A Tale of Two Houses

When all the numbers were in, the Zero Energy home performed extremely well. The results for June 18, 1998—a day with the hottest daytime temperatures ever recorded in al-

J

So air-conditioning is a necessity. But it's also a big energy drain,
developed and built so efficiently that a relatively small PV sys-

J

The project's designers were looking to answer two important ques-
tions: Could a home in a climate such as central Florida's be engi-

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The Florida Solar Energy Center (FSEC) designed a project to answer
this challenge. Two homes were built with the same floor plan on near-

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This news is important for city planners, architects, builders, and
homeowners not only in the Sunshine State, but elsewhere, too. The
solar/energy efficiency combo worked so well in Florida that it can—
and should—be tried in other parts of the country.

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J

The answer to both questions turned out to be a resounding "yes!"
And the Zero Energy home especially impressed because it was not con-
ected to the utility grid. The spikes that dip below the zero line indicate the
times when the Zero Energy home generated more power than it needed to
cover its daytime electrical loads. The energy stored in the batteries was
erected and built so efficiently that a relatively small PV system
provided 85% of the power required for all electrical loads. These results need to be taken
very seriously by anyone looking to save energy... and the environment.

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Outage, the home generates its own power,
thereby reducing power demand on the utility grid.

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Florida Solar Energy Center (FSEC) —Conceived and implemented the project.

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The numbers are equally impressive for the months of the year with lower average prices. Over the
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The zero Energy home produced more power than it required and supplied the excess to the utility grid.

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It maintains cooler indoor temperatures.

The Zero Energy home outperforms a conventional home in all respects.

J

The following is a list of Project Participants:

Florida Solar Energy Center


24-hour period, the Zero Energy home required only 199 watts of utility-supplied power on that hot July day (9:00 a.m. to 5:00 p.m.). The numbers are equally impressive for the months of the year with lower average prices. Over the
total of 833 watts. When the power supplied by the PV system is fac-
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Cooling Off Under the Sun

The Florida Solar Energy Center (FSEC) designed a project to answer two important questions: Could a home designed and built for Florida be so efficient that it needed for all electrical loads. These results need to be taken seriously by anyone looking to save energy... and the environment.

The project participants included the Florida Solar Energy Center (FSEC) as the project coordinator and FSEC's technical support resources. Sandia National Laboratories—paid for the PV system implementation. Florida Solar Energy Center (FSEC)—Coordinated and implemented the project.

Related Documents and Web Sites

For more information, contact:

Denny Farmer
Florida Solar Energy Center
7000 Southeast Avenue, Suite 200
Orlando, FL 32819
E-mail: dfarmer@fsec.ucf.edu

The numbers are equally impressive for the months of the year. Inefficient use of energy this year, the home generates its own power, thereby reducing power demand on the utility provider. During Times of peak demand, a Zero Energy Home outperforms a conventional model by providing almost all of its own energy needs throughout the year.

During times of peak demand, a Zero Energy Home generates more power than it uses, thereby reducing power demand on the utility provider. During Times of power outage, the home generates its own power, allowing the homeowner essential energy security. In a Florida study, a prototype Zero Energy Home outperforms a conventional model by providing almost all of its own power needs throughout the year.

A Tale of Two Houses

When all the numbers were in, the Zero Energy home performed extremely well. The results for June 18, 1998—a day with the hottest daytime temperatures ever recorded in central Florida—tell the story. During a 24-hour period, the Zero Energy home used 72% less power from nonrenewable sources than did the control home, despite the fact that the occupied Zero Energy home maintained cooler indoor temperatures. Next year, the home generates its own power, thereby reducing power demand on the utility provider. During times of peak demand, a Zero Energy Home outperforms a conventional model by providing almost all of its own energy needs throughout the year.

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The two homes were built in Lakeland, Florida, at the spring of 1988. They were constructed by the same builder and had almost identical components and locations. Both homes were engineered to be Passive Solar homes—energy-efficient homes that use the sun’s heat to warm the home during the winter and reduce the home’s energy needs to an absolute minimum. However, the two homes were heated and cooled to different levels, which reduced the homes’ energy loads to an absolute minimum.

The Zero Energy home was only 18% of the control home’s power cost. During the month of June, the occupied Zero Energy home consumed only 335 kilowatt-hours.

**Energy Bottom Line for June 1998**

<table>
<thead>
<tr>
<th>Home</th>
<th>Kilowatt-hours</th>
<th>Production (kWh)</th>
<th>Cost ($</th>
<th>% of control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>1,839*</td>
<td>0</td>
<td>0</td>
<td>100%</td>
</tr>
<tr>
<td>Zero Energy</td>
<td>837</td>
<td>502</td>
<td>335</td>
<td>60%</td>
</tr>
</tbody>
</table>

The Zero Energy home’s windows, accounting for almost one-fifth of the energy savings, were selected for their high heat reflectance and low absorptivity. The Zero Energy home’s air-conditioned space is allowed to increase overnight and while the house is unoccupied—decreasing electrical loads and further minimizing the Zero Energy home’s electrical load. These appliances and lighting also help reduce the home’s energy loads to an absolute minimum.

**Control Home Features**

- Single-glazed windows
- Standard incandescent lighting
- Standard appliances (electric range, electric water heater, refrigerator, and electric dryer)
- Gray/brown asphalt shingle roof (versus 1.5 feet for the control) produces twice as much shade, which is especially beneficial for controlling solar gain (heat buildup) on walls and windows.

**Zero Energy Home Features**

- Single-glazed windows with advanced solar control windows
- High-efficiency compact fluorescent lighting
- Energy-efficient, high-performance appliances
- Gray/brown asphalt shingles on the control home. Both homes are used in the interior comfort into the late afternoon and evening.

The smaller appliance, lighting, and air-conditioning loads result in further minimizing the Zero Energy home’s electrical load. These appliances and lighting also help reduce the home’s energy loads to an absolute minimum.

**What if?**

The demand for electrical energy in Florida is increasing constantly. We estimate that in 2010, the demand will be approximately 150,000 MW/year. This is equal to the production of almost 900 coal-fired power plants. If all homes were Zero Energy homes, this demand could be cut by nearly 100,000 MW/year. The figure above shows the potential energy savings of a Zero Energy Home under the most favorable conditions.

In the Florida case, building energy efficiency into the homes’ design produces not only a lower cost of living, but also a lower cost of energy. About the Solar Systems: The solar water heating system is a typical Florida solar collector (see diagram). At the beginning of June, when the system is first installed, the temperature of the hot water outlet is approximately 45°F. This is because the water storage tank is almost empty. The system is then charged by the thermal storage tank until the temperature of the hot water outlet reaches 150°F. This is done to ensure that the water is hot enough to meet the consumer’s needs. The solar collector is then used to heat the water up to its maximum temperature. When the water reaches this temperature, the system is said to be “on.” The system is then used to heat the water up to its maximum temperature.

The solar water heating system supplies most of the hot water for acceptable needs. The energy output is equivalent to that of a typical Florida solar collector. All of the electricity produced by the solar collector is consumed by the home’s electrical load. The electric portion of the energy output is consumed by the home’s electrical load. The electric portion of the energy output is consumed by the home’s electrical load.

**About the Solar Systems**

The solar water heating system is typically used for residential and commercial applications. It is a simple system that can be installed in most homes. The system is easy to use and requires minimal maintenance. It is also environmentally friendly, as it reduces the amount of energy required to heat the water. The system is also very energy-efficient, as it can deliver up to 50% of the energy required to heat the water. The system is also very cost-effective, as it can reduce the amount of energy required to heat the water by up to 50%.

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The two homes were built in Lakeland, Florida, at the spring of 1998. They were constructed by the same builder and had similar complete systems and nearly identical floor plans (of 2,425 square feet). The energy use of both homes was monitored for more than a year.

The objective was to test the feasibility of constructing a small, single-family, highly energy-efficient home to reduce the home's energy load to an absolute minimum. A test of high-efficiency features and the impact of advanced energy-conserving and demand-shaping technologies were performed on both homes, the Zero Energy home and the control home. The Zero Energy home included a number of new and innovative features that were shown to greatly reduce the home's electricity load.

The Zero Energy home's windows, accounting for almost one-fifth of the energy savings (for cooling), were selected to block most of the sun's energy and permit transmission of only visible light. The evacuated-tube solar water heater also eliminated any electrical requirements for heating hot water, thus allowing the peak period of electrical demand.

The solar water heating system supplies most of the hot water for acceptable modes, the energy output is equivalent to that of a 2-kW PV system.

The smaller appliance, lighting, and air-conditioning loads result in further minimization of the Zero Energy home's electrical load. These appliances and lighting also release less heat into the home while operating, which decreases the air conditioner of as much as one-third of its cooling capacity during the hottest hours. Oversizing the ducts allows high air flow, thus minimizing the energy cost (for cooling) of the air-conditioning system. The smaller appliance, lighting and air-conditioning load results in less PV capacity required to meet the home's total electrical load.

A programmable thermostat—set so that the indoor temperature is allowed to increase overnight and while the house is unoccupied—decreases electrical usage by several hours per day through operation. Running this air conditioner reduces the total electricity consumption and lowers utility costs.

The traditional wide roof overhang of old-style Florida homes causes overheating and poor energy performance. The precooled concrete walls help maintain cooled during daytime hours when the sun is shining. This allows the masonry to be pre-cooled at night, which is especially beneficial for controlling the air-conditioned space. This creates a large, pre-cooled reserve that is available whenever it is needed.

The interior-mounted, high-efficiency compact fluorescent lighting provides a combination of high efficiency, good color rendition, and moderate cost. The Zero Energy home's system achieved an overall efficiency of 2.3 W/lumens.

The homeowners participating in the 1998 Energy Bottom Line for June 1998 were Lakeland, Florida residents of the same neighborhood. Their homes were monitored from March 1 to June 30, 1998, and their utility meters were read at the time of the worst day of June 18, 1998, and for the month of June. This was a period of the hottest summer in some years. FSEC had shown that heat transfer to the duct system can flow through the combination of infiltration and duct leakage, which can contribute to the cooling energy cost. As a result, the Zero Energy home's duct system was upgraded to minimize such heat leakage.

The Zero Energy home's fans and air conditioner were set to minimum so as not to save energy. People invest in solar technology because it just doesn't make sense to build a new home without it because of the high demand savings. This is especially true in Florida where the solar technology power stretches further.

Energy Efficiency Enhances Solar Technology

The energy efficiency measures, solar technology’s investment value, and the combined system (half that of the control home) is highly unusual for a small home (2,425 square feet) in Lakeland, Florida. In the Zero Energy home, building energy efficiency into the building reduces cooling load, which means a smaller air-conditioning system with associated savings and higher operating efficiency.

The PV system was sized to provide power that would offset most of the household load as much as possible. Based on the predicted peak demand forafs a 4-kW PV array, (right after the inverter and the battery, the annual savings would be $13,268 in utility bills. Multiply those figures by 500 homes, and 500 homes in Florida, and the potential for savings is enormous.

About the Solar Systems

The Zero Energy home's heating system was a typical Florida's double-insulation system with a 24-kW solar collector on the roof of the house with a ground heat exchanger system and a ducted air-source heat pump (a typical air-conditioning system). The other was a ground heat exchanger plant (undersea). The ground source heat pump is grid-interactive, producing DC power that is converted to AC and then fed directly into the local utility distribution system. The City of Lakeland, Department of Electric and Water Utilities, which owns and operates the PV system, allows only a selected number of a residential PV systems to be utilized for grid.

The PV system was sized to provide power that would offset most of the household load as much as possible. Based on the predicted peak demand for a 4-kW PV array, the annual savings would be $13,268 in utility bills. Multiply those figures by 500 homes, and the potential for savings is enormous.

The demand for electrical energy in Florida is increasing at a faster rate than the energy supply. This means that each homeowner will have to increase the efficiency of their use or utility bills. Multiplying those figures by 500 homes, and 500 homes in Florida, and the potential for savings is enormous.
The two homes were built in Lakeland, Florida, at the spring of 1998. They were constructed by the same builder and had identical components and features. Fastforward to 2002, and the Zero Energy home was only 18% of the control home’s power cost. This compares to 1,839 kWh used by the Energy Bottom Line for June 1998, which is lower than it should be? The Zero Energy home’s air-conditioning takes care of cooling needs. But why make the conditioning take care of cooling needs? But why make the cooling load that exists only for late afternoon during the hottest hours. Oversizing the ducts allows high air flow and low-friction loss (previously shown to provide as much as a 10% drop in actual operating efficiency). This reduces the cooling load that must be met by the air-conditioning system. Running the air conditioner reduces the total electrical consumption and lowers utility costs.

The solar water heating system supplies most of the hot water for acceptable homes. The energy output is equivalent to that of a solar collector of 4-kW (seasonal energy efficiency ratio) downsized SEER 15.0, variable-speed, 2-ton air conditioner with field-verified cooling-coil operating efficiency. Running the air conditioner less reduces the energy used in utility bills. Multiply these figures by all 50 states, and the total savings for the 100,000 homes is 1.8 billion kWh.

The appropriate energy efficiency measures, solar technology’s investment value is magnified. Here’s where energy efficiency factors in: as a home’s energy efficiency increases, solar technology can offset more of the utility bill. This makes it a better investment, because solar technology’s investment value is magnified. Here’s where energy efficiency factors in: as a home’s energy efficiency increases, solar technology can offset more of the utility bill. This makes it a better investment, because solar technology’s investment value is magnified. Here’s where energy efficiency factors in: as a home’s energy efficiency increases, solar technology can offset more of the utility bill. This makes it a better investment, because solar technology’s investment value is magnified. Here’s where energy efficiency factors in: as a home’s energy efficiency increases, solar technology can offset more of the utility bill. 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Florida Solar Energy Center (FSEC) designed the Florida Solar Energy Home with solar energy technologies in mind and was targeted for an area like Florida where air-conditioning is used extensively. A prototype of this home was constructed and monitored carefully for energy use.

This home's air-conditioning load represents the biggest energy challenge. For most people, a summer spent in Florida's heat and humidity would be unbearable without it. So air-conditioning is a necessity. But it's also a big energy drain, accounting for about 35% of all electricity used in Florida homes. And because so much of the energy consumption comes from Florida, it's hard to find a home that is truly energy efficient and priced to local residential building practices, and the other (the “Zero Energy Home”) was designed with energy efficiency in mind and solar energy technologies.

The project's designers were looking to answer two important questions. Could a home in a climate such as Florida be engineered and built so efficiently that it didn’t require electricity for the summer of 1998—one of the hottest summers on record in Florida. And the test was especially rigorous, because it was conducted in the middle of June, the hottest month of the year. The results were equally impressive for the other home, despite the fact that the conventional model built alongside it—what the test home's air conditioner breezed along on 833 watts. When the power production by the PV system is factored in, the Zero Energy home required only 199 watts of utility-supplied power on that hot day in June. This is an outstanding 93% reduction compared to the control home.

The numbers are equally impressive for the rest of the year: the Zero Energy Home is a net energy producer, providing 72% of the energy for its electrical needs. The remaining energy is exported to the utility grid. During times of peak demand, a Zero Energy Home outperforms a conventional model by providing almost all of its own power needs throughout the year.

J ust imagine living in Florida, and your fantasies might turn to swaying palms, fresh orange juice... and lots of air-conditioning. For most people, a summer spent in Florida’s heat and humidity would be unbearable without it. So air-conditioning is a necessity. But it’s also a big energy drain, accounting for about 35% of all electricity used in typical Florida homes. And because so much of the energy consumption comes from Florida, it’s hard to find a home that is truly energy efficient and priced to local residential building practices, and the other (the “Zero Energy Home”) was designed with energy efficiency in mind and solar energy technologies.

The Florida Solar Energy Center (FSEC) designed the home (the “control home”) was designed with energy efficiency in mind and solar technologies. The homes were engineered and built so efficiently that it didn’t require electricity for the summer of 1998—one of the hottest summers on record in Florida. And the test was especially rigorous, because it was conducted in the middle of June, the hottest month of the year. The results were equally impressive for the other home, despite the fact that the conventional model built alongside it—what the test home's air conditioner breezed along on 833 watts. When the power production by the PV system is factored in, the Zero Energy home required only 199 watts of utility-supplied power on that hot day in June. This is an outstanding 93% reduction compared to the control home.

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Energy efficiency and solar energy technologies can result in zero net energy consumption from nonrenewable sources. During times of peak demand, a Zero Energy Home generates more power than it uses, thereby reducing power demand on the utility provider. During times of power outage, the home generates its own power, allowing the homeowner essential energy security. In a Florida study, a prototype Zero Energy Home outperforms a conventional model by providing almost all of its own power needs throughout the year.