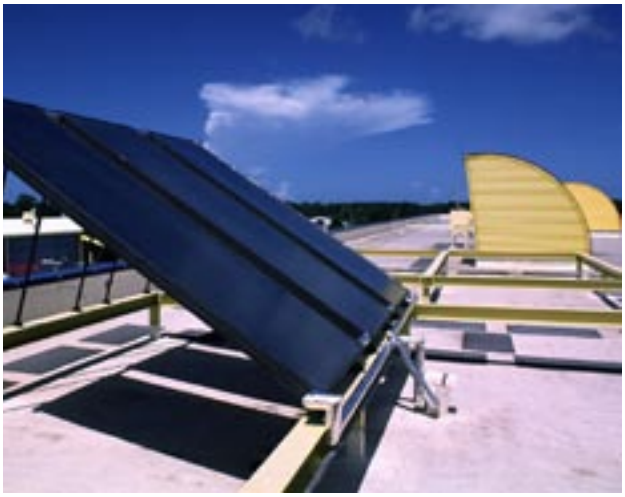

Solar Water Heating

How California Can Reduce Its Dependence on Natural Gas

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RESEARCH & POLICY CENTER

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How California Can Reduce Its Dependence on Natural Gas

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Executive Summary

Solar hot water systems capture energy from the sun to heat water for homes and businesses, thereby displacing the use of natural gas, or in some cases electricity, with free and limitless solar energy. Solar hot water could save California 1.2 billion therms of natural gas a year, the equivalent of 24 percent of all gas use in homes. To prevent global warming pollution, reduce dependence on imported fuel, and ease the price of natural gas, California should act now by jumpstarting a mainstream market for solar hot water.

Solar hot water is a simple, age-old technology that is used around the world.

- Solar collectors, usually placed on the roof of a home or business, absorb the sun's energy to heat water that is then stored in a water tank. The efficiency of the collectors can be as high as 87 percent, meaning very little solar energy is lost in the process.
- Solar hot water systems in California reduce fuel usage for water heating, usually natural gas, by 75 percent or more in the buildings that employ them. A stronger market for solar hot water systems can reduce California's dependence on natural gas, bring down the price of gas for all consumers, and reduce global warming pollution.
- Many countries are encouraging increased use of solar hot water technology. Worldwide installations grew 14 percent in 2005, led by China with almost 80 percent of today's worldwide market. On a per-person basis, Israel leads the way with 90 percent of all homes taking advantage of the technology. Worldwide, solar hot water capacity reached 88 gigawatts-thermal (GW_{th}) in 2005, with 46 million houses equipped with systems.
- The United States currently has 1.6 GW_{th} of solar hot water capacity installed, or 1.8 percent of global capacity. Hawaii, with a strong rebate program, installed almost half of the 9,000 new systems in the U.S. in 2006. California, Florida, and Arizona each installed about a thousand systems in the same year.

California could greatly increase its use of solar hot water, reducing the price of natural gas and the state's global warming impact.

- Virtually any building with a need for hot water and a roof exposed to the sun can take advantage of solar hot water, but less than 1 percent of California buildings have systems installed today.
- A study by KEMA-Xenergy, an energy consulting group, modeled the potential energy savings of various energy efficiency measures that could be utilized in California homes, including solar hot water. The study showed that solar hot water systems could save more natural gas than any other technology: 971 million therms per year in houses, apartments, and mobile homes across the state.
- Another study by KEMA-Xenergy found that solar hot water could save more natural gas than any other efficiency technology in commercial buildings as well. California's commercial buildings could save 219 million therms of natural gas a year by installing solar hot water systems.
- Between the residential and commercial potential for solar hot water,

California could save over a billion therms of natural gas, or 5.2 percent of all statewide consumption today.

- A study by the American Council for an Energy-Efficient Economy (ACEEE) modeled the effects of natural gas savings in California, Oregon, and Washington on the price of the fuel. The report found that efficiency measures leading to a 5.1 percent reduction in natural gas consumption would be accompanied by a 27 and 37 percent reduction in the wholesale price of natural gas in the Northern and Southern California markets, respectively.
- Solar hot water can reduce California's dependence on natural gas from outside the state. Currently California relies on imports for over 85 percent of its natural gas needs.
- Taking full advantage of solar hot water in California would reduce the state's global warming pollution from water heating by 6.8 million metric tons of carbon dioxide-equivalent per year, as much as the annual emissions of over a million cars. The savings represent about 5 percent of the total reductions needed to meet the state's global warming pollution cap by 2020.

Inconsistent and poorly designed public policies have kept solar hot water from making a meaningful contribution to California's energy needs.

- California has a long history with solar hot water. For example, in the late 1800s, before oil and gas became available in the West, more than one third of Pasadena residents had solar hot water systems.

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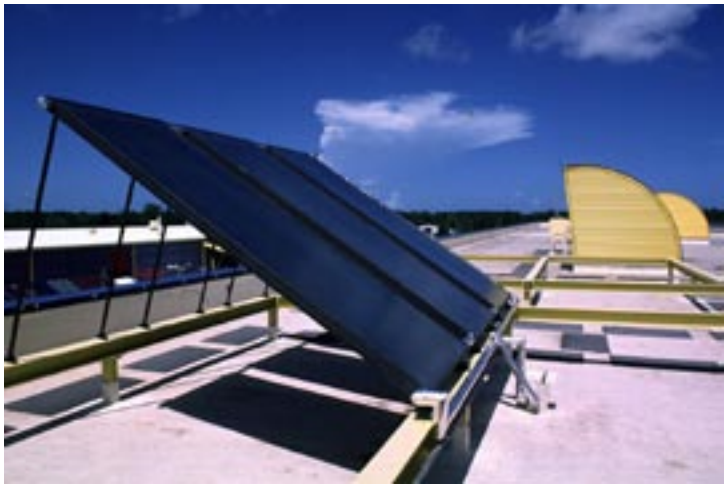
Solar hot water systems use conventional fuels as back-up to maintain the hot water supply even on the cloudiest winter days.

- The energy crisis of the 1970s renewed interest in solar hot water as a way to conserve fossil fuels, leading to tax breaks federally and in California. Without certification requirements, however, quality was inconsistent, and when energy prices dropped in the early 1980s, incentives were allowed to expire and the market collapsed.
- Fortunately, the market for solar hot water did not collapse in every country, and the technology has continued to improve steadily. As a result, today's solar hot water systems run a net profit for system owners in less than 10 years, but upfront costs and lack of public awareness are barriers to widespread utilization.

Appropriate policies will allow California to take advantage of the vast benefits of solar hot water.

- California should offer state rebates to reduce the upfront cost of solar

Florida Solar Energy Center



Businesses that use hot water can save money by installing solar collectors on the roof.

hot water systems, enforce quality standards, and ultimately encourage economies of scale and a mainstream market. These rebates should be secured for a 10 year period to give the industry confidence to invest in production, research and development.

- State and federal tax credits should be extended for 10 years to encourage investments in the industry and further reduce the upfront cost of solar hot water systems.
- California should encourage the installation of solar hot water systems in new homes, which reduces costs by up to 50 percent. At a minimum, all new homes should be "solar ready," and new homebuyers should always be given the option of installing solar hot water in new homes.
- All new government buildings, from the municipal to federal level, should install solar heating technologies to offset natural gas usage, save taxpayers money, and help meet targets for reducing global warming pollution.
- California and the federal government should create training programs to help prepare Californians for the new "green collar" jobs that will grow out of the shift to clean energy technology.
- California and the federal government should invest in educating the public about the benefits of solar hot water.

California's reliance on natural gas is a growing problem. Whenever the price of natural gas has spiked over the last few years, Californians have had to pay more to cook, heat water, and stay warm. And unlike most other states, more electricity consumed in California comes from natural gas than any other source, meaning high natural gas prices create a double whammy in utility bills for households and businesses. California consumes even more natural gas than gasoline; oil is not the state's only fossil fuel addiction.[1]

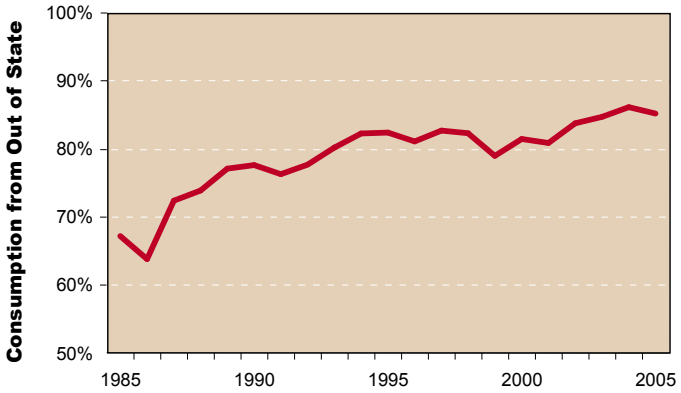
California has established a reputation as a leader in reducing fossil fuel consumption over the last few decades. The state has used efficiency standards to get more done with less energy, and has championed clean and renewable sources for the energy we do use. Since the nationwide energy crisis of the 1970s, for example, energy consumption per capita in California has remained relatively constant while American energy use overall has skyrocketed. And with rising awareness of global warming and its consequences, California recently became the first state to pass a mandatory cap on global warming pollution.

However, more remains to be done. Today, California relies more heavily on natural gas imports than it ever has in the past – more than 85 percent of our natural gas now comes from out of state.[3] (See Figure 1.) But while our overdependence on natural gas poses serious economic and environmental problems, solutions do exist.

California can once again take the lead in promoting energy-saving technologies – this time by expanding the use of solar water heating. Solar hot water systems can save more natural gas in California homes than any other technology. These simple systems use solar energy to heat water, work that is usually done by natural gas today. Since natural gas is expensive and sunshine is free, solar hot water saves money as well as fuel. Tragically, the technology is severely underused in California, despite abundant sunshine. Austria, for example, with a climate similar to Minnesota, installed over 40 times as many solar hot water systems as California in 2005, despite having less than a quarter of the state's population.[4]

With appropriate incentives, California can jumpstart a mainstream market for solar hot water, much like we have done for solar electric technologies, to reduce the state's dependence on natural gas. If history is any indication, the move could lead other states to do the same and even inspire action at the federal level. California should capitalize on this opportunity to build on its record of leadership toward energy independence and global warming solutions.

Figure 1: California Is Increasingly Dependent on Imported Natural Gas[2]



In the last two decades, California has become more reliant on natural gas from out of state; net imports have risen to more than 85 percent of total consumption.

What is Solar Hot Water?

Solar hot water uses energy from the sun to heat water, reducing the amount of natural gas, or in some cases electricity, needed for residential or commercial water heating. Solar hot water systems are highly efficient; up to 87 percent of the sun's energy that reaches a given section of roof can be absorbed by the system's collector.[5] Liquid in the collector, heated by the sun, is pumped to one or more storage tanks, thereby reducing or eliminating the need for conventional water heater fuel.

California Has Been Using Solar Hot Water Since the 1800s

Solar hot water is not new to California. The world's first commercialized solar hot water system was patented in the United States in 1891.[6] Solar hot water quickly became popular in California and many other states as an alternative to burning wood or expensive fuel. In Pasadena, a third of all homes had a solar hot water system by 1897.[7]

Perlin/Butti Solar Archives

A family stands outside their Pomona Valley, California home in 1913. Solar collectors, seen here above the windows, were a common sight in parts of California before natural gas discoveries dramatically lowered fuel prices in the 1920s.

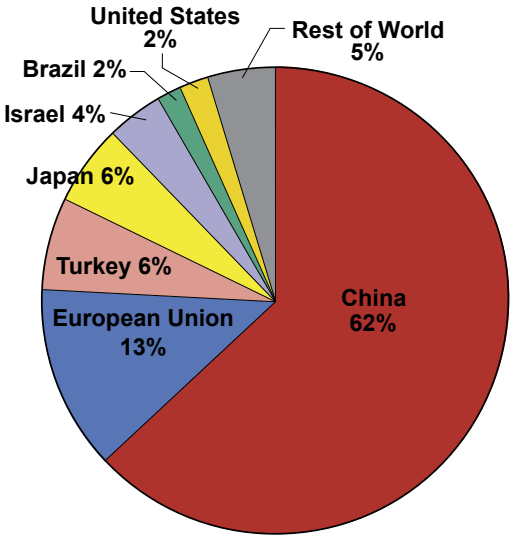
In the early 1900s, many inventors improved upon the original systems, making them more durable and efficient.[8] Solar hot water's popularity continued to grow in California until vast reserves of natural gas were discovered in the Los Angeles basin in the 1920s and 30s.[9] The environmental and health costs associated with burning oil and gas for heat and electricity were underappreciated, and their cheap prices severely dampened demand for solar hot water systems.

Solar Hot Water Is Popular Worldwide and Expanding Quickly

Solar hot water heaters have been in use in various parts of the world since their inception. While conceptually simple, the systems continue to improve as newer technologies enhance performance. As environmental, political, and financial concerns with fossil fuels grow worldwide, solar hot water has become popular in many countries, with the most widespread usage per capita in Israel, Cyprus, Greece, Austria, Turkey, and Japan.[13] By the end of 2005, 46 million houses across the globe had solar hot water systems, an impressive 14 percent increase over the year before.[14] (See Figure 2.) China is quickly taking advantage of the technology and is single-handedly responsible for almost 80 percent of the new systems.[15]

Four of the top five countries for solar hot water usage per person have something important in common with California: a Mediterranean climate.

Figure 2: Total World Solar Hot Water Capacity by Country[10]



The United States has less solar hot water capacity than 6 other countries. California was responsible for about 10% of new installations in the United States in 2005.

Mediterranean climates are characterized by warm summers and mild winters, making them ideal for solar hot water systems. The small temperature range throughout the year allows the systems to cover most hot water demands in the winter without overheating in the summer, meaning a larger portion of the water heating needs can be provided by the sun.

Different System Types Have Distinct Advantages

Collector Types

The most visible difference among systems is the type of collector used. Collectors fall into four main categories: unglazed, flat plate, batch, and evacuated tube.

Unglazed Collectors

The simplest collectors are unglazed; water passes through dark tubes or sacks that absorb sunlight without any glass or plastic cover. Unglazed collectors are cheaper than other types of collectors, and are the most efficient option for heating water to less than about 20° F above the temperature of the outside air.[16] Hot water used in houses is typically about 130° F, at which temperatures unglazed collectors lose a lot of heat back to the air.

Unglazed collectors are ideal for heating pools, which don't require high water temperatures. Solar hot water systems for pools are already relatively common in California and are not within the scope of this report.

Flat Plate Collectors

Flat plate collectors are essentially squat, water-filled boxes with a clear glass or plastic top facing the sun. (See Figure 3, page 11.) The translucent top,

A Note on Units: "Gigawatts Thermal"

Gigawatts thermal (GW_{th}) is a measure of heating power, or the capacity to generate energy in the form of heat. Each square meter of a solar hot water collector has a capacity of about 700 watts thermal (a billion watts thermal is one GW_{th}).[11] This means that during an hour at peak generation, a typical five square meter collector would produce 3,500 watt-hours of thermal energy, enough to bring 10 gallons of water at room temperature to a boil.[12] The 46 million solar hot water systems around the world have a combined capacity of about 88 GW_{th}.

Wagner & Co, Cölbe / European Solar Thermal Industry Federation (ESTIF)

Flat plate collectors are the most common type used for hot water in California houses.

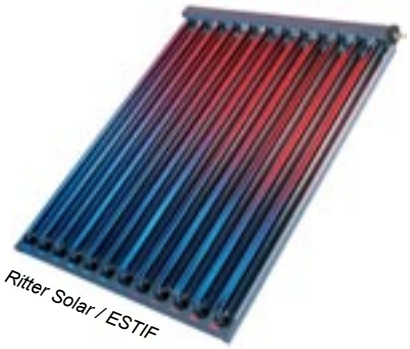
or "glazing," is designed to let sunlight in while preventing heat energy from getting out. The bottom of the collector is a black surface designed to absorb sunlight and release the energy as heat, which is in turn absorbed by the water and trapped by the glazing. Water flows into a lower corner of the collector and becomes heated before exiting through a higher corner.

The insulation provided by the glazing allows flat plate collectors to heat water as much as 130° F above the surrounding air temperature, depending on the angle of the sun, the exact design of the collector, and other factors. For example, if the outside temperature were 70° F, the water in a flat plate collector might reach up to 200° F. Anti-scalding devices ensure that the hot water used in the house doesn't exceed a pre-determined temperature, usually about 130° F. Flat plate collectors are the most common type used for hot water in American homes today, and are usually the most cost effective option for Californians.

Instead of water, flat plate collectors can also use a solution of water and propylene glycol, a non-toxic chemical commonly used in cosmetics and food, to prevent the pipes and collector from freezing during extremely cold temperatures. The heat absorbed by the solution is then transferred to water in a hot water tank, and then pumped back to the collector to be heated again. Solar hot water systems that only use water are "direct" systems, while those that use an antifreeze solution such as diluted propylene glycol are "indirect."

Batch Collectors

Batch collectors are sometimes called "integrated collector-storage" (ICS) systems because they house a storage tank for the hot water inside a flat plate-like collector. (See Figure 4.) Solar hot water systems with batch collectors are often simpler and cheaper than flat plate systems, since the collector and extra tank are combined, but are usually not quite as efficient. They are best suited to climates with only mild freezes, such as most of California. They also work best in buildings that require more hot water during the day or in the evening rather than early morning, since storing the hot water outside causes it to lose more heat on cold nights.



Ritter Solar / ESTIF

Evacuated tube collectors use high-tech insulation to heat water hundreds of degrees Fahrenheit above the surrounding air temperature.

Evacuated Tube Collectors

Evacuated tube collectors are made up of long, clear glass tubes containing a colored glass or metal tube to absorb the sun's energy. The space between the outer glass tube and the inner

absorber tube is evacuated (contains almost no air), making heat loss much slower and enabling the system to heat water to as much as 350° F or more.[17] Residential systems include measures to ensure that water used in the home does not rise above standard hot water temperatures.

Evacuated tubes can either circulate water directly through the absorber tube or be filled with a non-toxic solution that heats water as it passes by the top of each tube. Evacuated tubes are more expensive per unit area than other collectors, and are ideal for cold climates or buildings that use the hot water as an energy source for air conditioning or heating. Using hot water for air conditioning and heating is a great way to expand the fuel savings potential of solar hot water, though it is not considered in this report.

System Types

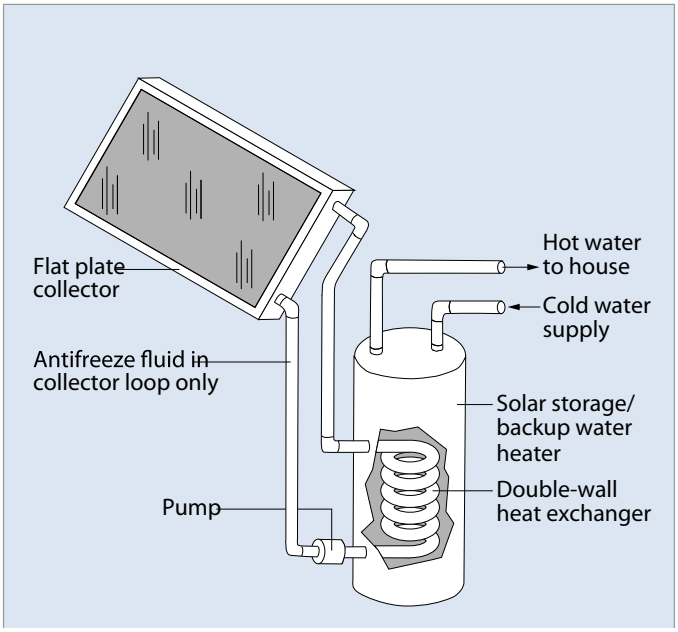
Solar hot water systems can also be characterized by attributes other than their collectors.

Single vs. Double Tanks

Some solar hot water systems use a single hot water tank to store hot water from the collector until it is drawn into the building for use. In one-tank systems, auxiliary fuel is used to heat water in the tank if it falls below a certain temperature. When a solar hot water system is installed on a building, the existing water tank can sometimes be modified to create a one-tank system.

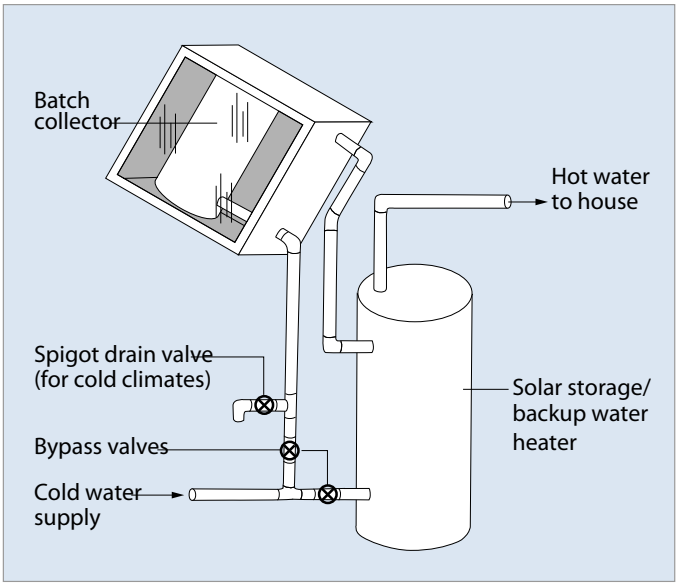
Most solar hot water systems use a separate storage tank to store hot water from the collector. Cooler water from the bottom of the storage tank is drawn into the collector to be heated and then returned to the top of the storage tank when hot. When hot water is used in the building, it comes directly from

Figure 3:
Indirect, Active Solar Hot Water System



This is an indirect (closed loop) active system with a flat plate collector and single tank.

Figure 4:
Direct, Passive Solar Hot Water System



Illustrations: Energy Efficiency and Renewable Energy, U.S. Department of Energy

This is a direct passive system with a batch collector and single tank.

the auxiliary tank, identical to tanks in most homes today. If the water drawn from the storage tank is not hot enough, fuel is burned in the auxiliary tank to heat up the water to a predetermined temperature. Two-tank systems are easy to retrofit by simply adding the solar hot water storage tank to the existing system. Sometimes the storage tank is directly attached to the collector, as with a batch collector system, or a well-insulated tank just above the collector on the roof. This design allows for simple "passive" systems (see below).

Active vs. Passive Systems

Active systems use pumps to circulate the water or antifreeze solution between the collector and the storage tank. When antifreeze is used, which avoids freezing in cold climates, it passes though coils in the tank to transfer the heat to the water. (See Figure 3.) Active systems require a pump to maintain circulation and are the best at providing the most heating power. Large-scale applications of solar hot water are generally active systems.

Passive systems don't need a pump to circulate water or antifreeze from the solar collector to the water storage tank. Circulation happens naturally because water heated in the collector becomes lighter and rises to the storage tank, allowing cooler water to flow into the collector. In order to allow the heated liquid to flow up to the storage tank without the help of an electric pump, the tank must be located in or above the collector, either on the roof or in an attic. (See Figure 4.) In direct passive systems, when hot water is drawn from the auxiliary tank for use in the house, the existing water pressure pushes hot water from the storage tank into the auxiliary tank, and cold water takes its place to be heated by the collector. While all solar hot water systems can save money in the long term, passive systems have the lowest upfront cost and are usually the least expensive per watt-hour thermal produced.[18]

Florida Solar Energy Center

Solar hot water, like this large commercial system, is a solar thermal technology.

Solar Thermal

The term "solar thermal" applies to many different types of solar technologies and solar design. By definition, it includes any system that uses sunlight to gather energy in the form of heat. Solar thermal technologies include solar hot water as well as concentrating solar power (CSP) and passive solar. CSP uses highly reflective surfaces to concentrate sunlight over a large area onto a smaller surface that absorbs the heat, which is in turn used to create electricity. Passive solar describes any technology, including passive solar hot water systems, that uses heat from the sun without assistance from conventional energy sources like electricity. Common architectural applications of passive solar include orienting buildings and windows toward the sun.

Solar technologies that are not "solar thermal" include solar electric panels (solar photovoltaics), which transform sunlight directly into electricity, and hybrid lighting, which uses fiber optic cables to channel sunlight into rooms.

System Costs and Savings

Installing a solar hot water system on an existing home costs about $6,000, depending on the amount of hot water used in the home, the location of the existing hot water tank, and the extent of shade on the roof. Solar hot water collectors can be mounted adjacent to solar electric panels (photovoltaics) on the same roof face, and are significantly smaller. (See photograph at right.) When included in new homes, a system may cost as little as $3,000 because of reduced installation costs.[19] The existing federal tax credit reduces the effective price by 30 percent, to $4,200 and $2,100, respectively.

Systems are designed to last several decades, over which time they save owners 75 percent or more of their water heating fuel. In California, which has tiered rates for gas and electricity use, in which consumption above a set baseline costs much more, financial savings can be proportionally larger than the actual fuel savings. At today's prices, a California homeowner can save more in fuel costs over eight years than the system cost to install.[20] Households with greater hot water needs can buy larger systems and recoup their investment even faster.

Public Benefits

Solar hot water systems do more than just save homeowners money. By decreasing natural gas and electricity usage, solar hot water systems make all Californians better off. Global warming and air pollution, from burning natural gas directly as well as in electric power plants, decreases with the use of solar hot water. The significant natural gas savings also reduce California's dependence on fuel imports and lower the price of natural gas. The public benefits of solar hot water are discussed in more detail in the next chapter.

While solar hot water systems save money over their lifetime, the upfront costs discourage many households from installing them. Appropriate policies, however, can increase public awareness while providing economically beneficial incentives to install the systems, augmenting the benefits to all Californians.

National Renewable Energy Laboratory

These San Diego homes are using the sun for both hot water and electricity. The solar hot water collectors are the single rectangles that look like skylights, while the larger array in the back is a photovoltaic system.

California's Potential for Solar Hot Water

California's potential for solar hot water extends throughout the state, wherever there are buildings that use hot water. Already considered a leader in clean energy and solar technologies, the state's abundant sunshine, mild climate, and technological know-how make it ideal for solar hot water, much as it is ideal for the other rooftop technology, solar photovoltaics. When fully utilized, solar hot water can provide impressive benefits for the entire state.

Solar Hot Water Can Save Natural Gas and Electricity in California

Homes

About 38 percent of the natural gas used in California homes is used to heat water.[21] KEMA-Xenergy, an international consulting and testing company, modeled the potential energy savings of various efficiency measures in California homes in 2003. The model used figures for the energy currently being used in water heating to help determine how much energy solar hot water and other technologies could save. Houses that already had the technology or that didn't have any access to sunlight were counted as having no potential for savings. With solar hot water saving an average of 80 percent of water heating energy, the study showed that the technology could save 971 million therms of natural gas and 1,126 gigawatt-hours of electricity per year in homes across the state.[22]

Businesses

Another study by KEMA-Xenergy modeled the natural gas savings potential from solar hot water systems in California's commercial buildings. Applicability is more varied in the commercial sector because some buildings, such as offices, have very low hot water demands while others, such as high-rise hotels, have very high demand but might be limited by roof space. KEMA assumed just 60 percent of water heating energy in applicable buildings would be covered by solar hot water systems, meaning that California business could save 219 million therms of natural gas a year.[23]

Combined Savings

Combining the residential and commercial potential, California could save about 1.2 billion therms of natural gas with solar hot water technology. In 2005, the last year for which data are available, that amount would comprise about 24 percent of residential natural gas usage, or 5.2 percent of all statewide consumption.[24]

Public Benefits of Solar Hot Water Systems

Dramatically reducing natural gas consumption with solar hot water has benefits that extend to all Californians. These benefits demonstrate the need for California to encourage the installation of solar hot water heaters in the state.

Economic Benefits

Fully utilizing solar hot water systems in California would reduce demand for natural gas, leading to reduced gas prices. A 2006 report by the American Council for an Energy-Efficient Economy found that a modest drop in natural gas consumption in the Pacific West market (California, Oregon, and Washington) could dramatically reduce the price of natural gas in California in the near and middle term. Specifically,

the study found that a 5.1 percent decrease in natural gas usage in the region by 2010 would be accompanied by a 27 and 37 percent drop in wholesale gas prices in Northern and Southern California, respectively. Such a scenario would save consumers $23 billion dollars in the first few years alone.[25]

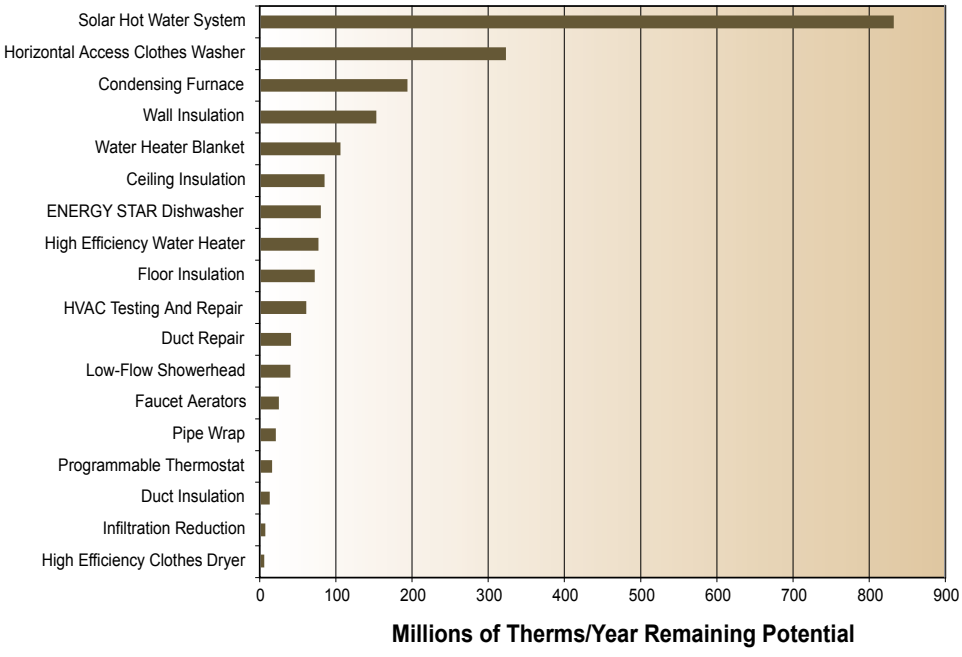
In addition to the fiscal benefits of lowering natural gas demand, California would also benefit from decreased dependence on imported natural gas. California will have better ability to manage its own economy in the future if it doesn't have to rely on outside sources to supply its energy. Furthermore, lower imports will reduce the pressure to build potentially dangerous liquefied natural gas (LNG) terminals on California's coast.

Environmental Benefits

With the recent passage of the first statewide cap on global warming pollution, California has taken commendable action towards solving one of its greatest environmental challenges. Unchecked global warming will affect California in many adverse ways including rising sea level, extreme weather patterns, disrupted agriculture, and natural ecosystem disturbances. Fortunately, taking advantage of the solar hot water potential in California is one of many ways the state can take a concrete step toward solving the problem.

Realizing California's potential for solar hot water would save 6.8 million metric tons of carbon dioxide-equivalent per year, the amount of global warming pollution emitted by 1.2 million cars.[26] Those emissions reductions represent about 5 percent of the cuts necessary to meet California's new goal of reducing global warming pollution to 1990 levels by 2020.[27]

Figure 5: Solar Hot Water Systems Have the Greatest Natural Gas Saving Potential in California Homes



According to a 2003 study by KEMA-Xenergy, solar hot water systems hold the largest potential in California for reducing natural gas consumption in homes. When all gas-saving measures are implemented together, solar hot water systems would save 831 million therms per year. Implemented alone, the savings from solar hot water would reach 971 million therms.

Source: KEMA-Xenergy

Public Policy and Solar Hot Water: Lessons from the 1970s and 1980s

After dropping in popularity with the discovery of fossil fuel reserves in the West in the early 1900s, solar hot water had a comeback in California and nationwide after the oil embargo of 1973. Eager to cut back on energy consumption, the federal government created a 40 percent tax rebate for solar hot water systems in the 1970s. California also cut the price of the systems by the same amount, resulting in incentives totaling 80 percent of the cost of a new system.[28]

Many businesses sprung up for the sole purpose of filling the rocketing demand for the solar hot water systems. The government incentives, however, failed to include performance standards, and the quality of the systems varied greatly. While the majority of businesses were legitimate, some businesses had no experience in installing solar hot water systems and were more concerned with reaching as many customers as possible than with providing a quality product.

Just a few years later, in the early 1980s, concerns over energy shortages simmered down and the government subsidies were suddenly removed in their entirety. The industry collapsed, leaving no one to be held accountable for poorly installed systems. Understandably, consumers who were saddled with failed and irreparable solar hot water systems soured on the technology. As a result, other forms of solar energy – such as solar photovoltaic panels – are much more well-known today than solar hot water.

VELUX / ESTIF

When solar hot water systems are built into a home during construction, they can pay for themselves twice as fast.

The mistakes of the solar hot water "boom" of the 1970s and early 1980s were not due to a technological failure, but rather a policy failure. The experience has shown that it is not enough to provide generous subsidies in order to create a strong, durable market for a new technology. Instead, incentives should be paired with certification requirements that ensure that consumers are purchasing a quality product. And they should be designed so as to encourage the orderly growth of the industry over the long term.

However, by failing to adequately promote solar hot water heating, California is currently missing a golden opportunity to save energy and reduce global warming pollution. Well-made, well-installed solar hot water systems provide water heating to millions of homes in China, Israel, Austria, Turkey, Japan, as well as other states like Hawaii.

Today in California, rising energy prices, widespread concern about global warming, and a modernized industry provide the perfect opportunity to take back the lead on solar hot water. With appropriate policies, California can make solar hot water a mainstream product with environmental and economic benefits that extend beyond the home.

California and the United States can and should help solar hot water fulfill its energy and pollution-saving potential. State and federal policy makers should:

Create a Stable Statewide Rebate Program

The best way to take advantage of solar hot water technology in California is with a rebate to encourage growth in consumer demand, ultimately creating a mainstream market and lowering prices through economies of scale. A stable supply of rebates to cover up to one third of the upfront costs of the systems would help encourage a robust market in the state. The rebate should be guaranteed for ten years so manufacturers and installers can safely invest in the California market, helping bring down prices further. Hawaii's 35 percent rebate has successfully propelled the state to about half of the total U.S. solar hot water market today.[29] In addition to making these rebates available statewide, California should carve out at least 10 percent of available funds to promote solar hot water systems on low-income and affordable housing projects to help ensure the benefits of solar heating technologies are enjoyed by all Californians.

Extend the Federal Tax Credit

Extending the federal and state tax credits for ten years will compliment a rebate plan, making it easier for all Americans to use solar hot water while also encouraging private research and development by creating certainty in the marketplace. Similar to rebates, the tax credits are most effective when guaranteed for long periods of time so that the industry knows that their investments in the market will pay off in the future. Those investments help the technology continually improve and bring the cost down even further.

Enforce Industry-Wide Standards

Attaching mandatory standards to eligibility for rebates and credits gives consumers confidence in the products on the market and prevents unscrupulous businesses from taking advantage of the state and federal rebates. The Solar Rating and Certification Corporation (SRCC) is an independent non-profit that was formed by state and industry bodies in the 1980s for this purpose, and is already used to certify solar hot water systems in California. California should ensure that solar hot water lives up to its full potential by working with the industry to verify installation quality. California should also continue to update and require certification and training for California's solar installers through the California State Licensing Board.

Include Solar Hot Water on New Homes

Nearly all new homes built in California should come equipped with solar heating technologies. Installing solar technologies while a home is being built can cut costs by up to 50 percent while helping shave demand for natural gas within the residential sector. At a minimum, California should require that all new homes be "solar ready" and that all new homebuyers be given the option

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California should use solar hot water to save money, natural gas, and the environment.

to add a solar heating system to their home prior to its construction. Houses that are "solar ready" are designed to easily allow connections between the future solar panels and the hot water distribution system, reducing the cost of retrofit installations.

Install Solar Hot Water on Government Buildings

All new government buildings, from the federal to the municipal level, should install solar heating technologies to offset natural gas usage, save taxpayers money and help the government meet global warming reduction goals.

Create Training Programs

In order to help prepare Californians to work in the growing clean energy industry, California should invest in "green collar" job training. Equipping workers with the skills to install high quality solar hot water systems as well as other renewable energies will increase the benefits of the technologies and encourage a healthy industry.

Educate Consumers and the Public

Consumer education is a great way to encourage widespread usage and help consumers get the best value out of the system they decide to install.

Notes

[1] More electricity from natural gas: In 2005, 38 percent of gross electricity generation consumed in California was from natural gas. The next biggest electricity fuel was coal at 20 percent: California Energy Commission, *2005 Gross System Electricity Production*, 7 September 2006.

More energy from natural gas than gasoline: In 2003, California consumed 2.3 quadrillion BTU (quads) of natural gas and 1.9 quads of motor gasoline. By comparison, all petroleum products amounted to 3.8 quads and all energy products in California totaled 8.1 quads: Energy Information Administration, *Energy Consumption by Source, 2003*, updated 23 October 2006, downloaded from: www.eia.doe.gov/emeu/states/sep_sum/html/sum_btu_tot.html, 2 March 2007.

[2] California Energy Commission, *California Natural Gas Supply by Source*, 30 August 2006.

[3] Ibid.

[4] Austria installed 163 MW_{th}: European Solar Thermal Industry Federation, *Solar Thermal Markets in Europe*, June 2006; The United States installed about 35 MW_{th}: Eric Martinot, The Worldwatch Institute for the Renewable Energy Policy Network for the 21st Century, *Renewables Global Status Report: 2006 Update*, 2006; California installed about one-ninth of all US solar hot water systems: Les Nelson, Solar Energy Industries Association, *Solar Heating Overview*, Presented at the American Solar Energy Society's National Solar Conference, 11 July 2006, downloaded from www.solar2006.org/presentations/forums/f14-nelson.pdf, 15 January 2007.

[5] The absorption efficiency depends on the type of collector used, the temperature difference between the heated liquid and outside air, and the intensity of the sunlight: Andy Walker, National Renewable Energy Laboratory, *Solar Water Heating*, updated 26 February 2007, downloaded from: www.wbdg.org/design/swheating.php, 7 March 2007.

[6] John Perlin, California Solar Center, *Solar Evolution: The History of Solar Energy,* downloaded from www.californiasolarcenter.org/history_solarthermal.html, 16 January 2007.

[7] California Energy Commission, *The Energy Story*, 22 April 2002.

[8] See note 6.

[9] California Energy Commission, *The Energy Story*, 22 April 2002; John Perlin, California Solar Center, *Solar Evolution: The History of Solar Energy,* downloaded from www.californiasolarcenter.org/history_solarthermal.html, 16 January 2007.

[10] Eric Martinot, The Worldwatch Institute, for the Renewable Energy Policy Network for the 21st Century, *Renewables Global Status Report: 2006 Update*, 2006.

[11] European Solar Thermal Industry Federation, *Recommendation: Converting Solar Thermal Collector Area to Installed Capacity*, downloaded from www.estif.org/fileadmin/downloads/Technical_note_solar_thermal_capacity.doc, 2 March 2007.

[12] A kilowatt thermal (1,000 watts thermal and 0.000001 GW_{th}) is equivalent to 3,412 British Thermal Units (BTU), which is defined as the energy necessary to heat a pound of water by 1° Fahrenheit. A gallon of water weighs about 8.3 pounds in standard conditions. Room temperature is around 72° Fahrenheit and water boils at 212° Fahrenheit under standard conditions.

[13] These six countries have, respectively, the most solar hot water capacity per person, though China has the majority of all gross capacity: Eric Martinot, The Worldwatch Institute, for the Renewable Energy Policy Network for the 21st Century, *Renewables 2005: Global Status Report*, 2005.

[14] See note 10.

[15] Ibid.

[16] Andy Walker, National Renewable Energy Laboratory, *Solar Water Heating*, 26 February 2007, downloaded from www.wbdg.org/design/swheating.php; Natural Resources Canada, *Solar Collectors*, 8 June 2006, downloaded from www.canren.gc.ca/tech_appl/index.asp?CaId=5&PgID=282, 1 March 2007.

[17] David Darling, "Evacuated Tube Collector," *The Encyclopedia of Alternative Energy and Sustainable Living*, downloaded from www.daviddarling.info/encyclopedia/E/

AE_evacuated_tube_collector.html, 1 March 2007.

[18] For more information on types of solar hot water systems, see: Energy Efficiency and Renewable Energy, U.S. Department of Energy, *Solar Hot Water*, available online at www.eere.energy.gov/consumer/your_home/water_heating/index.cfm/mytopic=12850.

[19] Les Nelson, President, Western Renewables Group, personal correspondence, 25 January 2007.

[20] Solar Depot, *Residential Systems: Solar Hot Water*, downloaded from solardepot.com/r_solar_hot_water.htm, 5 March 2007; Les Nelson, President, Western Renewables Group, personal correspondence, 25 January 2007; Sue Kateley, California Solar Energy Industries Association, personal correspondence, 6 March 2007.

[21] Fred Coito and Mike Rufo, KEMA-Xenergy Inc, for Pacific Gas & Electric Company, *California Statewide Residential Sector Energy Efficiency Potential Study*, April 2003.

[22] Savings figures from summing relevant technical potentials in "Non-Additive Measure Results" appendices: Fred Coito and Mike Rufo, KEMA-Xenergy Inc, for Pacific Gas & Electric Company, *California Statewide Residential Sector Energy Efficiency Potential Study*, April 2003.

[23] 219 million therms figure from summing relevant technical potentials in "Non-Additive Measure Results" appendix: Fred Coito and Mike Rufo, KEMA-Xenergy Inc., for Pacific Gas & Electric Company, *California Statewide Commercial Sector Natural Gas Energy Efficiency Potential Study*, 14 May 2003.

[24] Energy Information Administration, U.S. Department of Energy, *Natural Gas Navigator: Natural Gas Consumption by End Use*, January 2007.

[25] William Prindle, R. Neal Elliott, and Anna Monis Shipley, American Council for an Energy-Efficient Economy, *Impacts of Energy Efficiency and Renewable Energy on Natural Gas Markets in the Pacific West*, January 2006. Note that the 5.1 percent drop in gas consumption in the ACEEE scenario would not be fully achieved through full implementation of solar hot water in California. In the ACEEE scenario, Oregon and Washington undergo simultaneous drops in natural gas usage. Even if Oregon and Washington also took full advantage of solar hot water, however, the reduced price from lowered gas demand for water heating will inevitably increase gas consumption somewhat in other areas, reducing the overall impact on both consumption and price.

[26] Natural gas emits 116.39 lbs of CO_2/MMBTU when burned, and every million U.S. cars emits about 5.5 million metric tons of CO_2 equivalent ($MMTCO_2E$) a year: Environmental Protection Agency, *Unit Conversions, Emissions Factors, and Other Reference Data*, November 2004. 6.31 $MMTCO_2E$ come from the natural gas savings. The other 0.49 come from electricity savings, calculated with a pollution intensity factor from 2004: 4.32×10^{-4} MMT CO_2E/GWh. The 2004 factor was calculated from total global warming pollution from the California power sector in the year (including imports), divided by total purchased energy in the state: California Energy Commission, *Inventory of California Greenhouse Gas Emissions and Sinks: 1990 to 2004*, December 2006; Energy Information Administration, U.S. Department of Energy, *State Electricity Profile: California*, June 2006.

[27] To meet the goal, California needs to reduce today's global warming pollution emissions by about 145 million metric tons of CO_2 equivalent by 2020: California Climate Action Team, California Environmental Protection Agency, *Climate Action Team Report to the Governor and Legislature*, 8 December 2005.

[28] See note 19.

[29] Energy Efficiency and Renewable Energy, U.S. Department of Energy, *Solar Energy Technologies Multi-Year Program Plan: 2007-2011*, January 2006; Union of Concerned Scientists, *Solar Water Heating*, 19 September 2005, downloaded from: www.ucsusa.org/clean_energy/renewable_energy_basics/solar-water-heating.html.