2.3.3 SOLAR BUILDINGS

Technology Description

Solar building technologies deliver heat, light, and cooling to residential and commercial buildings. By combining solar building technologies with solar electric generation (using photovoltaics) and very energy-efficient building envelopes, lighting, and appliances, it is possible to create "Zero Energy Buildings" (see photo for an example demonstration home). Zero-energy buildings have a zero net need for off-site energy on an annual basis.

Zero-energy home, the "Solar Patriot."

System Concepts

- In solar heating systems, solar-thermal collectors convert solar energy into heat, usually for domestic hot water, pools, and space heating.
- In solar cooling systems, solar-thermal collectors convert solar energy into heat for absorption chillers or desiccant regeneration.
- In solar lighting systems, sunlight is transmitted into the interior of buildings using glazed apertures, light pipes, and/or optical fibers.

Representative Technologies

- Active solar heating systems use pumps and controls to circulate a heat-transfer fluid between the solar collector(s) and storage. System sizes can range from 1 to 100 kW.
- Passive solar heating systems do not use pumps and controls but rather rely on natural circulation to transfer heat into storage. System sizes can range from 1 to 10 kW.
- Transpired solar collectors heat ventilation air for industrial and commercial building applications. A transpired collector is a thin sheet of perforated metal that absorbs solar radiation and heats fresh air drawn through its perforations.
- Hybrid solar lighting systems focus concentrated sunlight on optical fibers and, with a controller, combine natural daylight with conventional illumination, depending on sunlight availability.

Technology Status/Applications

- Typical residential solar systems use glazed flat-plate collectors combined with storage tanks to provide 40%-70% of residential water heating requirements. Typical systems generate hot water equivalent to supplying 2,500 kWh/year at a cost of about 8¢/kWh.
- Typical solar pool heating systems use unglazed polymer collectors to provide 50%-100% of residential pool heating requirements. Typical systems generate 1,600 therms or 46,000 kWh/year and have 25% of the market.

Current Research, Development, and Demonstration

RD&D Goals

- Near-term solar heating and cooling RD&D goals are to reduce the costs of solar water and space heating systems to 4¢/kWh from their current cost of 8¢/kWh using polymer materials and manufacturing enhancements.
- Near-term, zero-energy building RD&D goals are to reduce the annual energy bill for an average-size home by 50% by 2004 and to zero by 2020.
- Near-term solar lighting RD&D goals are to demonstrate the second generation of the system with an enhanced control system.

RD&D Challenges

- Solar heating and cooling RD&D efforts are targeted to reduce manufacturing and installation costs, improve durability and lifetime, and provide advanced designs for system integration. One key R&D issue is durability. Polymer materials in solar heating systems must survive harsh service environments that include exposure to elevated temperatures, moisture, and ultraviolet radiation.
- Zero-energy building RD&D efforts are targeted to optimize various energy efficiency and renewable energy combinations, integrate solar technologies into building materials and the building envelope, and incorporate solar technologies into building codes and standards.
- Demonstration of hybrid lighting-system performance and reliability in the field are critical to the success of solar lighting.

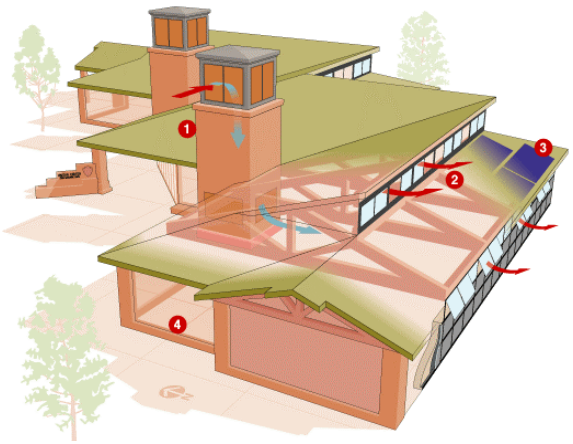
RD&D Activities

- Key DOE program activities are targeted to demonstrate lower cost and improved reliability of components and systems, develop advanced systems and applications, and support the next commercial opportunities for these technologies.
- DOE support of RD&D has been required because solar manufacturers are generally small businesses with limited resources and expertise. These manufacturers are constantly facing manufacturing and system design issues that affect the reliability, lifetime systems costs, and overall cost effectiveness of their products, yet they do not have the resources to conduct reliability and cost-reduction R&D. DOE and its national laboratories, however, have extensive expertise and facilities that can be critical to the long-term success of these manufacturers.

Recent Progress

- More than 1,000 MW of solar buildings PV systems are operating successfully in the United States, generating more than 3 million MWh/year.
- The energy costs of solar-thermal systems have been reduced through technology improvements by more than 50%, saving more than 5 million MWh/yr in U.S. primary energy consumption.

Commercialization and Deployment Activities



Zero-energy buildings require integrated design of the entire building, including energy-saving features, one or more electricity-generating sources, and an energy-management system to monitor and control operations. The Zion National Park Visitor Center, while not totally zero-energy, is one of the Park Service's most energy-efficient buildings.

- About 1.2 million solar water-heating systems have been installed in the United States. However, due to relatively low energy prices, there are currently only approximately 8,000 installations per year.
- Several hundred transpired solar collector systems have been installed, including installations for Ford Motor Company, General Motors, Federal Express, the U.S. Army, and the Bureau of Reclamation.
- Four multidisciplinary and four state-based homebuilding teams have begun the initial phase of designing and constructing Zero Energy Homes for various new construction markets in the United States. One homebuilder, Shea Homes in San Diego, is currently building and selling 300 houses with Zero Energy Home features, including solar electric systems, solar water heating, and very energy-efficient construction.

Market Context

- Retrofit markets: There are 73 million existing single-family homes in the United States. A potential replacement market of 29 million solar water-heating systems is based on the assumption that only 40% of the homes have been built with suitable orientation and absence of shading needed for solar water-heating systems.

- New construction markets: In 2000, 1.2 million new single-family homes were built in the United States. Assuming 70% of these homes could be sited to enable proper orientation of solar water-heating systems, new construction represents another 840,000 possible system installations each year.
- The ultimate market for zero-energy buildings includes both residential and commercial buildings. However, the near-term focus is on residential buildings and, in particular, single-family homes in the Sunbelt areas of the country. Of the1.2 million new single-family homes built in the United States in 2000, 44% of these new homes were in the southern region of the country and 25% were in the western region, which are prime areas for solar buildings and technologies.
- Solar building technologies will reduce daytime peak electricity requirements.