



## Building America Case Study

# Indirect Solar Water Heating Systems in Single-Family Homes

Greenfield, Massachusetts

### PROJECT INFORMATION

**Project Name:** Wisdom Way Solar Village

**Location:** Greenfield, MA

**Partners:**

Rural Development, Inc. (RDI),  
[ruraldevelopmentinc.org](http://ruraldevelopmentinc.org)

Consortium for Advanced, Residential  
Buildings (CARB), [carb-swa.com](http://carb-swa.com)

**Building Component:** Solar water  
heating

**Application:** Single-family

**Years Tested:** 2010–2013

**Applicable Climate Zone(s):** Cold

### PERFORMANCE DATA

Cost of energy-efficiency measure  
(including labor): \$9,600

Projected energy savings: 80% of water  
heating energy in this home, which  
averages 40 gal/day of hot water

Projected energy cost savings: \$134/year

In 2011, Rural Development, Inc. (RDI) completed the construction of Wisdom Way Solar Village (WWSV), which is a development of 20 very efficient homes in Greenfield, Massachusetts. The homes feature R-40 walls, triple-pane windows, R-50 attic insulation, and airtight construction. All homes also have photovoltaic (PV) systems and solar domestic hot water (SDHW) systems. Auxiliary water heating is provided by tankless gas water heaters. With the SDHW systems, RDI hoped to eliminate most of the need for gas for water heating and get the homes closer to zero energy.

Each home has its own solar thermal system consisting of 29-ft<sup>2</sup> flat-plate collectors coupled with a 110-gallon storage tank. Two-bedroom homes have two collectors; three- and four-bedroom homes have three collectors. A propylene glycol solution transfers heat from the solar panels to a heat exchanger in the bottom of the storage tank. A circulator powered by direct current (DC) moves the fluid, and the pump is powered by a small dedicated PV module on the roof. To reduce the risk of overheating, a buried copper coil serves as a heat dump when the storage tank reaches its maximum temperature.

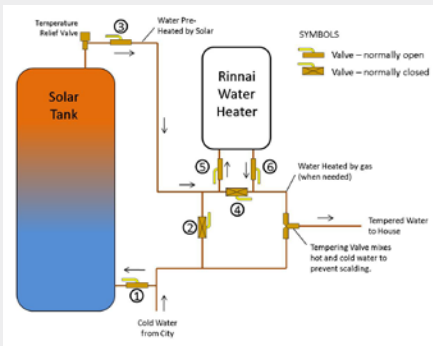
The Consortium for Advanced Residential Buildings (CARB), a U.S. Department of Energy Building America team, was able to monitor the performance of one of the SDHW systems for more than two years. After many initial problems with the systems' installation and operation, the systems are providing most of the water heating energy. The system monitored provided 80% of the water heating energy needed.

Because the homes had efficient gas water heating, the solar savings were only \$134 per year. In addition, maintenance costs can further reduce the annual savings benefit. Even with incentives, it is hard to justify the high installation costs of these solar thermal systems based on these modest energy savings.

DESCRIPTION



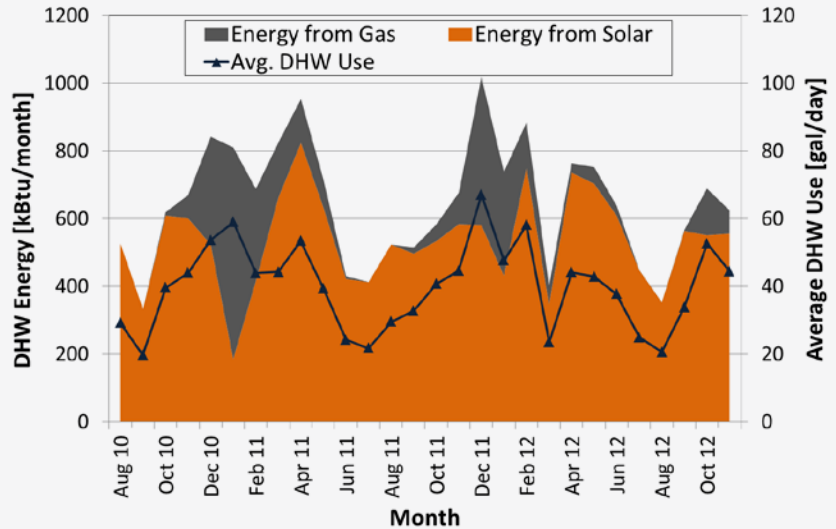
Water that has been preheated in the solar storage tank enters the tankless water heater where the water is heated more as needed. By monitoring the gas consumed, CARB saw that the tankless water heater operated less efficiently in this configuration.



CARB assisted RDI in writing the section of the homeowner’s manual focused on the solar thermal system. The manual outlines the basic operation, how to assess how well the system is working, and how to bypass the gas heater during summer months if desired.

For more information see the Building America measure guideline report *Indirect Solar Water Heating in Single-Family, Zero Energy Ready Homes* at [buildingamerica.gov](http://buildingamerica.gov).

Image credit: All images were created by the CARB team.



The solar system provided 80% of water heating loads overall. During some summer months the gas water heater was turned off completely.

Lessons Learned

- By using a solar water heating system that was not reviewed by a national certification body such as the Solar Rating & Certification Corporation or the International Association of Plumbing and Mechanical Officials, there were several significant problems with the systems during installation and initial operation, which included:
  - The DC circulators and PV modules were too small, and both needed to be replaced with larger versions.
  - The heat dumps (to protect from overheating) were buried beneath basement slabs rather than underground outside. Also, heat dumps were connected inconsistently, and several systems overheated.
  - The manufacturer of the heat transfer fluid mislabeled several batches. Systems needed to be filled with the correct solution.
  - Poor coordination led to long pipe runs between the storage tanks and gas water heaters in three homes.
- When heating water preheated by solar, the gas water heaters were less efficient than when heating cold water.
- Even when providing 80% of water heating loads, the solar system saved \$134 per year.
- Even though a grant covered the entire SDHW system cost (\$9,600), in hindsight the developer would not have installed SDHW systems and would have installed more PV capacity.

Looking Ahead

Even with substantial incentives, the costs of SDHW systems in colder climates are hard to justify with very modest savings. For these systems to become more widespread, there must be significant cost reductions.