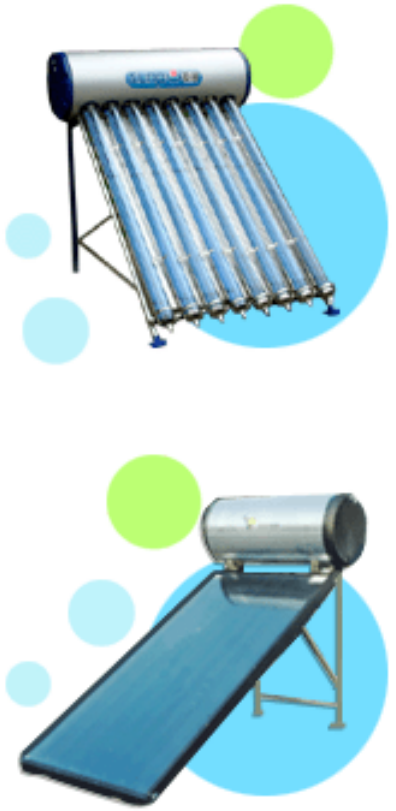


2001 World Solar Thermal Market

Solar Water Heating Market - China

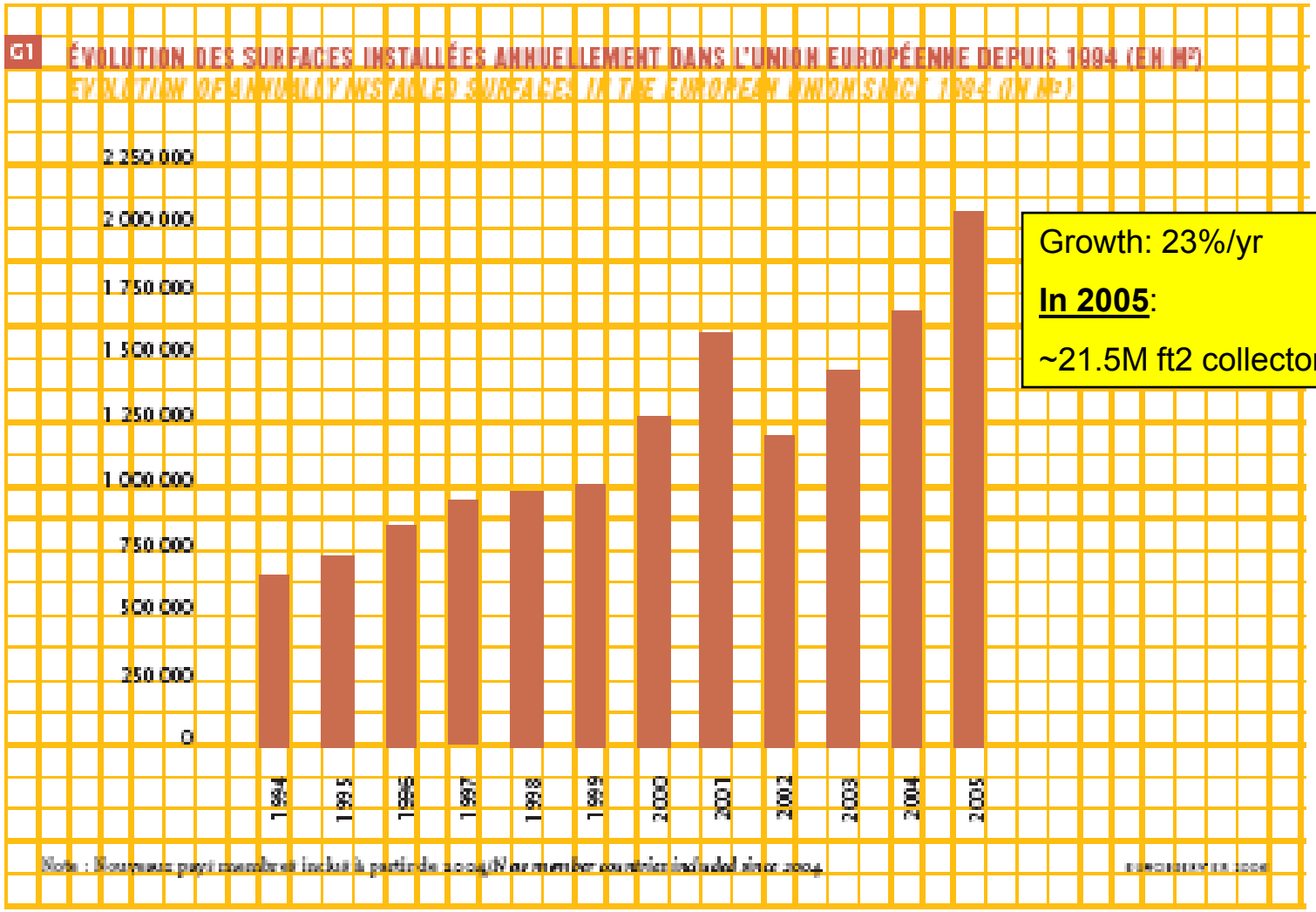


Growth: 27%/yr
$ Systems 2003: $0.8B



Renewable Energy World 1/05

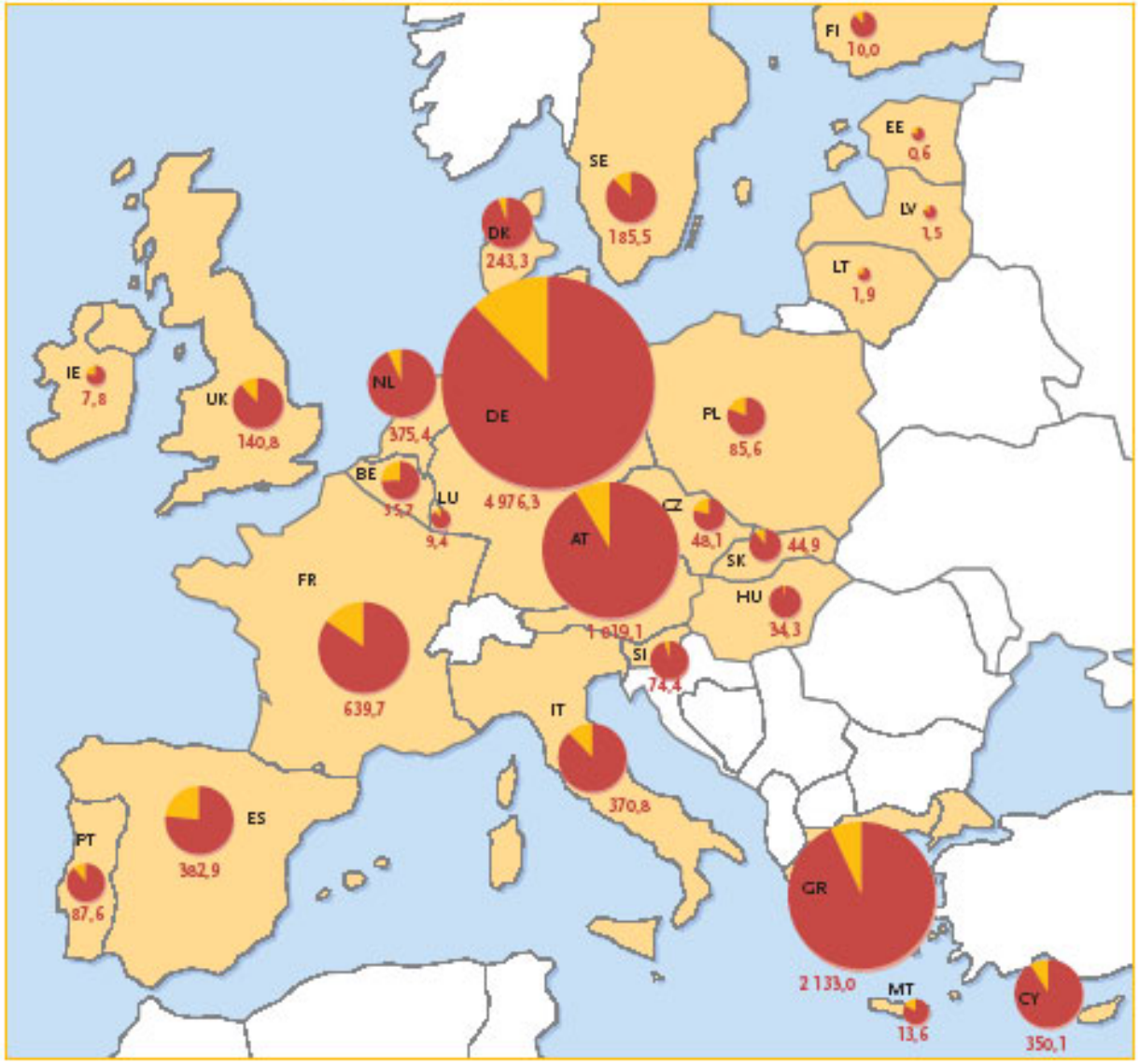
Solar Thermal Market - Europe



EurObserv'ER Solar Thermal Barometer 2006

Solar Thermal Market - Europe

PARCS DE CAPTEURS SOLAIRES THERMIQUES DES PAYS DE L'UNION EUROPÉENNE
CUMULATED CAPACITY OF THERMAL SOLAR COLLECTORS IN THE EU COUNTRIES



Parc installé dans les pays de l'Union européenne à fin 2005 (en MWth)/
Cumulated installed capacity in the European Union countries at the end of 2005 (in MWth)

Part installée en 2005 (en MWth)/
Share installed in 2005 (in MWth)

PARC TOTAL DE L'UNION EUROPÉENNE/
TOTAL INSTALLED CAPACITY IN EU

12 087

EUROBSERV'ER 149

SOLAR THERMAL BAROMETER