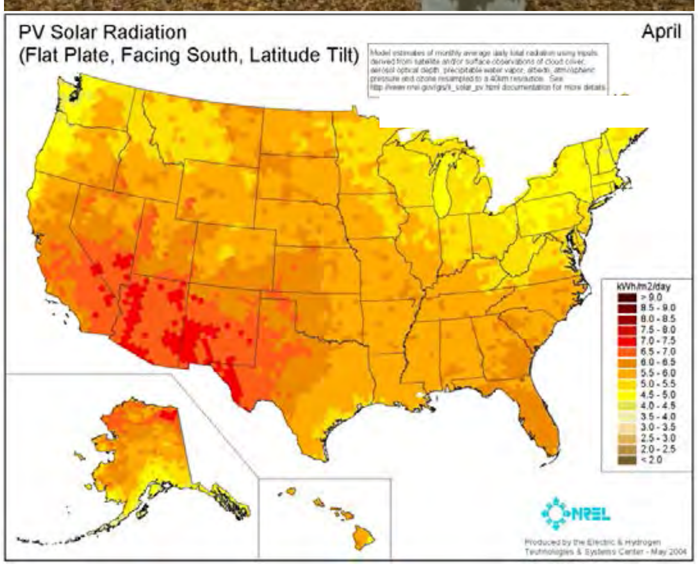
Solar Thermal Policy in the U.S.: A Review of Best Practices in Leading States



Renewable Energy Applications for Delaware Yearly (READY)

Center for Energy and Environmental Policy

University of Delaware

December 2013

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Solar Thermal Policy in the U.S.: A Review of Best Practices in Leading States

Final Report

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- Front Page Top Picture – Solar Thermal Array at Kent County Waste Water Treatment Plant

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Executive Summary

Since 2005, public and governmental support of renewable energy technologies has grown markedly. The American Recovery and Reinvestment Act of 2009 (ARRA) expanded federal financial support for clean energy research, investment, and deployment. Concurrently, states and local governments also expanded their financial and regulatory support for renewable energy in an effort to take advantage of new markets, support job and economic growth, reduce carbon emissions, improve environmental quality, and enhance energy security. These policy initiatives helped to initiate an explosion of private investment into clean energy technologies in recent years. Solar energy received a large share of this policy interest and financial investment.

A vast majority of the investment into solar energy went to solar photovoltaic (PV) technologies. As a result, the price of PV panels has fallen dramatically and the installation rate of PV exploded. Solar thermal technologies have not experienced the same explosion of investment and installation that PV has experienced. Compared to its potential, the growth in the installation of solar thermal in Delaware since 2005 has been modest.

Chapter 1 provides an introduction to this report by highlighting the overall development of solar thermal technology and the major acts that provided momentum for many renewable energy technologies.

Chapter 2 provides an overview of solar thermal technologies and their applications. Technologies are divided into low-, medium-, and high-temperature systems. Low- and medium temperature technologies are most commonly used in residential applications to heat water for domestic use and swimming pools. In non-residential applications, medium and high-temperature collectors are used to heat water for domestic uses as well, such as in multi-tenant buildings or hotels. Medium and high-temperature collectors can also be used to supply process heat in industrial applications such as food processors. Low-temperature systems to heat swimming pool water account for the majority of solar thermal systems currently installed in the U.S.

Chapter 3 reviews current U.S. installation status and costs for solar thermal systems. Focusing on medium-temperature collectors, the prices per ft^2 and the quantity of installations is described. Hawaii, Florida, Nevada, Arizona, and California are leading the way in terms of receiving domestic shipments of solar thermal technologies. The high solar insolation resource of these states explains, in part, the higher per-capita shipments compared to other states. However, states with lesser solar resources, such as Connecticut, Vermont, and Illinois, are receiving more shipments of solar collectors on a per-capita basis than sunny states such as New Mexico and Utah. This suggests that other factors, besides a state's solar resource, have a large impact on the demand for solar collectors.

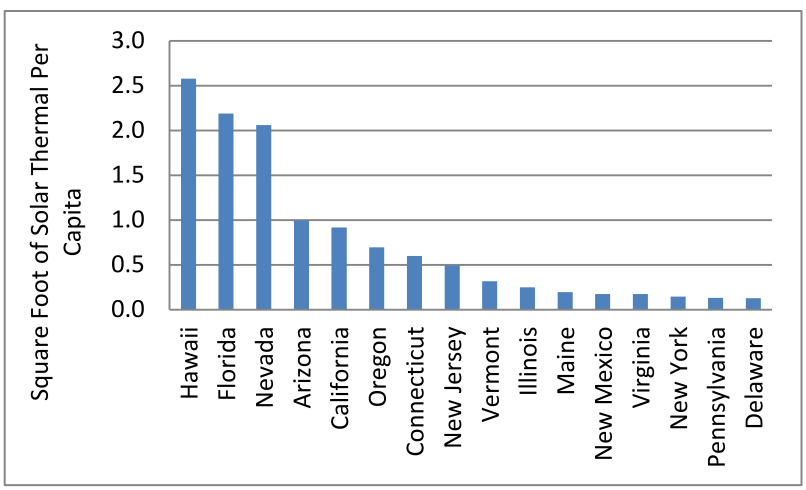


Figure ES 1: Cumulative Per Capita Solar Installations by State, 2001-2009.
Source: (U.S. EIA, 2012).

Chapter 4 provides a brief overview of federal policies, which serve as the backdrop for state policies. The two 30% federal tax credits are the most important federal incentives, providing the biggest economic boost for solar thermal installations. For the commercial sector, the accelerated depreciation of MACRS is also an important incentive. Beyond these tax incentives, the other federal incentives have a de minimis impact on the solar thermal market in Delaware.

Chapter 5 provides case studies of ten states — Arizona, California, Connecticut, Delaware, Florida, Hawaii, Illinois, New Jersey, Oregon and Vermont. Each case study outlines state policies supporting solar thermal technologies and provides an impact overview where data was available. Case studies considered policies in two broad categories: financial and regulatory. The following are findings from our analysis of the case studies.

- Delaware has been only moderately successful in supporting solar thermal, with over $225,000 granted in support of 80 solar thermal systems since 2005. In Delaware, the installation of residential solar thermal systems has not gained sufficient traction to create a robust market, even with the long-standing grants available from the Green Energy Program.
- Solar thermal energy has not received the same level of policy attention that PV and other renewable energy technologies have. There is room for improvement in the solar thermal market in Delaware and in the state's policy support of solar thermal energy.
- Ample solar resources enhance solar thermal economics, but high quality resources are not mandatory to promote solar thermal deployment. Several states, such as Vermont and Connecticut, have lower solar insolation, but policies in these states have supported solar thermal markets and increased installations.
- Policies that specifically target solar thermal technology are more suited to enhance deployment and for promoting the technology. The California Solar Initiative (CSI)-Thermal program and Hawaii's rebate program are examples of programs that have achieved some success in solar thermal system deployment.
- Incentives that provide a direct upfront rebate or grant are more successful at driving deployment than loan or financing policies. California, Oregon, and Vermont all saw substantial increases in solar thermal shipments with the start of rebate programs.
- While useful in a more robust market, loan and financing programs like PACE haven't demonstrated the ability to drive market transformation and jumpstart a state solar thermal market like rebates can.
- Solar thermal companies in recent years have been successful in marketing to certain segments of the non-residential market with high thermal demands such as multi-tenant buildings, hotels, food-processors, and breweries.
- Rebate and grant programs are more conducive to third-party financing arrangements like power purchase agreements (PPA) and leases. In the solar thermal market, the emergence of the PPA model has been driver of growth in the market, primarily in commercial installations. An enhancement to the Green Energy Program that would make this emerging solar thermal business model more viable in Delaware would be to raise the grant cap on non-residential systems to a higher amount, e.g., $25,000 or $100,000.
- Another enhancement to the current solar thermal incentives in Delaware would be to dedicate a portion of some funding source — the Green Energy Fund, the SEU, or other funding source — to

solar thermal incentives. Emerging markets like the solar thermal market in Delaware are able to scale up when there is a stable and known amount of funding on an annual basis.

- A program that has predictable step-declines in grant or rebate levels provides an emerging industry with an incentive to lower installations costs and to fund more installations. The CSI-Thermal program is a good example of a program with predictable, declining incentives over a multi-year period. This model worked well for PV, so California applied the same policy model to solar thermal.
- Requiring contractors to become NABCEP-certified within one year after becoming a Participating Contractor would further establish the professionalism and competency of solar thermal contractors.
- Another regulation that could be tweaked is the RPS. Changing the RPS to allow all solar thermal systems to be an eligible energy resource in the RPS would provide another source of potential revenue for solar thermal systems that offset natural gas, oil, or propane.

Solar thermal systems have a long history of use and represent an excellent option to promote distributed, renewable energy production. They already represent a cost-effective alternative in some applications and markets, and policies supporting more widespread and rapid deployment will bolster markets and improve renewable energy portfolios while decreasing residents' and businesses' exposure to conventional energy price volatility and supply constraints. Environmental benefits will also result from reduced fossil fuel use and lower CO_2 emissions.

Chapter 1: Introduction

Solar thermal technologies have been in commercial operation since the end of the 19th century (Perlin, 2005). In sunny states with high fuel costs, solar thermal systems were used to heat water or provide space heat and were preferred to the types of furnaces that required constant attention and refueling such as wood, coal, or coal-gas. With the development of oil-fired, natural gas-fired, and electric furnaces that had reliable distribution networks, solar thermal systems fell in popularity except in locales with little access to modern energy supplies and services.

The energy crises in the 1970s renewed interest in renewable energy technology including solar thermal technologies. Starting in 1979, a very active national market for solar thermal developed in response to a 40% federal income tax credit, capped at $4,000. By 1984, 2% of water heaters installed in the U.S. were solar hot water systems, with over 180,000 systems installed in that year. With the ending of the federal tax credits in 1985, the solar hot water market crashed. The solar hot water market also suffered from poor quality installations and fly-by-night companies. Since 1984, the penetration rate of the solar hot water systems has never risen above 0.4% (Hudon, Merrigan, Burch, & Maguire, August 2012).

During this 1970s, the popularity of solar thermal technology also began to rise in nations such as Japan, Australia, and Israel (Perlin, 2005). Today, solar thermal water heaters are common in China, India, and many other nations with high oil or gas costs and extensive solar resources. In contrast, the U.S. lags behind many countries including less sunny countries such as Sweden and Ireland.

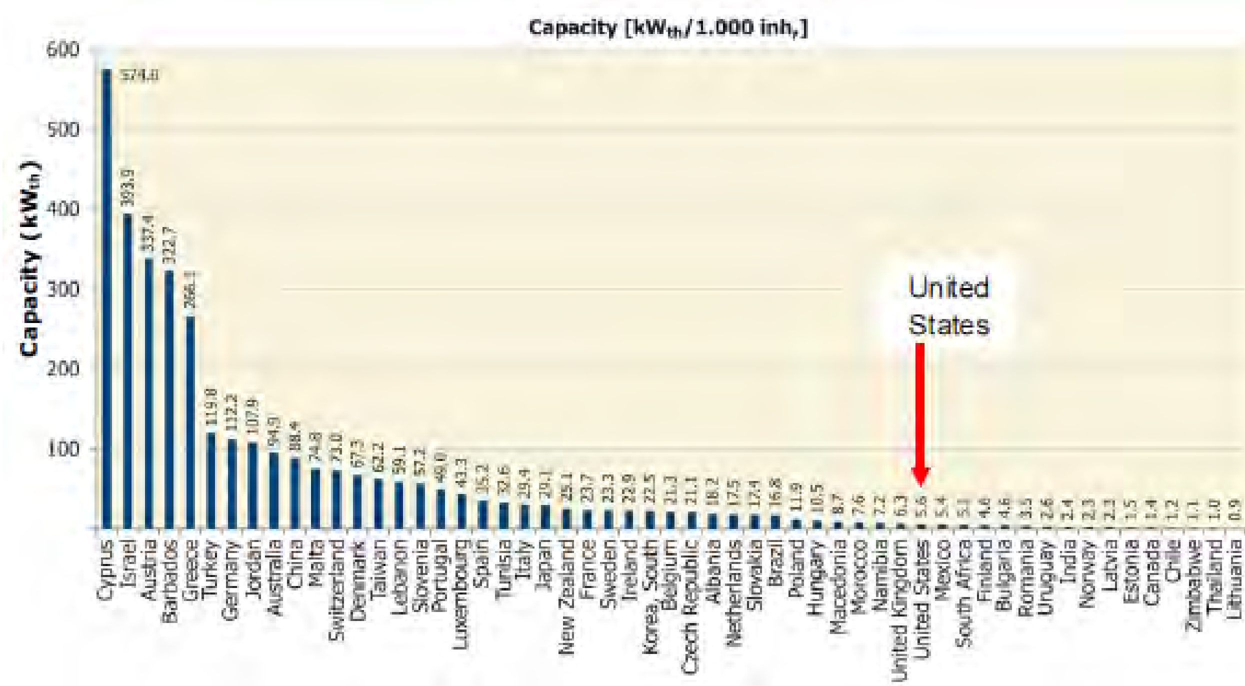


Figure 1: Glazed and Evacuated tube Collector Capacity Per 1,000 Inhabitants, 2011.
Source: (Hudson et al. August 2012).

Since 2005, public and governmental support of renewable energy technologies has grown markedly. Federal legislation such as the Energy Policy Act of 2005 (EPAct), the Energy Independence and Security Act of 2007 (EISA), and the American Recovery and Reinvestment Act of 2009 (ARRA) expanded federal financial support for clean energy research, investment, and deployment. Concurrently, states and local governments also expanded their financial and regulatory support for renewable energy in an effort to take advantage of new markets, support job and economic growth, reduce carbon emissions, improve environmental quality, and enhance energy security. These policy initiatives helped to initiate an explosion of private investment into clean energy technologies in recent years. Solar energy received a large share of this policy interest and financial investment.

A vast majority of the investment into solar energy since 2005 went to solar photovoltaic (PV) technologies, which convert solar energy directly into electricity. One result of this investment is that the price of PV panels has fallen dramatically in the past several years. Another result is the dramatic increase in the installation of PV, with over 3 GW in new PV capacity installed in the U.S. in 2012, a record year for the industry (Solar Energy Industries Association, 2013).

Solar thermal technologies, which use the heat in solar energy in a variety of applications, have not experienced the same explosion of investment and installation that PV has experienced. However, the deployment of non-swimming pool solar thermal systems in the U.S. has grown in recent years (U.S. Energy Information Administration (EIA), 2013a). This growth is mainly due to policies such as federal and state tax incentives, state grant and loan programs, and ARRA funding to states and local governments.

Compared to its potential, the growth in the installation of solar thermal in Delaware since 2005 has been modest, with about 80 systems installed (DNREC, 2012). From a national perspective, a 2007 National Renewable Energy Laboratory (NREL) report estimated the technical potential of solar water heating in the U.S. at about 1 quad (1 quadrillion BTU or 293,083,000 MWh) of energy savings per year, equivalent to an annual CO^2 emissions reduction potential of about 50 to 75 million metric tons (Denholm, 2007). In Delaware in 2010, 11.7 million metric tons of CO^2 emissions were emitted (U.S. EIA, 2013b). At least 10% of the energy consumed in Delaware is used for thermal purposes such as to heat water for domestic use in homes or businesses or for industrial processes (Delaware Energy Task Force, 2003). Solar thermal energy technologies are capable of meeting a significant portion of the thermal energy demand in Delaware.

To further explore the potential of solar thermal energy use in Delaware, this study provides: an overview of existing solar thermal technologies and their applications; a review of installation and cost data for solar thermal systems in the U.S.; an overview of federal policies impacting solar thermal; and explores the policies of ten states in cases studies. Based upon this analysis, recommendations are offered for future solar thermal policy development in Delaware.

Chapter 2: Solar Thermal Technology Overview

All solar technologies capture the radiation from the sun and transform it into useful energy. Solar photovoltaic (PV) technologies convert solar radiation directly into electricity. Solar thermal technologies collect the heat in solar radiation, concentrating it in some manner, to produce heat at useful temperatures. Applications of solar thermal technologies include:

- Heating water for domestic hot water.
- Preheating boiler and process water used in commercial and industrial applications.
- Producing steam for electrical generators.
- Space heating.
- Heating water for absorption refrigeration/air conditioning applications.
- Heating water for swimming pools.

2.1 SOLAR THERMAL COLLECTORS

While applications of solar thermal may have different end uses, the one thing all solar thermal technologies have in common is an apparatus that will collect the sun's radiant energy. Solar collectors absorb the radiant energy of the sun and change it into heat energy. The range of solar thermal collectors can be loosely grouped according to operating temperature ranges. The U.S. Energy Information Administration (EIA) classifies solar collectors into three groups: low-temperature, medium-temperature, and high-temperature. Unglazed and glazed flat-plate collectors are generally used for low and medium-temperature applications. Evacuated-tube collectors and concentrating collectors are usually used for high-temperature applications.

2.1.1 Low-Temperature Collectors

Low-temperature collectors, also known as unglazed flat-plate collectors, can heat water to operating temperatures up to 120°F and can increase water temperature to as much as 40°F over the ambient air temperature. These collectors have a relatively simple design – they consist of a black plastic absorber with flow passages, have no glass cover; no insulation, and no expensive materials such as aluminum or copper. They are less efficient in collecting solar energy when outdoor temperatures are much lower than the desired temperature, but are quite efficient when outside air temperatures are close to the desired water temperature. They are also usually less expensive than other solar collectors. These features make them highly suitable for swimming pool water heating, uses that require only a moderate increase in temperature, and use during the summer months (i.e., after the last freeze and before the first freeze).

The use of solar thermal energy to heat swimming pool water is the predominate use of solar thermal energy in the U.S. Solar swimming pool water systems can be cost competitive with gas or electric water heaters and are seen as one of the most cost-effective applications of solar thermal systems (U.S. Department of Energy (DOE), 2012). Because most solar swimming pool water systems use low-temperature collectors, these types of collectors are often called swimming pool collectors. However, large or year-round swimming pool complexes may use higher temperature solar thermal technologies to heat pool water.

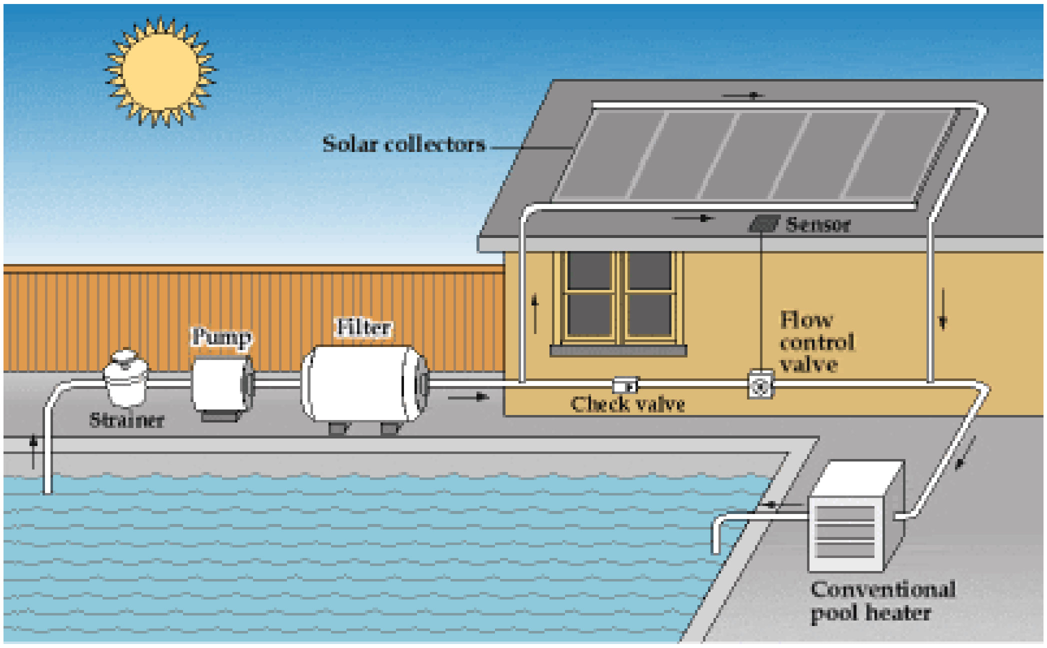


Figure 2: Pool Heating Image.
Source: (U.S. DOE, 2012).

The major components of a typical solar thermal pool heating system include a solar collector, a filter, a pump, and a flow control valve. Together, these components pump pool water through a filter and then through the solar collectors. The pool water is heated as it passes through the solar collectors before returning to the pool. Also, during peak summer months, heat can be expelled from the pool by circulating the warm water through the collectors.

2.1.2 Medium-Temperature Collectors

Medium-temperature collectors can heat water or another fluid to operating temperatures of 120°F to 180°F. Glazed flat-plate collectors are the most commonly-used medium-temperature collectors and usually heat water to 120°F to 140°F. The most common use of flat-plate collectors is for the heating of domestic hot water, but these types of collectors can also be used for other purposes including space heating preheating water for industrial process heat.

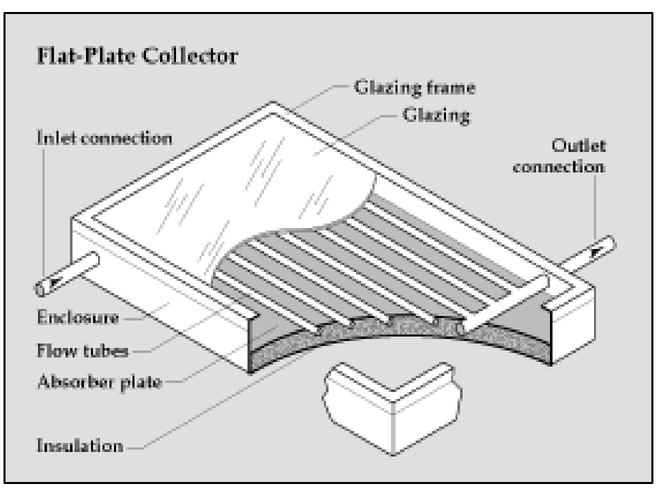


Figure 3: Flat-Plate Collector.
Source: (U.S. DOE, 1996).

As illustrated in Figure 2, flat-plate collectors consist of a frame (usually made of aluminum or steel) backed by a layer of insulation that reduces thermal losses out the back of the collector. The absorber plate collects the incoming near-infrared and visible solar radiation and transfers it to the circulating fluid inside the flow tubes. A selective coating on the absorber can be used to minimize the amount of infrared radiation lost, maximize the absorption of solar radiation, and increase the efficiency of the unit. The glazing or glass placed over the unit should have the highest transmission properties possible to allow all wavelengths of solar radiation to pass through

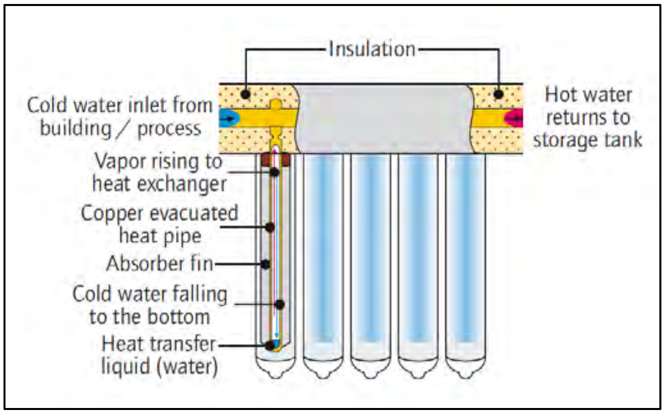


Figure 4: Evacuated Tube Collector.
Source: (International Energy Agency, 2012).

to the absorber. The glass must be strengthened to ensure it can withstand the exposure to summer and winter weather.

In cases where circulating fluid temperatures need to be higher, when the outdoor temperature can get very low, or where overcast skies are common, evacuated-tube collectors (see Figure 4) can be used in place of flat-place collectors. Evacuated-tube collectors are of rows of parallel glass tubes consisting of an outer tube and an inner tube (usually coated with a selective coating that absorbs solar radiation and inhibits heat losses). The air between the outer and inner tubes has been "vacuumed out" to minimize heat loss. Heat from the inner tube gets transferred to a heat transfer liquid (water or alcohol) which boils, rises through the tube as steam, and comes into contact with a pipe containing the water to be heated. The heat transfer liquid condenses as it loses heat and drops back down the tube, shown in the figure below. Due to the circular shape of evacuated tubes, sunlight is perpendicular to the glazing of the tubes for most of a day. This characteristic can allow the tubes to perform well in both direct and diffuse solar radiation (i.e., cloudy days).

2.1.3 High-Temperature Collectors

High-temperature collectors can heat water or other fluids above 180°F. Some highly-efficient flat-plate collectors can fit in this category as can evacuated-tube collectors. Applications that can use high-temperature collectors include commercial and industrial hot water heating, steam production, or solar air conditioning.

Concentrating solar collectors can produce temperatures well in excess of 200°F. These collectors focus solar radiation onto a line or a point — the absorber for the system. The concentration of energy results in higher temperatures than for flat plate collectors, causing the circulating fluid to boil. The steam can be used for industrial or institutional applications or a conventional steam turbine, generating electricity. Solar concentrators also can be integrated into combined steam and gas turbine cycle.

There are several types of concentrating solar thermal collectors. Fresnel linear collectors use reflectors on long, thin strips of mirrors positioned to a variety of angles to focus the sunlight onto a receiver filled with water. The water in the receiver pipes boils, generating a high-pressure, moderate-temperature steam that can be used as the input for industrial processes.

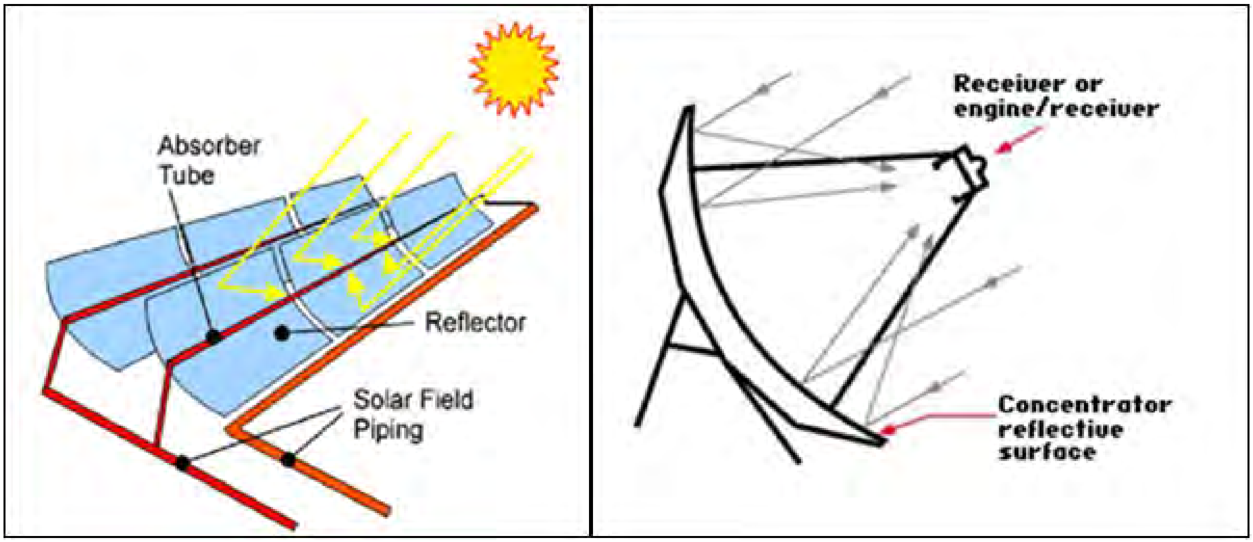


Figure 5: Parabolic Trough and Dish Collectors.
Source: (NREL, 2010; European Commission, 2013).

Parabolic troughs, which can heat a liquid up to 930°F (Jefferson, 2005), consist of a long, semi-circular mirrored trough with an absorber tube running down the central axis. The mirrors focus the sunlight onto the absorber tube and the fluid within (usually hot oil or pressurized water). Parabolic troughs track the sun as it moves across the sky during the day, shifting the trough along its axis, typically oriented in an east-west direction. Dish collectors, instead of using a circulating fluid to generate steam, dish collectors have motors mounted directly at the site of the absorber/receiver, producing steam, and generating the electricity. All of these concentrating solar technologies generally operate in areas with consistent direct sunlight (e.g., desert areas in the U.S. Southwest) and are therefore not suitable for Delaware's climate.

2.2 STORAGE TANKS

Most solar thermal applications require water tanks to store the collected thermal energy. In many residential and other small non-residential applications, specialized 80 or 120-gallon hot water tanks with built-in heat exchangers are used. For larger systems, multiple manufactured tanks can be used or tanks can be built on-site to best match the needs (e.g., insulated or uninsulated) of the particular solar thermal application.

2.3 PASSIVE SYSTEMS

Solar thermal technologies can be subdivided into "passive" and "active" applications. Many "passive" solar technologies involve the use of building design elements, such as window glazing, double wall construction, clerestory windows, convective air loops, and similar design elements to take advantage of the heat of the sun in the winter and to prevent the infiltration of warm air in the summer. These passive technologies are usually classified as demand side energy savings techniques rather than supply-side sources of energy and passive technologies fall outside the scope of this research. Other passive systems use solar collectors to concentrate the energy of the sun, but rely on natural convection and gravity to circulate the collected energy—they do not contain pumps or other mechanical systems. Passive systems are usually not practical for applications larger than a residential hot water system.

The most common passive, direct solar thermal collector systems are thermosiphon and integral collector storage (ICS) systems (Union of Concerned Scientists (UCS), 2005). More common in warmer climates, these passive systems do not use pumps or electrical devices to move water through the

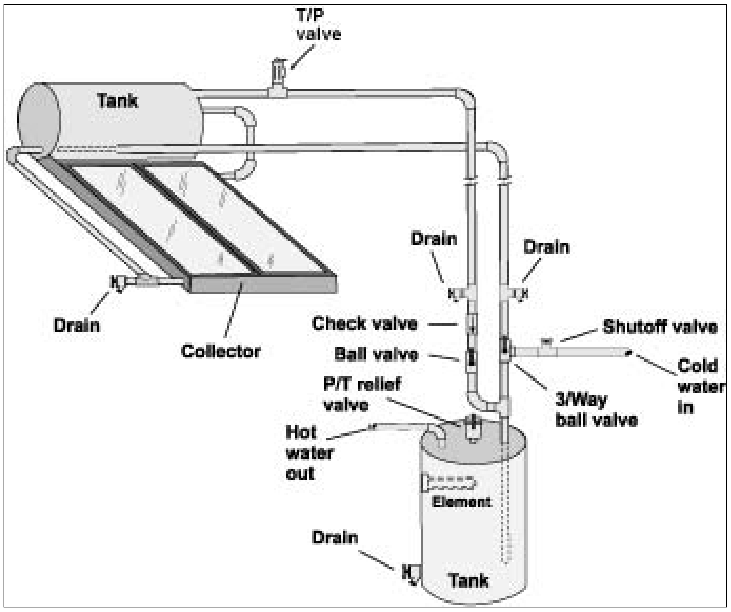


Figure 7: Thermosiphon System.
Source: (UCS, 2005).

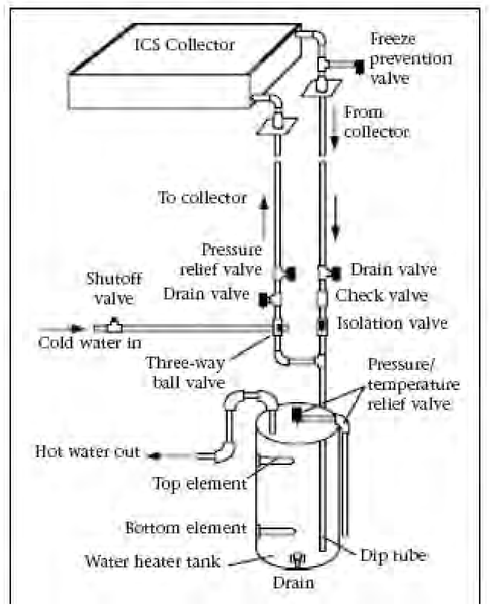


Figure 6: Integrated Collector Storage System.
Source: (Wise Home Design, 2013).

collectors. Therefore, the water that moves through the solar collector is the same water that is stored in the hot water tank. Because these systems do not use pumps, they are often considered simple and reliable (UCS, 2005).

For colder climates, indirect thermosiphon systems can be used. Thermosiphon systems generally involve two tanks and a solar thermal collector. In this system, potable water is pumped directly into a water tank located on the roof. The water stored in the tank then passes through the solar water heater and to the auxiliary tank, which is located at the ground level. Drawbacks of these systems include the weight of the tank/system and additional considerations of roof design.

ICS Systems are slightly different than thermosiphon systems. Instead of a tank and a solar thermal collector, the hot water storage system serves as the collector (UCS, 2005). This passive, direct system does not require pumps or controllers to move water. Heat transfer between the solar collector and the water drives the flow of water. As hot water is drawn from the top, cold replacement water flows through the bottom. When there is a demand for hot water, cold water flows into the collector, hot water flows to the hot water tank, and hot water that was stored in the tank is provided to meet the demand. To protect against freezing, these systems have a flush-type freeze protection valve near the collector. As temperature drops, the valve opens to allow a continual flow of warmer water through the system to prevent freezing. An illustration of this system is provided below. However, these systems are generally not used in colder climates because of low efficiencies.

2.4 ACTIVE SYSTEMS

"Active" solar thermal technologies use solar collectors to heat a fluid (usually water or antifreeze) and then a pump circulates that fluid. Active systems use electric pumps to circulate a heat-transfer fluid. Active systems are more expensive than passive systems but are also more efficient. Because the pumps in active systems use electricity, they will not function in a power outage unless there is a photovoltaic circulator or back-up generator.

2.4.1 Open-Loop Systems

Active systems are also characterized as open-loop (also called direct) or closed-loop (also called indirect). Open-loop systems circulate process or potable water through a collector and this water is then used directly for end-uses. These systems are most often used where freezing temperatures do not or rarely occur or where local water quality is not an issue. Since temperatures in the Delaware drop well below freezing numerous times each winter, open-loop systems are not appropriate for this area.

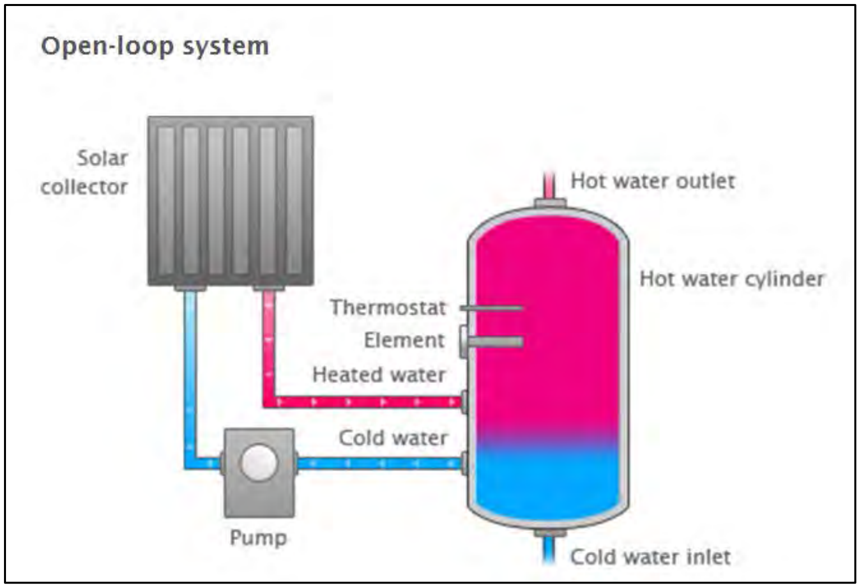


Figure 8: Open Loop Water Heating System.
Source: (Right House, 2013).

2.4.2 Closed-Loop Systems

Closed-loop systems pump a heat-transfer fluid through collectors. The heat-transfer fluid can be distilled water or a nontoxic glycol antifreeze solution, however, glycol antifreeze is a slightly less efficient heat-transfer fluid than water. Heat exchangers transfer the heat from the fluid to the intended end-use: water, air for space heating, or a refrigerant for solar absorption cooling. Double-walled heat exchangers prevent contamination of potable water.

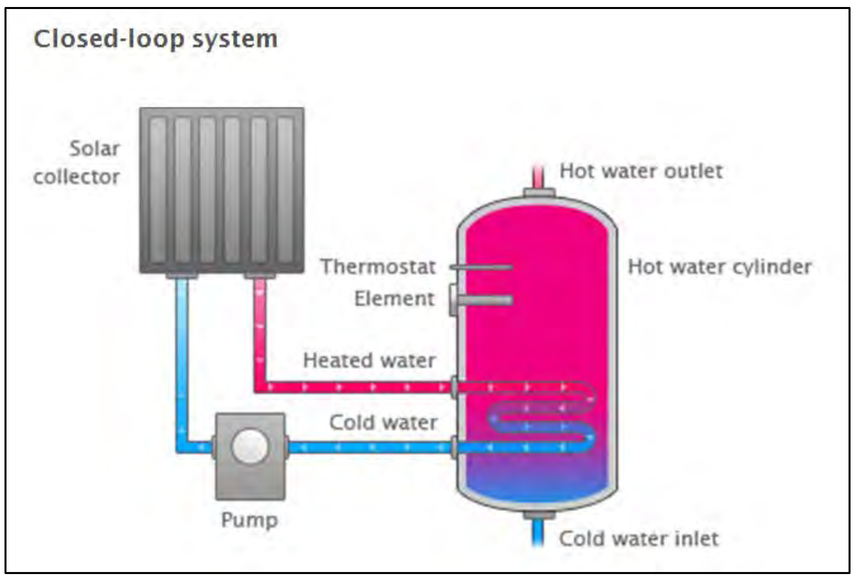


Figure 9: Closed Loop Water Heating System.
Source: (Right House, 2013).

Closed-loop systems are used in areas subject to sustained freezing temperatures because they provide good freeze protection. The two freeze-protection methods most appropriate for the climate of the Delaware are pressurized glycol systems and drainback systems. If a system is properly designed and installed according to the design, then either a glycol or drainback design would be an effective system for Delaware.

2.4.3 Glycol Antifreeze Systems

A nonionic water-glycol antifreeze solution circulates in this closed-loop system. Advantages of this type of system are that it offers excellent freeze protection, the sloping of collector fields is less critical, and pumps can usually be sized only for hydronic circulation, meaning smaller pumps, and less parasitic energy. Disadvantages of glycol systems include: lower heat transfer efficiency compared to drainback systems; the greater maintenance needed to monitor antifreeze quality – the stagnation of some antifreeze mixtures at high temperatures and exposure to air may cause the glycol to breakdown; and the glycol may need to be changed every few years.

2.4.4 Drainback Systems

This type of system uses a non-pressurized, closed loop that circulates a heat-transfer fluid. The fluid is forced through the collectors by a pump and then is drained by gravity to the storage tank and heat exchanger. When the pumps are off, the collectors are empty, thereby providing freeze-protection. The advantages of drainback systems include: excellent freeze protection when properly installed; an inexpensive and effective heat transfer fluid (water); and water generally is not in the collectors during stagnation so it is not lost and thus does not need to be changed as often as in other systems. Disadvantages of these systems are: the solar collectors and all piping exposed to weather must be located above the drainback tank; the collector and piping must be properly sloped; the collector field must be checked periodically for settling (i.e., poor drainage); the drainback tank must be sized and insulated sufficiently; and the pumps usually must be larger than for circulating loops meaning larger parasitic losses. However, in large systems in moderately freezing climates, these issues may be easier to address than in other situations.

2.5 SOLAR THERMAL APPLICATIONS

As mentioned above, the use of solar thermal energy to heat swimming pool water has been the predominate use of solar thermal energy in the U.S., in terms of number of installations. Although few in number, the large solar thermal electric generating plants using concentrating technologies that have been installed and are being installed in the U.S. Southwest and California will generate hundreds of MWs of electricity. Below is a brief overview of other applications of solar thermal.

2.5.1 Solar Hot Water Systems

Traditionally, the most well-known application of solar thermal energy is for the heating of domestic hot water for single family homes. Other applications of solar thermal to heat water include:

- Heating water for domestic use in hotels, motels, and apartments and other multi-tenant buildings.
- Heating water for large commercial users of hot water including restaurants, laundry mats, and breweries.
- Heating water for institutional facilities with large hot water usage including correctional facilities, hospitals, and schools.
- Pre-heating process water for industrial applications.

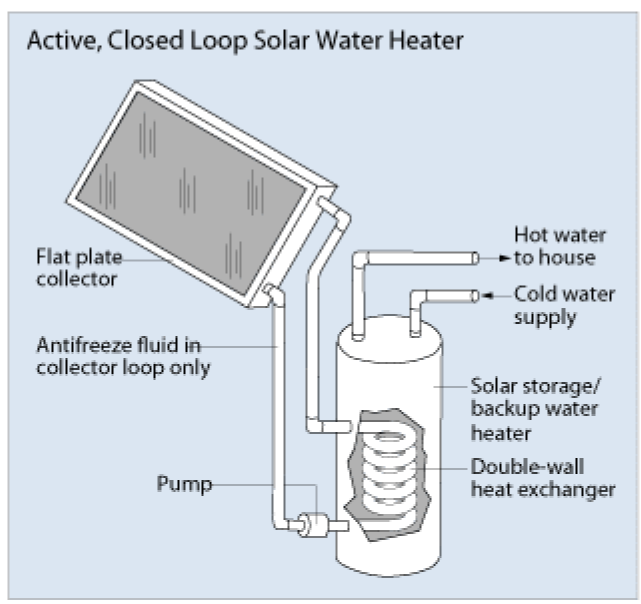


Figure 10: Active, Closed Loop Solar Water Heater.
Source: (U.S. DOE, 2013).

2.5.2 Solar Space Heating

Either water or air can be used as the circulating medium in a solar space heating system. In typical hot water space heating systems, the heated water gets pumped to radiators and heat is dispersed throughout the building. Solar heated water can also be used with heat exchangers for force air heating systems or for radiant floor heating as demonstrated below.

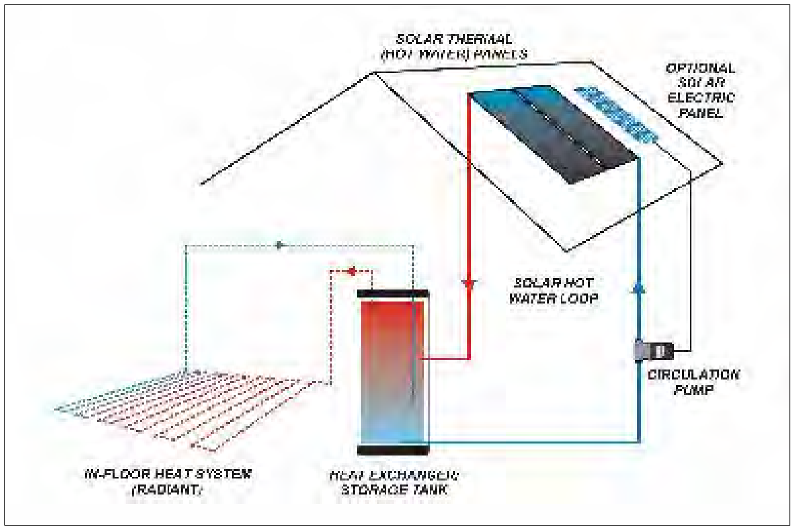


Figure 11: Liquid and Air Solar Thermal Systems.
Source: (Aladdin Solar Systems, 2013).

Solar thermal systems can also use air as the circulating “fluid”. Transpired air solar collectors consist of perforated dark metal plates with an air space between the building wall and the metal plate. Fans blow warmed air from the collector through the building’s duct system. A heat storage unit may be added to ensure ‘round the clock’ warming. Transpired air collectors can warm the air by as much as 40°F. A solar air heating system is shown in figure 12.

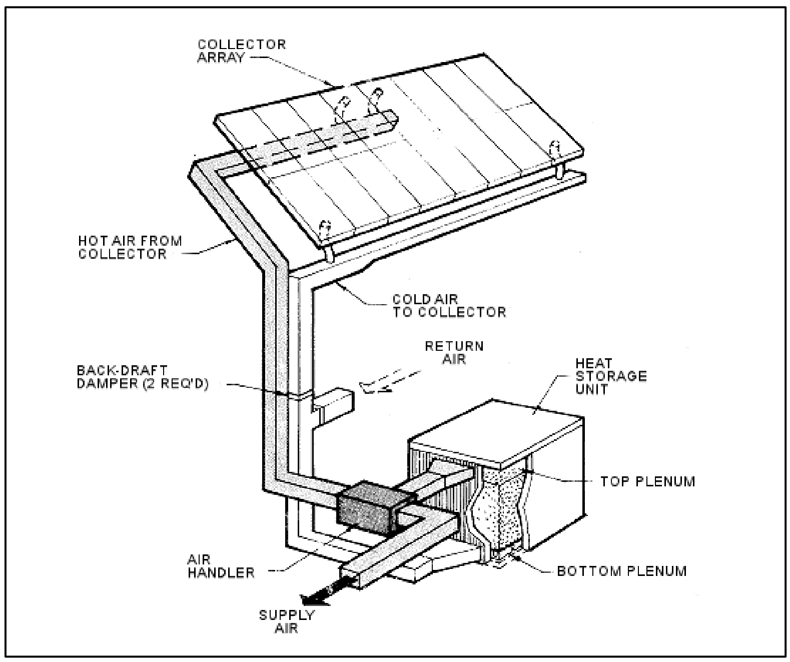


Figure 12: Solar Air Heating System.
Source: (Warmair, 2013).

2.5.3 Solar Cooling

While absorption cooling does not enjoy the widespread familiarity in the U.S. that vapor compression cooling does, absorption cooling is the first and oldest form of air conditioning and refrigeration. The technology is commonly used in large industrial facilities where waste process heat is available. In recent decades, small units (10 tons and up) have become commercially available.

An absorption air conditioner or refrigerator does not use an electric compressor to mechanically pressurize the refrigerant. Instead, the absorption device uses a heat source, such as natural gas or a solar collector array, to evaporate the already-pressurized refrigerant from an absorbent/refrigerant mixture. This takes place in a device called the vapor generator. Although absorption coolers require electricity for pumping the refrigerant, the amount is very small compared to that consumed by a compressor in a conventional electric air conditioner or refrigerator and is within the realm of possibility for solar electric pumps.

Where cooling is required, single-effect absorption chillers use solar thermal heat at approximately 190° to 200°F to provide process cooling at 45°F. Waste heat at about 85°F is either used elsewhere in the preheat process or is rejected to a cooling tower. The system provides the best cooling when it is needed most – when the sun is high and hot.

Solar absorption cooling may be able to compete with conventional cooling technologies, especially when time-of-use rates and peak-demand price spikes are taken into consideration. Single-effect absorption coolers are the best match for use with flat plate solar collectors. It is also possible to produce ice with a solar powered absorption device, which can be used for cooling or refrigeration. Although the potential market for solar cooling is large, high initial costs and more complex engineering than solar heating have limited the adoption of solar cooling (Warmair, 2013).

2.6 CONCLUSIONS

Overall, solar thermal technologies operate under a wide variety of temperatures and applications. Low temperature, medium temperature, and high temperature collectors have different attributes that make each type of technology more suitable for different applications. The next chapter covers the national cost and installation information within the U.S. The chapter, as does the rest of the report, focuses on low- and medium-temperature solar thermal collectors. A few states, such as California and Arizona, have subsections that detail high-temperature, concentrating solar thermal electric-generating systems. Because Delaware does not have the requirements for large-scale solar thermal electric plants — high insolation (most days are sunny), low humidity, and very large tracts of land — policies related to concentrating solar thermal technologies have not been evaluated in this report.

Chapter 3: Trends in Installations and Costs of Solar Thermal

Data on solar thermal is less robust than it is for other renewable energy technologies. For example, data on solar photovoltaic installations are reported in a direct energy measure — kW of capacity, which makes calculations of energy production fairly straightforward. Two solar photovoltaic installations of 5 kW, with the same orientation and tilt, on two houses next to each other, will produce the same amount of usable energy. Figuring out the production (or offset energy) of a solar thermal system is more complex than it is for a photovoltaic system. Installations of solar thermal collectors are reported in a non-energy measure of ft^2. The same two houses with identical-sized solar hot water systems, with one house occupied by a family of two and the other eight, will use significantly different amounts of energy from the solar hot water systems. Furthermore, the overall and temporal production will vary significantly in comparison of one ft^2 of a swimming pool collector, a flat plat collector, and an evacuated-tube collector.

Another issue in solar thermal data is that the U.S. EIA, a national authority on energy data, has stopped publishing new data on solar thermal and the last year for complete data is 2009. Other available sources for solar thermal data after 2009 are limited in scope and detail.

3.1 COSTS OF SOLAR THERMAL COLLECTORS

Solar thermal collector prices vary greatly due to the technology used, but tend to coincide the temperature classification, i.e., low temperature collectors cost the least and high temperature collectors cost the most. In Table 1, the prices of low-temperature and medium-temperature solar thermal collectors from 1986 to 2009 are shown. The prices for low-temperature collectors have hovered around \$2 per ft^2 since 1999 after generally being above \$2.50 per ft^2 in the pre-1999 years. The prices of medium-temperature collectors have risen since the mid-1990s and have hovered around \$20 per ft^2 since 1998.

Table 1: U.S. Solar Thermal Collector Total Average Price, 1986 to 2009.

Year	Low-Temperature Collectors (\$ per ft^2)	Medium- Temperature Collectors (\$ per ft^2)
1986	2.30	18.30
1987	2.18	13.50
1988	2.24	14.88
1989	2.60	11.74
1990	2.90	7.68
1991	2.90	11.94
1992	2.50	10.96
1993	2.80	11.74
1994	2.54	13.54
1995	2.32	10.48
1996	2.67	14.48
1997	2.60	15.17
1998	2.83	19.12
1999	2.08	W*
2000	2.09	W*
2001	2.15	W*
2002	1.97	W*
2003	2.08	19.30

2004	1.80	W*
2005	2.00	W*
2006	1.95	W*
2007	1.97	W*
2008	1.89	19.57
2009	1.94	22.32

Source: (U.S. EIA, 2012). *Prices were withheld (W) by U.S. EIA in some years due to concerns that revealing pricing data would yield proprietary company information.

Table 2 provides a more detailed look at the data for low-temperature and medium-temperature collectors 2008 and 2009. Unlike solar photovoltaic prices — which have declined greatly in the past ten years, the prices for the most commonly used medium-temperature collector — flat plates — have actually increased in recent years. This data suggests that prices for flat plate collectors will not experience the precipitous decline in prices experienced in the solar photovoltaic industry.

Table 2: Solar Thermal Collector Quantity: Revenue, and Average Price, 2008 and 2009.

	2008			**2009**		
Type	**Quantity (1,000 ft^2)**	**Revenue ($1,000s)**	**Average Price ($ per ft^2)**	**Quantity (1,000 ft^2)**	**Revenue ($1,000s)**	**Average Price ($ per ft^2)**
Total Low-Temperature	14,015	26,518	1.89	10,511	20,411	1.94
Liquid and Air	28	1,256	45.46	22	883	40.31
ICS/Thermosiphon	321	6,631	20.66	147	4,830	32.80
Flat Plate	1,842	32,043	17.40	1,783	34,642	19.43
Evacuated Tube	351	9,009	25.69	328	8,481	25.88
Concentrator	19	1,170	62.20	27	2,646	99.10
Total Medium-Temperature	**2,560**	**50,109**	**19.57**	**2,307**	**51,483**	**22.32**
U.S. Total	**16,575**	**76,627**	**4.62**	**12,818**	**71,894**	**5.61**

Source: (U.S. EIA, 2012).

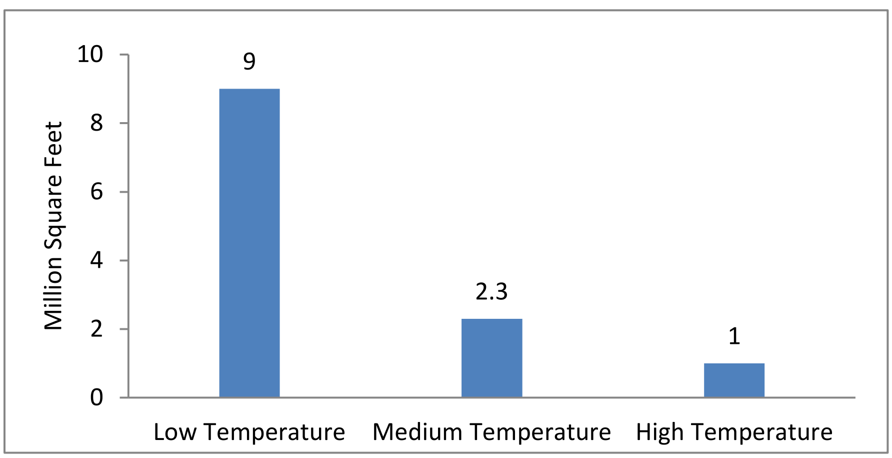


Figure 13: Solar Thermal Collector Domestic Shipments by Type, 2009.
Source: (U.S. EIA, 2012).

3.2 SHIPMENTS OF SOLAR THERMAL COLLECTORS IN THE U.S.

For the latest year with complete data from the U.S EIA (2009), domestic shipments of collectors were dominated by low-temperature collectors, which account for approximately 10.5 million ft^2 of shipments, or slightly more than 73% of the market. The primary use of low-temperature solar thermal collectors is to heat swimming pool water. Medium-temperature solar collectors account for approximately 2.3 million ft^2 of installations, which is roughly 19% of the market. The primary use of flat-plate collectors is to heat domestic water for homes. In 2009, the residential sector accounted for approximately 84% and commercial sector accounted for 8% of shipments in the U.S. (U.S. EIA, 2012).

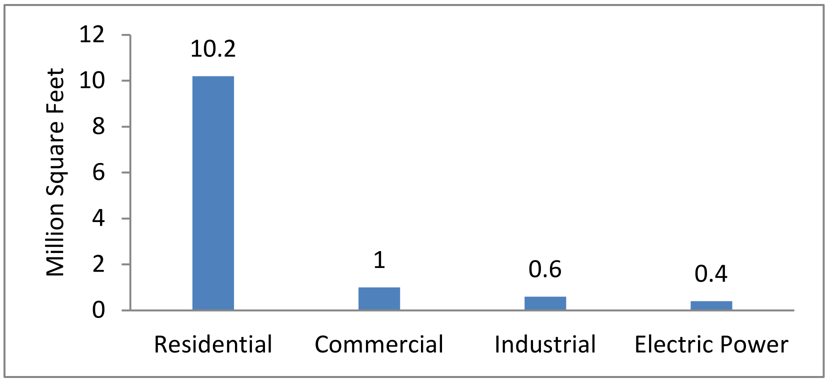


Figure 14: Solar Thermal Collector Domestic Shipments by Market Sector, 2009.
Source: (U.S. EIA, 2012).

From 2000 to 2007, low-temperature and medium-temperature domestic shipments rose steadily (U.S. EIA, 2001 to 2009). Starting in 2007, low-temperature shipments started declining because of the decline of the swimming pool and housing markets, which were impacted by the recession. Because the installation of low-temperature swimming pool collectors does not usually receive incentives by utilities or federal, state, or local governments, the market for swimming pool collectors can be directly impacted by declines in the general economy and housing market in particular. Applications using medium-temperature collectors have received incentives by the federal government (e.g., the 30% tax credit), and state and local governments. In contrast to the low-temperature swimming pool collector market, the impact of the recession and the down housing market had on the medium-temperature collector market was minimal, due, in part, to the incentives provided by federal, state, and local governments.

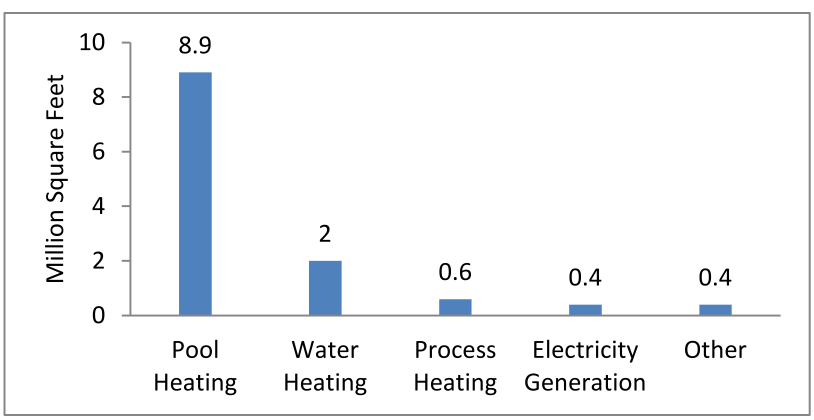


Figure 15: Solar Thermal Collector Domestic Shipments by End Use, 2009.
Source: (U.S. EIA, 2012).

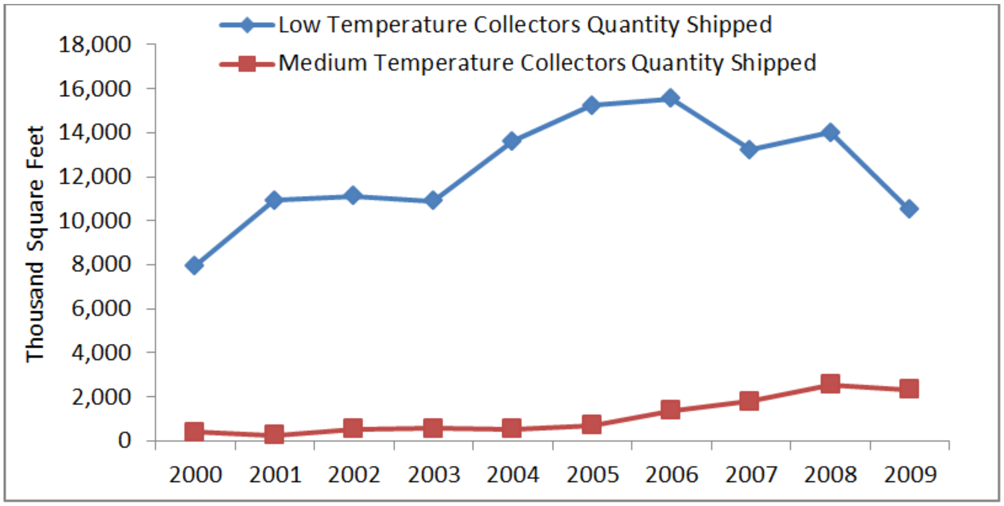
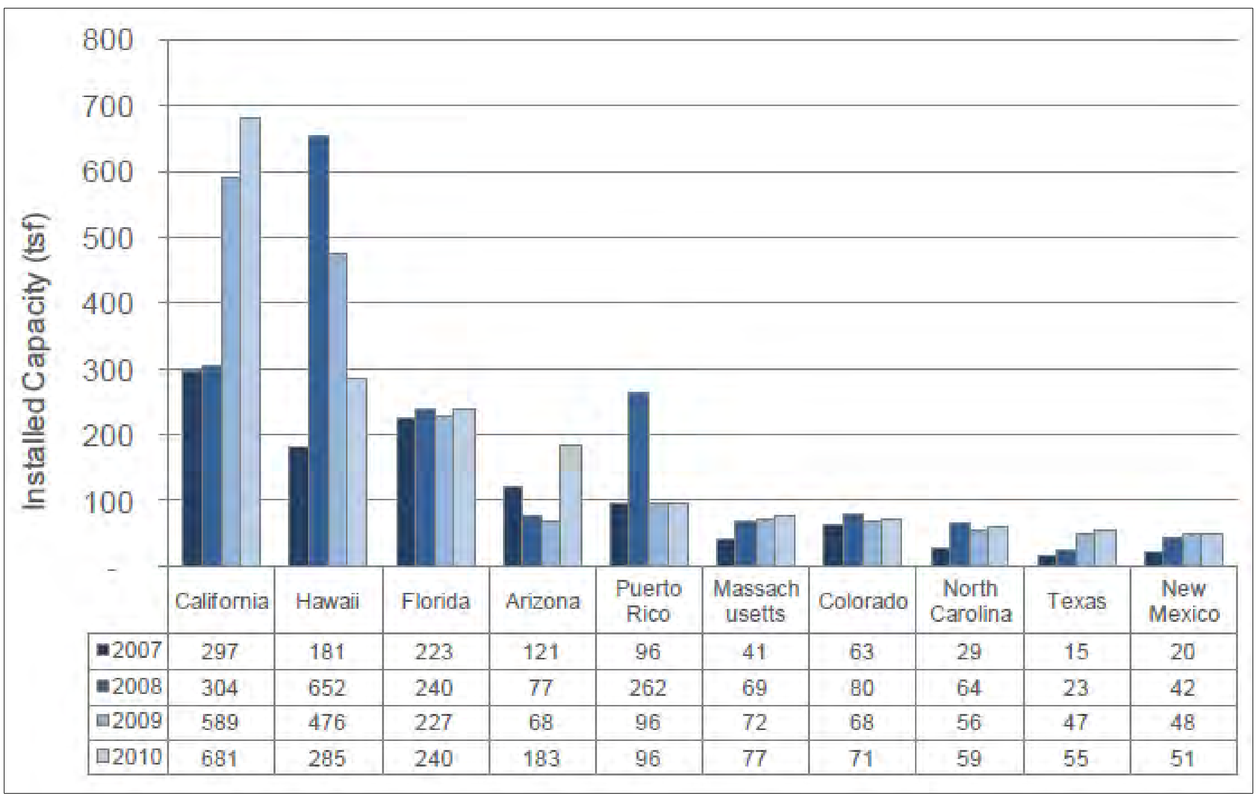


Figure 16: Domestic Solar Thermal Collector Shipments Year vs. Quantity Shipped.
Source: (U.S. EIA, 2012).



	California	Hawaii	Florida	Arizona	Puerto Rico	Massach usetts	Colorado	North Carolina	Texas	New Mexico
2007	297	181	223	121	96	41	63	29	15	20
2008	304	652	240	77	262	69	80	64	23	42
2009	589	476	227	68	96	72	68	56	47	48
2010	681	285	240	183	96	77	71	59	55	51

Figure 17: SWH collector area shipments between 2007 and 2010, SEIA-GTM (2011).
Source: (Hudson, et al., 2012).

The following chart includes the top ten states based on the ratio of the sum of solar shipments from 2002 to 2009 and the state population— in other words, ft^2 per capita. The states that have higher levels of solar insolation, such as Hawaii, Florida, Nevada, and Arizona, have high levels of solar thermal use. However, states with comparably lower levels of solar insolation, such as Oregon, Connecticut, and

Vermont, also have high ratios of solar thermal isolations (U.S. EIA, 2012). According to this analysis, Delaware ranks 16th in per-capita solar thermal installations.

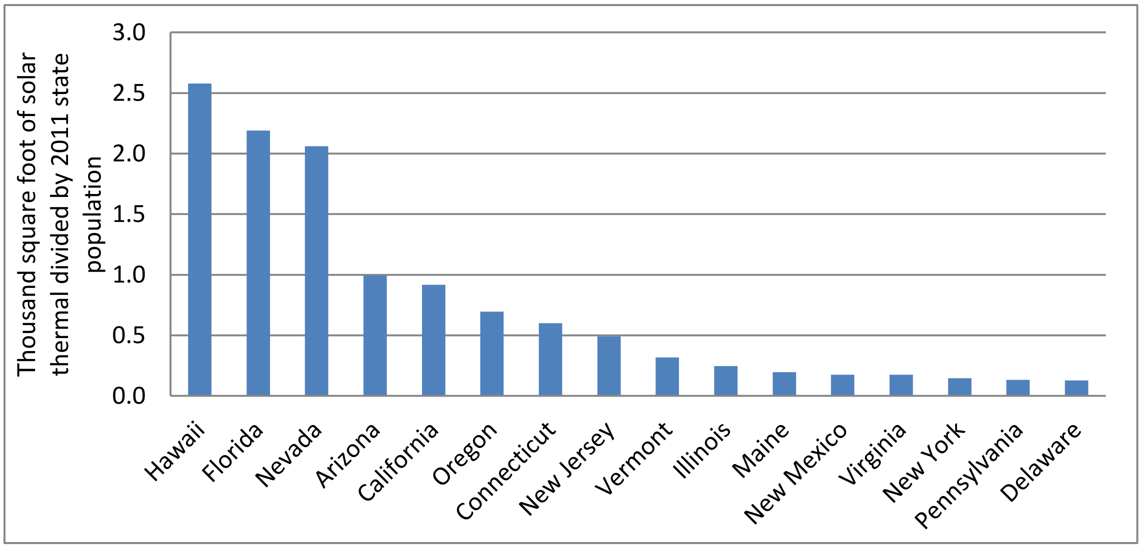


Figure 18: Per Capita Solar Thermal Shipment Destinations from 2002 to 2009.
Source: (U.S. EIA, 2012).

3.3 CONCLUSIONS

Hawaii, Florida, Nevada, Arizona, and California are leading the way in terms of receiving domestic shipments of solar thermal technologies. The high solar insolation resource of these states explains, in part, the higher per-capita shipments compared to other states. However, states with lesser solar resources, such as Connecticut, Vermont, and Illinois, are receiving more shipments of solar collectors on a per-capita basis than sunny states such as New Mexico and Utah. This suggests that other factors, besides a state's solar resource, have a large impact on the demand for solar collectors.

The following chapters provide additional information on the federal, state, and local policies that are driving investments into solar thermal and explore the policies of some of the states with the highest per-capita shipments of solar collectors.

Chapter 4: Federal Incentives and Policies Overview

The following describes the federal incentives and policies that are available or may have an impact on solar thermal installations in Delaware. The two 30% federal tax credits are the most important federal incentives, providing the biggest economic boost for solar thermal installations. For the commercial sector, the accelerated depreciation of MACRS is also an important incentive. Beyond these tax incentives, the other federal incentives have a de minimis impact on the solar thermal market in Delaware. Solar thermal swimming pool systems are not eligible for any of the following incentives.

4.1 FINANCIAL INCENTIVES

4.1.1 Business Energy Investment Tax Credit

This tax credit allows taxpayers to take a credit on their federal business taxes of up to 30% of the installation costs (i.e., equipment and labor) of a solar thermal system placed in service on or before December 31, 2016. Originating from Title 26, Section 48, of the United States Code (26 USC § 48), this tax credit was expanded and extended by the Energy Improvement and Extension Act of 2008 and the American Taxpayer Relief Act of 2012. After December 31, 2016, the 30% tax credit will revert to 10%.

4.1.2 Residential Renewable Energy Tax Credit

This tax credit allows taxpayers to take a credit on their federal personal taxes of up to 30% of the installation costs (i.e., equipment and labor) of a solar thermal system placed in service on or before December 31, 2016. To be eligible for the credit, the solar thermal system must generate at least 50% of the heated water used in the residence and must be certified by the Solar Rating and Certification Corporation or comparable organization. This tax credit was established by EPAct (26 USC § 25D) and expanded and extended by the Energy Improvement and Extension Act of 2008 and the American Recovery and Reinvestment Act of 2009. After December 31, 2016, the 30% tax credit will expire under current law.

4.1.3 Modified Accelerated Cost-Recovery System (MACRS)

Businesses can use the Modified Accelerated Cost-Recovery System (MACRS) to recover investments in solar thermal property through accelerated depreciation deductions. Solar thermal equipment is classified as having a 5-year property life (26 USC § 168(e)(3)(B)(vi)). The Economic Stimulus Act of 2008 included a 50% first-year bonus depreciation (26 USC § 168(k)) and this provision has since been extended and modified several times, most recently in January 2013 by the American Taxpayer Relief Act of 2012. To receive the bonus depreciation, installations must be placed in service by December 31, 2013.

4.1.4 Energy Conservation Subsidy Exclusion

Under Title 26, Section 136 of the U.S. Code, direct subsidies from public utilities to consumers (both residential and non-residential) for energy conservation measures (the definition of this term implies that solar-thermal systems are an “energy conservation measure”) may be eligible to be excluded from taxable income on a taxpayer’s federal tax return. According to the Internal Revenue Service’s (IRS) Publication 525, other types of utility subsidies, that may come in the form of credits or reduced rates, might also be eligible for this exclusion (IRS, 2013).

4.1.5 USDA High Energy Cost Grant Program

The U.S. Department of Agriculture (USDA) offers a grant program to rural communities for energy generation, transmission and distribution facilities. Within the community, the average home energy costs must be 275% above the national average in order to qualify. Applicable technologies include solar thermal applications, energy efficiency/weatherization installations, and improved generation, transmission, and distribution facilities. In 2012, $7 million in grants was awarded in competitive funding (USDA, 2013).

4.1.6 Renewable Energy System and Energy Efficiency Improvement Grant Program

The Food, Conservation, and Energy Act of 2008 created USDA's Rural Energy for America Program (REAP) which provides grants, loans, and technical assistance to agricultural producers and rural small businesses. The Act mandates allocations up to $70 million and up to $25 million in discretionary funding each year. The American Taxpayer Relief Act of 2012 extended discretionary funding for Fiscal Year 2013. Under REAP's umbrella, the Renewable Energy System and Energy Efficiency Improvement Grant program provides grants to help agricultural producers and rural businesses reduce energy costs and develop rural renewable energy supplies, including small- and large-scale solar power and thermal systems. The USDA issues periodic competitive solicitations and the grant solicitation for 2013 offered grants for renewable energy between $2,500 and $500,000 (up to 25% of eligible project costs (USDA, 2013).

4.1.7 Renewable Energy System and Energy Efficiency Improvement Guaranteed Loan Program

Under USDA's REAP umbrella (see above), the Renewable Energy System and Energy Efficiency Improvement Guaranteed Loan Program offers loan guarantees to support rural renewable energy development, including small- and large-scale solar power and thermal systems. The maximum amount of a loan is $25 million and the minimum is $5,000. Up to 75% of total eligible project costs can be covered through this program (USDA, 2013).

4.1.8 Energy Efficient Mortgage Program

The Energy Efficient Mortgage (EEM) program provides for two types of mortgages that credits a home's energy efficiency in the mortgage. An energy improvement mortgage finances the energy upgrades of an existing home in the mortgage loan using monthly energy savings from the improvements. An energy efficient mortgage uses the energy savings from a new energy efficient home to increase the home buying power of consumers and capitalizes the energy savings in the appraisal. This type of mortgage could allow a home buyer to buy a higher quality home because of the lower monthly costs of heating and cooling the home. Solar thermal systems are considered an energy efficiency improvement. Fannie Mae, Freddie Mac, the Federal Housing Administration, and the Veteran's Administration have adopted special underwriting guidelines for energy efficiency mortgages. Energy Star rated homes are also often marketed with energy efficient mortgages (Resnet, 2013).

4.2 RULES AND REGULATIONS

4.2.1 Federal Energy Management Program

EPAct established federal energy efficiency and conservation goals for all existing and new federal buildings and campuses. These goals or standards were extended by the Energy Independence and Security Act of 2007 and other statutes since then have enhanced or extended various targets for federal building energy performance, including the target of new or existing federal buildings undergoing major renovations to meet at least 30% of hot water demand with solar equipment. Executive Order 13423 reinforced renewable energy standards for buildings and allowed non-electric renewables, such as solar thermal systems, to count towards renewable energy targets (U.S. DOE, 2011).

4.2.2 Energy Star for Solar Hot Water Heaters

The Energy Star program recently adopted standards for solar hot water heaters. These products must meet minimum requirements for energy efficiency, hot water delivery, warranty period, and safety (Energy Star, 2013).

Chapter 5: Case Studies

Ten states were chosen for case study based on three criteria — the perceived strength and variety of solar thermal policies, the resulting impacts of the policies, and regional diversity, including states in the Northeast that have policies and a climate similar to Delaware's. The analysis in each case study is broken down into two sections — "Financial Incentives" and "Rules and Regulations." Financial Incentives include policies such as tax incentives, initial capital incentives, loans, and rebates. Rules and Regulations include policies such as building standards, access guidelines, mandates, and renewable portfolio standards.

5.1 ARIZONA

With a population of 6.5 million, a total area of 113,990 square miles, high solar insolation throughout almost the entire state, average solar irradiation of 5.5 kWh/m2/day (Marion & Wilcox, 1994), three of the top five sunniest cities in the U.S., an average of 321 days of sunshine (National Oceanic and Atmospheric Administration (NOAA), 2013), Arizona has perhaps the greatest potential for installation of solar thermal systems in the nation.

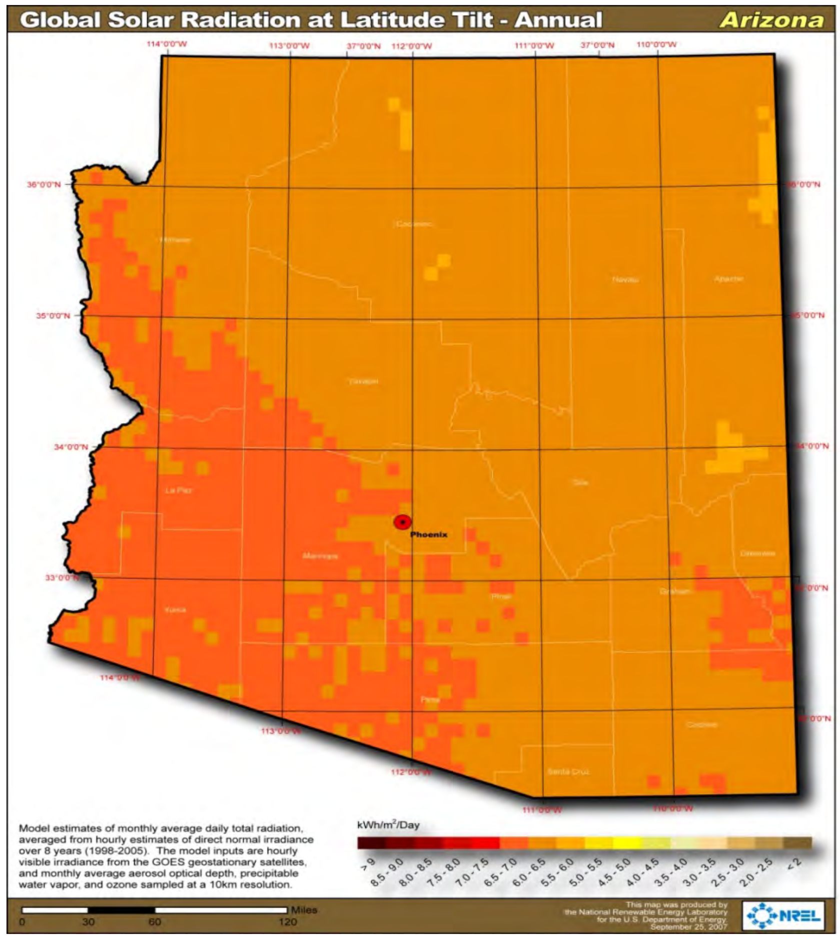


Figure 19: Arizona Annual Solar Radiation at Latitude.
Source: (NREL, 2013).

5.1.1 Financial Incentives

Residential Solar Tax Credit

In effect since 1995, taxpayers who install solar water heating, solar space heating, or solar cooling systems at their residence are allowed to take a tax credit in the amount of 25% of the cost of the installation, with the credit capped at $1,000 (A.R.S. § 43-1083 and State of Arizona, 2012).

Non-Residential Solar Tax Credit

In effect since 2006, taxpayers who install a solar water heating, solar space heating, solar thermal process heating, and solar cooling system on a business are allowed to take a tax credit, applied against corporate or personal taxes, up to 10% of the installed cost of a system. The maximum credit per taxpayer is $25,000 per installation and $50,000 in total credits in any year. The Arizona Commerce Authority (ACA) may certify tax credits up to a total of $1 million each calendar year. A solar thermal installation can only receive a credit for the year in which the system was placed into service. Once the

ACA certifies $1 million in tax credits, no more credits are available for that year and systems will are not eligible for a credit in the next year (A.R.S. §43-1085).

Renewable Energy Production Tax Credit

Arizona provides a tax credit which can be earned by producing energy from renewable energy systems with at least 5 MW of generating capacity. This credit, which can be earned for 10 years from the start date of the generating plant regardless of ownership changes, is for: $0.04/kWh for the first two years of production; $0.0035/kWh for years 3 to 4; $0.03/kWh for years 5 to 6; $0.02/kWh for years 7 to 8, and $0.01/kWh for years 9 to 10. The maximum tax credit which can be claimed for a single system in a calendar year is $2 million, with an aggregate maximum of $20 million for a single calendar year (A.R.S. § 43-1083.02 and State of Arizona, 2013).

Energy Equipment Property Tax Exemption

Arizona provides a property tax exemption for solar energy equipment which produces solar energy primarily for on-site consumption. The assessment considers the solar energy system to have no added value to the property for tax purposes (A.R.S. §42-11054).

Solar Equipment Sales Tax Exemption

Arizona provides a state sales tax exemption (local sales taxes may still apply) for solar energy devices and their installation. In 2012, Arizona extended this exemption to the sale or transfer of Renewable Energy Credits (RECs) or "any other unit created to track energy derived from renewable energy resources" (A.R.S. § 42-5061, A.R.S. § 42-5075, A.R.S. § 42-5063, A.R.S. § 42-5159, and Arizona Solar Center, 2013).

Utility Incentives

Arizona's utility companies offer rebates and production incentives for solar thermal energy. For 2013, Arizona Public Service (APS), the state's largest utility offered rebates and production incentives to residential (solar water heating, $0.40/kWh-displaced and solar space heating, $0.50/kWh-displaced) and commercial (small solar water heating systems, $0.68/kWh savings; large solar water heating systems, $0.41/kWh ; solar pool heating, $0.09/kWh displaced; solar process/space cooling, $0.90/kWh displaced, solar and process/space heating, $0.41/kWh displaced) customers who install solar thermal systems. These incentives provide APS with RECs associated with the energy generated by the systems that receive an incentive. After providing about $800,000 for incentives for solar thermal in 2013, in September, the funding was depleted and funding for 2014 is pending a decision by the Arizona Corporate Commission. Other utilities offer similar up-front incentives, with various maximums, based on their system size or first-year energy estimated generation. Like APS, the incentive is provided with a requirement that the customer signs an agreement assigning RECs to the utility for period up to 20 years. Utility incentives include: rebate of $0.75/kWh provided by Duncan Valley Electric Cooperative and Mohave Electric Cooperative; $0.50/kWh provided by Sulphur Springs Valley EC; $0.40/kWh provided by UniSource Energy Services and Tucson Electric Power; and a rebate of $0.35/kWh provided by Salt River Project (SRP) (DSIRE, 2013).

5.1.2 Rules and Regulations

Solar Equipment Certification

Components of solar thermal systems including collectors, heat exchangers, and storage units sold or installed in Arizona must have a warranty of at least two years after the installation of these systems (A.R.S. § 44-1762).

Solar Construction Permitting Standard

Arizona prohibits a county or municipality from requiring a stamp from a professional engineer for a solar thermal installation. In addition, any building or permit fee assessed by a county or municipality for solar construction must be directly attributable to and defray the cost of issuing the building or permit fee (A.R.S. § 11-323 and A.R.S. § 11-323).

Design Standards for State Buildings

New state building projects over 6,000 ft^2 are required to include an evaluation of certain solar energy features including site orientation, utilization of active and passive solar energy for space heating, and utilization of solar water heating (ARS § 34-452).

Renewable Energy Standard

Arizona's renewable portfolio standard (RPS), called the Renewable Energy Standard, requires at least 15% of the energy sold by utilities to be produced from renewable energy resources by 2025. Eligible technologies include solar thermal. Starting in 2013, at least 30% of the requirement must be met with distributed energy generation and 50% of this requirement must come from residential applications and the remaining 50% from nonresidential, non-utility applications. For renewable energy systems that produce heat, each 3,415 British Thermal Units (BTUs) produced by such a system equals one REC and each REC is a bundled package of three elements: the kWh; the renewable attributes; and any environmental attributes (Arizona Corporation Commission, 2013).

5.1.3 Impacts of Policies

Arizona has strong tax-based incentives for solar thermal. Arizona's RPS allows distributed solar thermal technologies including solar thermal heating, cooling, and industrial process heat to meet the requirement of its RPS. The distributed energy carve-out in the RPS has led to the development of rebates and upfront REC payments by the state's utilities – a development unlikely without the carve-out. These policies have led to a robust solar thermal market in Arizona — as noted in Section 3.2 above, Arizona is ranked 4th in per capita installation of solar thermal. However, in 2013, the Arizona Corporation Commission has been more hostile to solar and has made decisions detrimental to solar (Wichner, 2013).

5.2 CALIFORNIA

California has strong solar resources, with most cities having between 150 and 200 clear days each year.

5.2.1 Financial Incentives

Property Tax Exclusion for Solar Energy Systems

California law, which expires on December 31, 2016, allows for a property tax exclusion for solar hot water, solar space heat, and solar thermal process heat for 100% of the system's value. Additional equipment and system components such as storage devices, conditioning and transfer equipment, pipes and ducts are eligible for property tax exclusion, up to 75% of their cash value (California State Board of Equalization, 2013 and Cal Rev & Tax Code § 73).

PACE Financing

Property-Assessed Clean Energy (PACE) financing is a concept born and bred in California. PACE programs finance investments in renewable energy, energy efficiency or water conservation improvements on a property by attaching loans to a property rather than to a property owner, often in the form of an additional line on property tax bills. PACE loans can be preferable to traditional loans because they ease credit risks and allow a more equitable share of costs between property owners and tenants. The loans can be repaid over a period from 5 to 20 years, depending on the size of the project. If a property owner sells his or her property, the owner forfeits ownership of the financed system, which is transferred to the party that purchases the property. There are currently six local governments that administer their own programs, two programs that operate statewide and administer various local governments' programs. Solar thermal technologies are eligible for all currently operating PACE programs in California. California law also allows PACE loans to finance projects with solar leases and power purchase agreements (DSIRE, 2013).

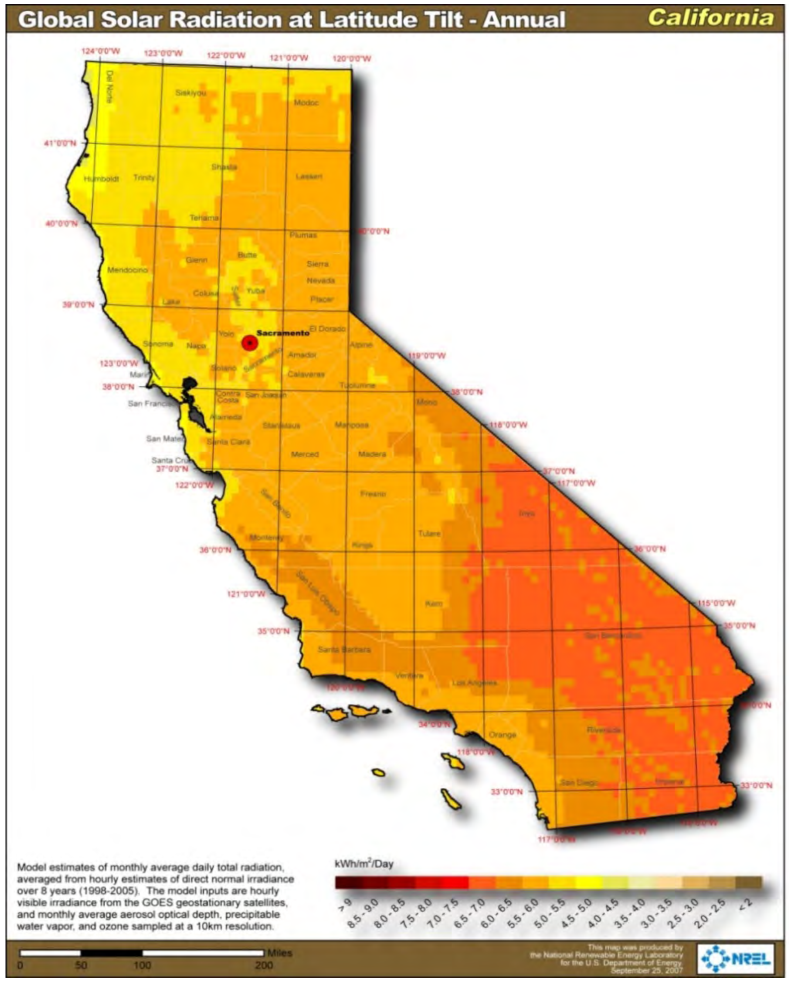


Figure 20: California Annual Solar Radiation at Latitude.
Source: (NREL, 2013).

California Solar Initiative Thermal Program

The California Solar Initiative (CSI), a result of legislation (CA Public Utilities Code § 2860, et seq.) passed in 2006, is administered by the CPUC. With lessons learned from a 30-month pilot program administered by the California Center for Sustainable Energy in San Diego Gas and Electric's (SDG&E) territory, the CPUC launched the CSI Thermal Program in 2010. Funded from a charge on the distribution rates of the state's major investor-owned electric and gas utilities — Pacific Gas and Electric (PG&E), Southern California Edison (SCE), Southern California Gas Company (SCGC) and SDG&E — the CPUC has allocated over $350 million through 2017 to the CSI Thermal Program. Of this allocation, $250 million is reserved for technologies that will displace natural gas usage and $100 million is set aside for technologies that will displace electricity usage. The goal of the CSI Thermal Program is to reduce the initial capital cost of solar thermal systems, accomplished through the provision of rebates to the customers of PG&E, SCE, SCGC and SDG&E. The following tables provide the upfront incentive or rebate amounts and the step down parameters.

Table 3: CSI-Thermal Incentive Step Tables

Natural-Gas Displacing Systems

Step	Incentive for Average Residential System	Funding Amount	Incentive Per Therm Displaced	Therms Displaced Over System Life
1	$2,175	$50,000,000	$18.59	97,500,000
2	$1,535	$45,000,000	$13.11	109,687,500
3	$900	$45,000,000	$7.69	146,250,000
4	$380	$40,000,000	$3.23	212,727,275
Total		$180,000,000		566,164,775

Electricity-Displacing Systems

Step	Single-Family Incentive ($/kWh)	Incentive for Average Residential System	kWhSavings
1	$0.54	$1,467	2,730
2	$0.38	$1,048	2.733
3	$0.22	$602	2,727
4	$0.10	$263	2,714

Systems Eligible for Low-Income Incentive

Step	Single-Family Low-Income Per Therm	Incentive Cap for Single-Family Low-Income Projects	Multifamily Low-Income Incentive Per Therm Displaced	Incentive Cap for Multifamily Low-Income Projects
1	$25.64	$3,750	$19.23	$500,000
2	$20.52	$3,000	$15.39	$500,000
3	$15.38	$2,2500	$11.53	$500,000
4	$9.40	$1,376	$7.05	$500,000

Source: (CPUC, 2013).

Incentives for electric-displacing systems are lower than natural gas-displacing systems because electric-displacing systems are more cost-effective. Step downs for electric-displacing systems are triggered by step changes for natural-gas displacing systems. In 2012, the CPUC established a low-income residential incentive program that provides increased rebate levels for low-income residences. The CSI Solar Thermal Program also allocates funds for training, marketing, and research. The following table breaks down the CSI Solar Thermal Program allocation (CPUC, 2013).

Table 4: CSI-Thermal Program Elements

CSI-Thermal Program Elements	Sub-Elements	Gas-displacing Budget	Electric-displacing Budget
Incentives	General Market Incentive	$180 million	$100.8 million
	Low-income Incentive (10% of total)	$25 million	-
	Subtotal	***$205 million***	***$100.8 million***
Market Facilitation	Marketing & Outreach	$25 million	$6.25 million
	Subtotal	***$25 million***	***$6.25 million***
Program Administration	General Administration	$15 million	Subject to CSI
	Measurement & Evaluation	$5 million	$1.25million
	Subtotal	***$20 million***	***$1.25 million***
Total		**$250 million**	**$108.3 million**

Source: (CPUC, 2013),

Municipal Utilities Incentives

Burbank Water and Power provides $1,500 rebates for the purchase of solar water heaters. The City of Palo Alto Utilities offers upfront performance-based incentives for residential, commercial and industrial customers who install solar water heating systems with caps of $2,719 for residential gas-displacing systems, $1,834 for residential electricity or propane-displacing systems, and $100,000 for commercial installations. The Redding Electric Utility offers rebates for solar water heating of 50% of cost of panel, up to $1,000 for 1st panel, up to $500 for 2nd panel, and up to $250 for 3rd panel. The Sacramento Municipal Utility District's (SMUD) Solar Domestic Hot Water Program provides rebates, to customers who install solar water heating systems, dependent on how much electricity the system will offset annually: 800 to 1,399 kWh, $500; 1,400 to 2,199 kWh, $1,000; and 2,200 kWh or greater, $1,500. SMUD also operates the Residential Loan Program that provides 100% financing to customers who install solar water heating systems, installed by a SMUD-approved solar water heating contractor (DSIRE, 2013). The Santa Clara Water & Sewer Utilities (SCW&SEU) supplies, installs, and maintains solar water heating systems for its residents and businesses. Under Solar Water Heating Program, the hardware (solar collectors, controls and storage tanks) is owned and maintained by the SCW&SU under a rental agreement. The renter pays an initial installation fee and a monthly utility fee. There is a monthly service charge for all systems based on the number of panels (Santa Clara City Solar Utility, 2013).

5.2.2 Rules and Regulations

California Solar Contractor Licensing

California's Contractors State License Board (CSLB) issues licenses for different classifications of contractors in the state. The CSLB issues a solar specific contractor license, under the specialty contractor classification C-46. Solar contractors are defined as those who "install, modify, maintain and repair thermal and photovoltaic solar energy systems" (CSLB, 2013). Solar contractor licensees are not certified to conduct other types of contractor work except when that work involves installation of a solar energy system. However, due to the growing number of solar projects, the CSLB has identified other classifications that qualify to perform such projects. The following table lists license classifications.

Table 5: Classification Code of California

Classification Code	Classification Title	Description
A	General Engineering	Authorized to perform active solar energy projects
B	General Building	Authorized to perform active solar energy projects with definition of B&P Code Section 7057
C-4	Boiler, Hot-water Heating, and Steam Fitting	Authorized to perform projects that include solar heating equipment associated with systems authorized by this classification
C-36	Plumbing	Authorized to perform any project using solar equipment to heat water or fluids
C-46	Solar	Authorized to install, modify, maintain and repair thermal and photovoltaic solar energy systems
C-53	Swimming Pool	Authorized to include the installation of solar heating in swimming pool projects

Source: (Contractors State License Board, 2013).

California Green Building Action Plan for State Facilities

In 2007, a law was enacted mandating all state facilities are required to install solar water heaters where such an installation is determined to be cost-effective (CA Government Code § 14684.1)

5.2.3 Impact of Policies

California has a well-earned reputation for developing effective programs help bring down the costs of renewable energy. While California boasts some of the largest absolute shipments and installations of solar thermal in the nation, California is only fifth overall per-capita (U.S. EIA, 2012). However, the CSI-Thermal Program should expand the deployment of solar thermal technologies with its large injection of rebate funding. As of July 2013, the Program has provided 1,215 rebates totaling $56.3 million in three years of operation. However, the CPUC has characterized participation in this program as "slow". The CPUC's CSI Annual Program Assessment cites low natural gas prices that have made the economics of solar thermal projects displacing natural gas as less economic, especially for residential customers, as the reason for the "slow" participation. On the other hand, the demand by customers displacing electric-solar thermal systems has been high as has the demand for rebates for the CSI-Thermal Low Income Program.

5.3 CONNECTICUT

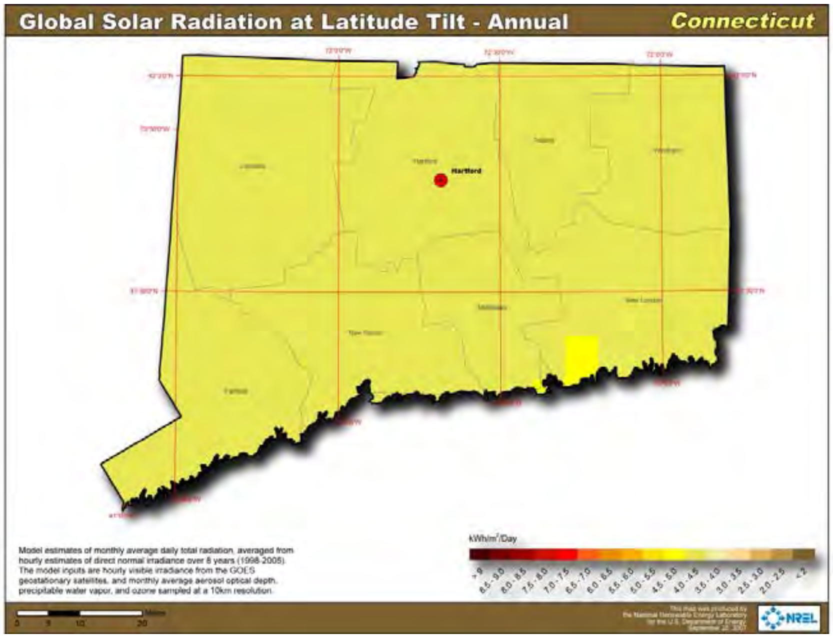


Figure 21: Connecticut Annual Solar Radiation at Latitude.
Source: (NREL, 2013).

In comparison to Arizona and California, Connecticut, has just a fair solar resource — Hartford experiences 321 cloudy or partly cloudy days per year. However, Connecticut has had a history of supporting renewable energy and recently created the Clean Energy Finance and Investment Authority (CEFIA), self-described as the nation's first full-scale clean energy finance authority. CEFIA is funded by a variety of sources including a surcharge on residential and commercial utility bills, federal funds, private investment, and auction proceeds from the Regional Greenhouse Gas Initiative. Like Delaware's Sustainable Energy Utility, CEFIA can issue bonds, has the flexibility to change or establish renewable programs on an as-needed basis, and operates its programs under the banner of "Energize CT".

5.3.1 Financial Incentives

Sales and Use Taxes Exemption

The full cost of the installation (including labor) of active solar water or space heating systems are exempt from sales and use taxes (Conn. Gen. Stat. § 12-412 and Connecticut Department of Revenue Services, 2013).

Property Tax Exemption

Active solar water or space heating systems installed residences on or after October 1, 2007 are exempt from property taxes. Beginning in October 2014, commercial and industrial systems are also eligible for this property tax exemption (Conn. Gen. Stat. § 12-81 (57) et seq.).

Commercial Solar Hot Water Incentive Program

CEFIA's Commercial Solar Hot Water Incentive Program is a competitive program for customers of Connecticut Light & Power or United Illuminating that funds solar thermal hot water projects for commercial properties with a total allocation of $2,000,000. The program awards grants or low-cost financing through a five round request-for-proposal process. While there are no pre-determined grant and loan terms as CEFIA decides to fund the projects based on project economics, there are grant limits (e.g., $60/ft2 of collector and 50% of gross project cost) and loan parameters (e.g., limit of 80% of net system cost and an interest rate of 2% to 6%). The fifth and final round ended on March 15, 2013 (CEFIA, 2013).

Solar Loan and Lease Programs

Energize CT's Smart-E Loan Program offers financing up to 80% of the total cost of the installation of solar water heating systems on homes with loan terms of 5 to 12 years with interest rates of 4.4.9% to 6.99%. Participants are required to use pre-approved lenders and contractors. Similarly, Energize CT's CT Solar Lease Program offers no money-down leases for the installation of solar water heating systems on homes, using pre-approved contractors (Energize CT, 2013).

Energy Conservation Loan Program

Established in 1979 and administered by the Connecticut Housing Investment Fund, Inc. (CHIF), the Energy Conservation Loan (ECL) program provides low interest loans to homeowner below specified household incomes. Loans are provided for terms up to ten years and interest rates are determined by the applicant's current income and the type of improvement. Loan awards are capped at $25,000 for single family dwellings, $2,000 per unit up to $60,000 per building multi-family dwellings. The loans are financed using sales of state bonds and the low interest rate schedules are subsidized by the major state utilities (C.G.S. 16a-40b and CHIF, 2013).

Clean Energy On-Bill Financing

Required by a law enacted in 2013, the Energy Conservation Management Board and the Clean Energy Finance and Investment Authority (CEFIA) must consult with electric distribution companies and gas companies to develop a residential clean energy on-bill repayment program by April 1, 2014. The program will be financed by third-party, private capital and managed by CEFIA. The program will prioritize projects by cost-effectiveness, and the repayment term of any project cannot exceed the expected life of the improvements. (Public Act No. 13-298).

PACE — Residential Sustainable Energy Program

This PACE financing program was authorized by the law in 2011. Like PACE programs in other states, loans to homeowners to install renewable energy equipment is repaid on property tax bills. Municipalities must first declare and demonstrate a need for a PACE loan program before they are legally permitted to establish one (Conn. Gen. Stat. § 7-121n). As in most other states with residential PACE, implementation of this residential PACE program has been suspended due to an adverse statement from the Federal Housing Financing Agency (FHFA).

C-PACE Financing

Commercial PACE or "C-PACE" financing program was established in 2012. C-PACE allows non-residential building owners to finance qualifying clean energy improvements (including solar thermal) by placing a voluntary assessment on their property tax bill to repay a loan over a period up to 20 years. If the property is sold, the repayment obligation transfers to the next owner. Participants are required to use pre-approved lenders and contractors (Energize CT, 2013b).

5.3.2 Rules and Regulations

Solar Contractor Licensing

The Connecticut Department of Consumer Protection (CDCP) requires special contractor licensing in order to perform dedicated solar thermal work. As directed by the Connecticut's regulations for state agencies in *Title 20*, which covers professional licenses, the CDCP is to issue one of two licenses: ST-1 or ST-2. ST-1 certifies solar thermal contractors to perform solar thermal work in the "installation, erection, repair, replacement, alteration, or maintenance of active, passive, or hybrid" solar thermal systems. The ST-2 license certifies a contractor as a solar thermal limited journeyperson, who can only perform work while employed by a contractor holding an ST-1 license. The CDCP is authorized to issue a solar thermal work "certificate" to any person who holds a Plumbing & Piping License (P-1, P-2, P-3, P-4), or Heating, Piping & Cooling License (S-1, S-2, S-3, S-4) as long as that person has also completed an approved solar thermal installation training course and has passed an approved solar thermal work exam (Conn. Gen. Stat. § 20-330 et seq. and CDCP, 2013).

5.3.3 Impacts of Policies

In 2008 and 2009, Connecticut was among the leading states nationwide in terms of total shipments of collectors by square foot and installations per-capita, over 428,000 ft^2 of collectors and an average of 0.059 ft^2 per-capita per year. The fourth round of the Commercial Solar Hot Water program allocated $576,029 in funds to seven different projects. A total of 11,723.6 ft^2 of solar thermal collectors were installed, with the largest individual projects being two that installed 3,624.6 ft^2 each. The fourth round was the largest fund disbursement of any round. Since 2009, the commercial program has funded the installation of 41,704 ft^2 of collectors (CEFIA, 2013). The residential solar hot water program has funded about 23,000 ft^2 of solar thermal (CEFIA, 2012 and CEFIA, 2013). However, the grant programs for solar thermal have been phased out and only various types of loans and a lease programs remains. The impacts on the rate of solar thermal installations by relying only on a portfolio of financing programs has yet to be determined,

5.4 FLORIDA

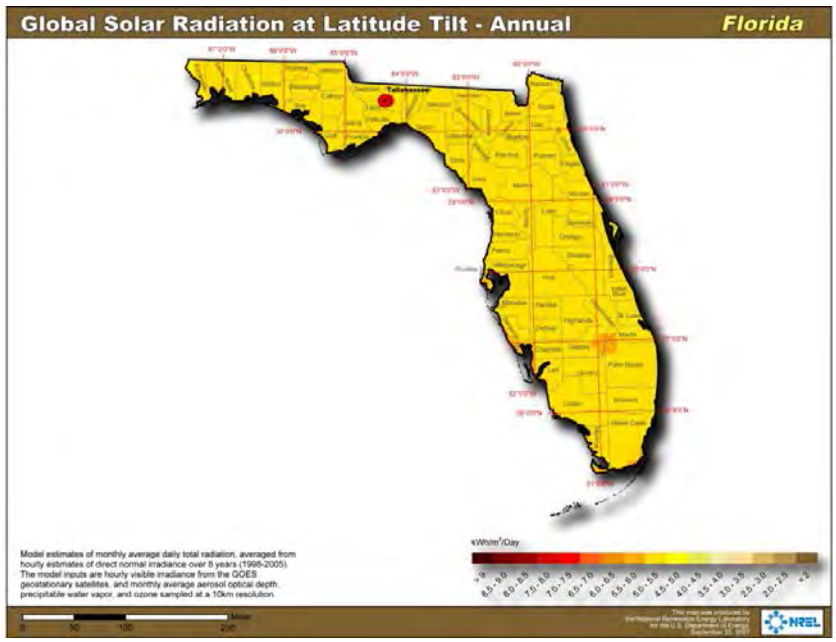


Figure 22: Florida Annual Solar Radiation at Latitude.
Source: (NREL, 2013).

Florida has a good solar resource, with an average of 4.2 kWh/m2/day (Marion & Wilcox, 1994), and on average, cities in the state experience 74 to 128 clear, sunny days each year (NOAA, 2013). Florida has had long history with solar thermal energy that has included thousands of systems being installed in the first several decades of the 20th century (Florida Solar Energy Research and Education Foundation, 2012). In 1975, the State of Florida created the Florida Solar Energy Center (FSEC), which is a research institute at the University of Central Florida responsible for researching, testing, certifying solar systems, and developing education programs (FSEC, 2013). There was a resurgence of solar thermal installations in the late 1970s and early 1980s due to federal tax credits and utility rebates, but after the expiration of federal tax credits in 1986, installations slowed to almost a halt until 2006, when federal tax credits and utility rebates were reinstituted. Even with a declining market after 1986, residents in Florida installed 136,000 solar water heaters from 1978 to 2006 (Florida Solar Energy Research and Education Foundation, 2012).

5.4.1 Financial Incentives

Solar Sales Tax Exemption

Solar energy systems, as well as their individual components, have been exempt from Florida's sales and use tax since July 1, 1997 (Fla. Stat. § 212.08).

Property Tax Exclusion for Residential Renewable Energy Property

For property tax assessments beginning January 1, 2014, 100% of the added value of solar thermal systems installed on or after January 1, 2013 (HB 277, 2013).

Lakeland Electric - Solar Water Heating Service

Lakeland Electric operates a unique program that offers solar-heated domestic hot water on a "pay-for-energy" basis. This municipal utility installs solar water heaters on participating customers' homes and bills the customer $34.95 per month regardless of use. Each solar water heating system is metered and equipped with a heating element timer as a demand management feature. Lakeland Electric plans to deploy up to 20,000 solar water heaters, producing the thermal equivalent of about 40,000 MWh per year upon full build-out (Lakeland Electric, 2013).

Utility and Local Government Rebates and Performance-Based Incentives

The Orlando Utilities Commission (OUC), Gulf Power, and Tampa Electric offer rebates up to $1,000 for installation of solar water heating systems. JEA's New Home Build Program offers rebates up to $800 for installations on new construction. The City of Winter Park and Progress Energy Florida offer rebates up to $550. The City of Longwood and Beaches Energy Services offer rebates up to $500. The City of Tallahassee Utilities, Fort Pierce Utilities, City of Ocala Utility Services, and The City of Lake Worth Utilities offer rebates up to $450. The OUC Solar Program purchases the RECs at $0.03/kWh from commercial customers who install a solar thermal energy system on their property and credits the customer monthly utility bills with the total REC purchase. The Clay Electric Cooperative offers rebates of $0.01 per BTU output estimated, with a maximum of $600. Florida Power and Light (FPL) offers a rebate of $1,000 for residential installations and $30/1,000 BTUh per day for commercial installations (DSIRE, 2013).

Utility and Local Government Loan Programs

For the installation of solar water heating systems, loans are offered these utilities/local governments up to the specified amount: City of Lauderhill, up to $2,000; Clay Electric Cooperative, up to $5,000; OUC, up to $7,500; City of Tallahassee Utilities and Gainesville Regional Utilities, up to $10,000; and St. Lucie County, up to $50,000 (DSIRE, 2013)

PACE Financing

PACE financing was authorized by state law in 2010 (Fla. Stat. § 163.08 et seq.). Like in most other states, most residential PACE programs have been suspended due to an adverse statement from the FHFA. However, commercial programs have not been impacted by FHFA statement and some local governments have figured out ways to implement residential PACE programs that avoid conflicts with the FHFA statement. The communities of Cutler Bay, Miami, South Miami, Pinecrest, Palmetto Bay, and Miami Shores formed the Clean Energy Green Corridor District and launched a PACE program with $230 million bond issuance with both residential and commercial customers eligible to participate in the program. Solar thermal systems are an eligible technology under the program (Clean Energy Green Corridor, 2013).

5.4.2 Rules and Regulations

Solar Equipment Certification

The Solar Energy Standards Act of 1976 established that FSEC develop standards for, and certify, all solar energy systems manufactured or sold in the state of Florida (Fla. Stat. § 377.705).

Solar Contractor Licensing

Contractors that install, maintain, or repair solar thermal systems for compensation must obtain a Solar Contractor license. To qualify for a license, installers must have four years of experience, which may include both installation and education and at least one year of experience must be in a supervisory role. An individual must also pass an examination to become certified as a solar contractor (Fla. Stat. § 489.105 et seq. Fla. Stat. § 489.113 et seq. and Florida Solar Energy Industries Association. 2013).

Energy Conservation in Public Buildings

The Florida Energy Conservation and Sustainable Buildings Act was enacted in 1974 and mandated the use of solar energy devices for heating and cooling state buildings when solar energy devices are determined to be cost effective over the life of a building and that schools with hot water demands greater than 1,000 gallons per day include a solar water heating system that meets 65% of that demand if the system is deemed economically feasible (Fla. Stat. § 255.251 et seq.).

5.4.3 Impacts of Policies

While Florida has no state-level direct incentives, there are number of utility and local government rebate programs. While these programs do help in a small way to improve the rate of solar thermal systems in Florida, the disjointed nature of differing incentive levels have not provided a consistent for the solar thermal to expand at a more rapid pace. In addition, the most active solar thermal market for in other states has been commercial customers, and very few utilities and local governments offer incentives for commercial systems.

5.5 HAWAII

With an average solar radiation of 5.1 kWh/m2/day across the state (Marion & Wilcox, 1994), Hawaii has a good solar resource. However, the solar resource can be quite variable, e.g., Hilo, which has one of highest annual rainfall averages of any city in the country, located only a few miles away from desert landscape. Because Hawaii imports 94% of its energy and pays the highest energy prices in the nation, solar thermal systems installed in Hawaii are usually more cost-effective than in other states with lower energy costs.

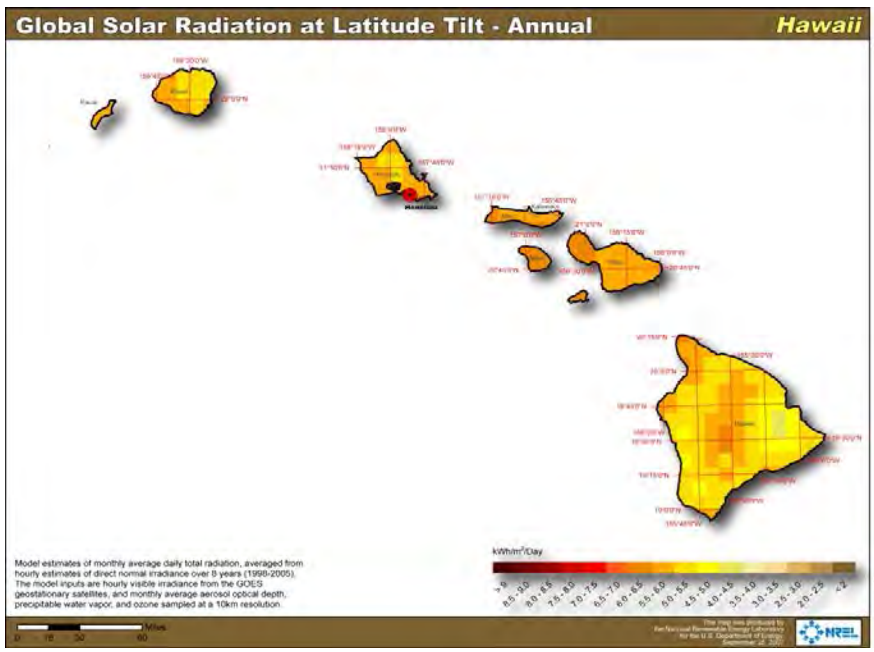


Figure 23: Hawaii Annual Solar Radiation at Latitude.
Source: (NREL, 2013).

5.5.1 Financial Incentives

Solar Energy Credit (Personal and Corporate)

Enacted in 1976, the Hawaii Energy Tax Credits (HRS §235-12.5) allow a taxpayer to claim an income tax credit up to 35% of the cost of the installation of a solar thermal energy system. Maximum allowable credits are as follows:

- Single family residential property is eligible for a credit of 35% of the actual cost or $2,250, whichever is less;

- Multi-family residential property is eligible for a credit of 35% of the actual cost or $350 per unit, whichever is less; and
- Commercial property is eligible for a credit of 35% of the actual cost or $250,000, whichever is less.

For newly constructed homes that have been required to install a solar water heater in accordance with (HRS § 196-6.5), this tax credit is not available.

Property Tax Exemption

The City and County of Honolulu provides 100% property tax exemption for 25 years for solar thermal (Revised Ordinances of Honolulu 8-10.15).

Solar Water Heating Rebate

Hawaii Energy's Solar Water Heating program offers a rebate of $1000 for residential customers on the islands of Oahu, Hawaii, Maui, Lanai, and Molokai. Instead of the rebate, homeowners have the option of participating in an interest buy-down program, where participating lenders $1000 to buy-down the interest rate to 0% or a low interest rate (depending on credit scores, etc.) Hawaii Energy is the entity that administers clean energy programs for electricity customers of the Hawaiian Electric Company (HECO) and its subsidiaries, Maui Electric Company (MECO) and Hawaii Electric Light Company (HELCO). Hawaii Energy is funded by ratepayers via a cents/kWh surcharge on utility bills that is a set percentage of total utility revenue, under contract with the Hawaii Public Utilities Commission (HPUC).

Kauai Solar Water Heating Rebate

The Kaua'i Island Utility Cooperative's Commercial Energy Wise Program provides $800 to $1,000 rebates for solar water heating systems installations (Kauai Co-op, 2013).

GreenSun Hawaii

GreenSun Hawaii is a credit enhancement program that provides local financial institutions such as banks and credit unions with access to a loan loss reserve program which may cover up to 100% of actual losses on eligible energy efficiency and renewable energy system investments. Financed by a grant from the U.S. Department of Energy using funds from The American Recovery and Reinvestment Act of 2009, the program has been able to leverage $2.67 million in federal funds into around $53.0 million in energy efficiency equipment loans. Solar thermal systems are an eligible technology under the program (Hawaii Community Reinvestment Corporation, 2013).

Utility and Local Government Loan Programs

The Honolulu Solar Loan Program, provided by the City and County of Honolulu, offers zero-interest loans to income-eligible homeowners for the installation of solar water heating systems through the City's Rehabilitation Loan Program (Honolulu Solar Loan Program, 2013). Residential homeowners in Maui Electric's territory with existing electric water heaters are eligible for a loan and must provide a down payment equal to 35% of the system cost after Hawaii Energy's rebate. This program also accepts applications from renters who have the property owner's permission. Funds are provided by the County of Maui and to date, the County of Maui has contributed a total of $700,000 in funding (Maui Electric Solar Water Heating Financing, 2013). The Kauai Community Federal Credit Union, Kauai County Housing Agency, the Kauai Island Utility Cooperative provide customers with zero-interest loans for solar water heating systems, to repaid in 60 months(Kauai Co-op, 2013).

5.5.2 Rules and Regulations

Solar Water Heating Requirements for New Residential Construction

In June 2008, a law (HRS § 196-6.5) was enacted that required the installation of solar water heater systems, comparable renewable energy systems, or on-demand gas water heaters in all new residential development projects constructed after January 1, 2010. Building permits are not issued for single-family homes that do not include a solar water heating system unless the energy resources coordinator approves a variance, due to: poor solar resource; an installation that is cost-prohibitive based on a life cycle cost-benefit analysis; a substitute renewable energy technology that is used as the primary energy source for water heating; or the installation of a gas tankless hot water heater device, approved by Underwriters Laboratories Inc.

Renewables and Efficiency in State Facilities & Operations

A law enacted in 2006 requires renewable energy, energy efficiency, and alternative fuels in state facilities and operations as well as public schools. A provision of the law requires solar water heating systems to be installed in all state facilities, if life-cycle cost-benefit analyses determines it to be cost-effective (HRS §196-9, et seq.).

Hawaii Energy Efficiency Resource Standard/Renewable Portfolio Standard

Hawaii's RPS (HRS § 269-91 et seq.) requires that by December 31, 2030, 40% of a utility's net electricity sales be derived from renewable energy resources including electrical energy savings brought about by the use of renewable displacement or off-set technologies, including solar water heating, seawater air-conditioning district cooling systems, and solar air-conditioning. A 2009 law (HRS § 269-96 et seq.) established the Energy Efficiency Portfolio Standard (EEPS). Until January 1, 2015, energy efficiency is included in Hawaii's RPS. However, beginning in 2015, energy efficiency and displacement or offset technologies (described above) will no longer be eligible to meet the requirements of the RPS and will instead be eligible to meet the EEPS. The HPUC will be responsible for establishing rules and specifying eligible technologies for the EEPS every five years starting in 2013. The EEPS has a goal of achieving 4,300 GWh of electricity use reduction by 2030 (HI PUC Order, Docket 2010-0037).

Solar Contractor Licensing

The following specialty licenses for solar contractors are available through Hawaii's Department of Commerce and Consumer Affairs: Solar Hot Water Systems Contractor (C-61a) and Solar Heating and Cooling Systems Contractor (C-61b). Plumbing contractors (C-37) are also allowed to install solar water heating systems. Solar contractor licenses require business and trade exams plus four years of experience. Solar water heating systems require the certification of a licensed plumber and, if the system is connected to a back-up energy supply, a licensed electrician (HAR §16-77-32 et seq. and HRS §444-7).

5.5.3 Impacts of Policies

An analysis of Hawaii's thermal energy policies, conducted in 2012, determined that:

- For the 20-year period from 1992 to 2011, a total of 74,018 solar water heating systems were installed in Hawaii;
- These solar water heating systems currently save 152,847 MWh per year, which is sufficient to power 21,695 homes annually.
- The cumulative economic value of these solar water heating systems to Hawaii is estimated to be approximately $332 million;
- The state tax credits provided for these solar water heating systems totaled approximately $116 million; and
- There is a direct correlation between the number of solar thermal installations and the level of support from state and federal credits (HSEO, 2012).

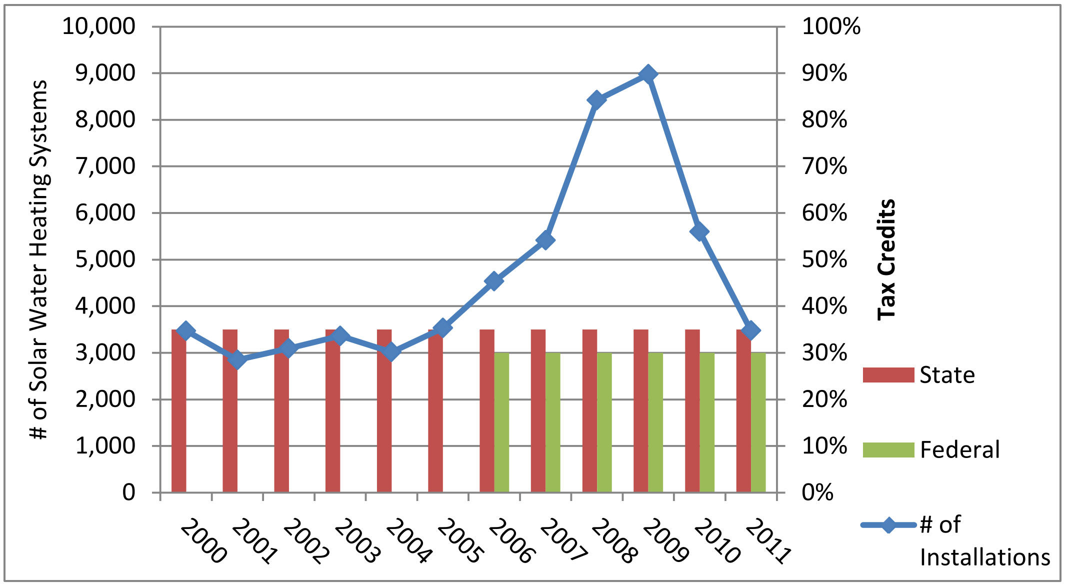


Figure 24: Incentives in Hawaii for Solar Water Heating Systems vs. Installations.
Source: (HSEO, 2012).

An analysis, conducted in 2013, on the economic impacts of Hawaii's solar tax credit found that solar water heating systems results in annual electricity cost savings of $1,018, and 9.9% rate of return for the average solar water heating system (Loudat, 2013).

5.6 ILLINOIS

Illinois has moderate solar resources with cities in Illinois experiencing about 250 cloudy or partly cloudy days annually and an average solar irradiation of 4 kWh/m2/day (Marion & Wilcox, 1994).

5.6.1 Financial Incentives

Property Tax Exemption

Per the Illinois property tax code, solar energy systems must be valued at no more than comparable conventional energy systems, meaning that for tax purposes property values will not increase after the installation of solar systems. For these purposes, solar energy systems means any system comprised of solar collectors and solar storage mechanisms used for generating electricity or heating and cooling (§ 35 ILCS 200/10-5 et seq.).

Solar Energy Rebate Program

The Illinois Department of Commerce & Economic Opportunity (IDCEO) administers the state's Solar and Wind Energy Rebate Program. Rebates for solar thermal projects are capped at 30% of project costs for residential and commercial applications and 40% for public sector and non-profit entities. The maximum rebate is $10,000.00 for residential customers, $20,000 for commercial customers, and $30,000 for public sector and non-profit entities. All customers of investor-owned utilities, municipal utilities, and cooperatives who contribute to the fund are eligible to receive rebates. Rebates are funded from a surcharge, of $0.05/month on residential customers and $37.50/month on non-residential customers, established under the 1997 Renewable Energy, Energy Efficiency, and Coal Resources Development Law (20 ILCS 687/6-1 et seq.). The surcharge funds the Renewable Energy Resources Trust Fund, which receives approximately $5,000,000 to $6,500,000 per year, to provide rebates for solar and wind projects. Since 1999, this rebate program has provided about $11 million in grants and rebates for solar thermal installations. However, in recent years, the Illinois state legislature has raided the Fund for the state's general budget. For 2014, only $1.5 million is available to fund rebates for photovoltaics, solar thermal, and small wind projects. In 2011, solar thermal subsidies represented about 15% of all incentive dollars and the program provided about $330,000 for 25 solar thermal project (IDCEO, 2013).

Community Solar and Wind Grant Program

The Community Solar and Wind Energy Grant Program provides grants for community-scale solar (including solar thermal) and wind energy projects — for solar thermal those grants are up to 30% of project costs for businesses and 40% of project costs for governments and nonprofits. The maximum grant award is capped at $250,000 (IDCEO, 2013).

City of Chicago - Small Business Improvement Fund

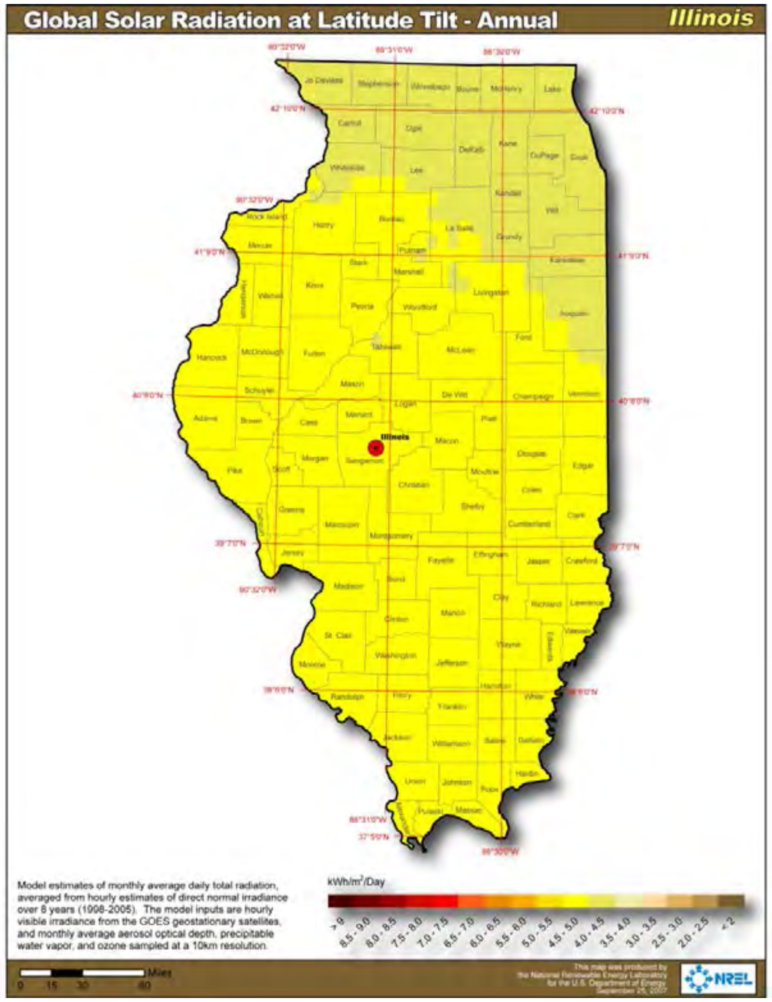


Figure 25: Illinois Annual Solar Radiation at Latitude.
Source: (NREL, 2013).

The Small Business Improvement Fund utilizes revenue from Tax Increment Financing (TIF) and provides grants up to 75% of the costs of upgrades (including solar thermal) to businesses within specific TIF districts to upgrade their facilities. Maximum incentives are: for an industrial property, $150,000; for a single owner, tenant, or landlord of a commercial property, $100,000; and for a multi-tenant building, $250,000 per property, or $50,000 per tenant/landlord (SomerCor 504 Inc., 2013).

Illinois Clean Energy Community Foundation Grants

With a $225 million endowment provided by Commonwealth Edison, the Illinois Clean Energy Community Foundation (ICECF) was established in 1999 as an independent foundation to invest in clean-energy development and land-preservation efforts. The ICECF provides competitive grants to programs and projects with various goals including to develop renewable-energy resources (including solar thermal). Award amounts are considered on a case-by-case basis, taking into account cost-effectiveness of the project, project innovation, simple project payback, other sources of funding and owner contribution (§ 220 ILCS 5/16-111.1. and Illinois Clean Energy Community Foundation, 2013)

Renewable Energy and Energy Efficiency Project Financing

The Illinois Finance Authority (IFA) issues tax-exempt bonds and credit enhancement for commercial as well as non-profit entities, including schools and community colleges, to install energy efficiency and renewable energy, including solar thermal (20 ILCS 3501.).

Green Energy Loans

Illinois business owners, non-profit organizations, and local governments seeking loans to install solar thermal (and/or other technologies and energy efficiency upgrades) may apply for a rate reduction, under the Green Energy Loan program, through the Illinois State Treasurer's Office, in partnership with eligible banks in the state. Loan amounts range from $10,000 to $10 million (Illinois State Treasurer's Office, 2013).

5.6.2 Impacts of Policies

Based on the cumulative installations per capita, Illinois is a top state in terms of square footage of solar thermal shipments per person. In addition, it has had a long-term stable policy in the state rebate program for solar thermal. However, a declining trend in shipments to Illinois has likely been due to the declining funding of the state rebate program and the raiding of the fund to balance the state's budget. In addition, the rebate program has not had a long-term plan to decrease incentive amounts per installation that would enable it to fund more installations and move the solar thermal industry to lower installation costs.

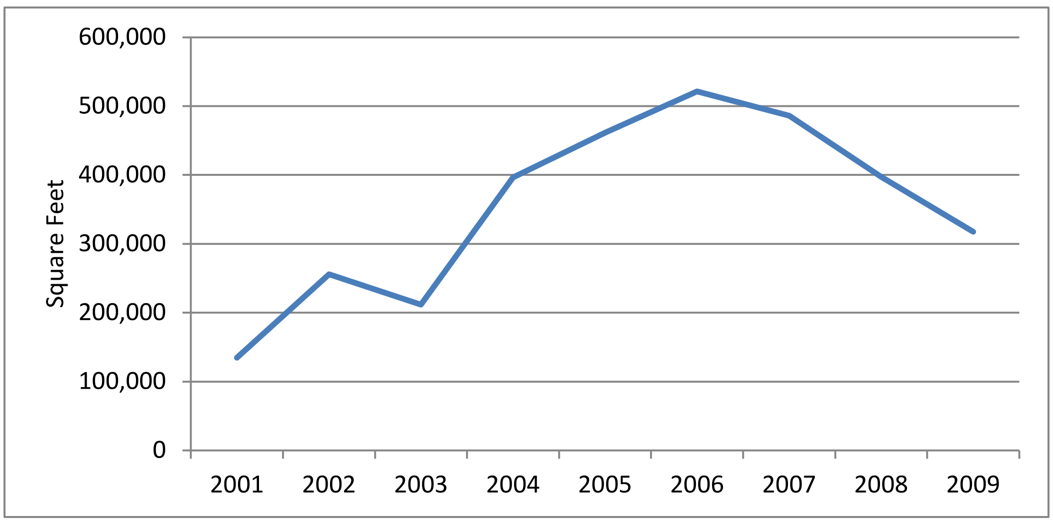


Figure 26 : Illinois Destination of Solar Thermal Collectors.
Source: (US EIA, 2012).

5.7 NEW JERSEY

New Jersey has moderate solar resources, the average solar irradiation across the state is about 4 kWh/m2/day (Marion & Wilcox, 1994) and the state experiences, on average, approximately 205 cloudy or partly cloudy days per year.

5.7.1 Financial Incentives

Solar Energy Sales Tax Exemption

All solar energy devices or systems designed to provide heating or cooling by transferring solar-generated energy, including devices for storing generated energy, are eligible for an exemption from the state's sales tax, currently 7% (N.J. Stat. § 54:32B-8.33 and N.J.A.C. § 18:24-26.1 et seq.).

Property Tax Exemption for Renewable Energy Systems

A law, enacted in 2008, provides a tax exemption from local property taxes for renewable energy systems including those that provide solar water or space heating (N.J. Stat. § 54:4-3.113a et seq.).

WARMAdvantage Program

The WARMAdvantage program offers rebates for replacing furnaces, boilers, and water heaters, including solar water heating systems. Rebates of $1,200 are available for replacing an existing water heater with an ENERGY STAR qualified solar domestic water heater. The program is currently available statewide to all New Jersey residents, including those residents who heat with propane or oil. Only retrofits to existing homes are eligible under this program, new construction is not eligible (New Jersey Clean Energy, 2013). This program is funded by a societal benefits charge that is collected as a non-bypassable charge imposed on all customers of New Jersey's seven investor-owned electric utilities and gas utilities. The Board of Public Utilities determines the amount that will be collected for any given year and approves a budget based on recommendations by the Office of Clean Energy. Like in Illinois, the New Jersey state legislature has raided the fund and used it to balance the state budget. Consequently, funding has been, and may continue to be, unstable in the future.

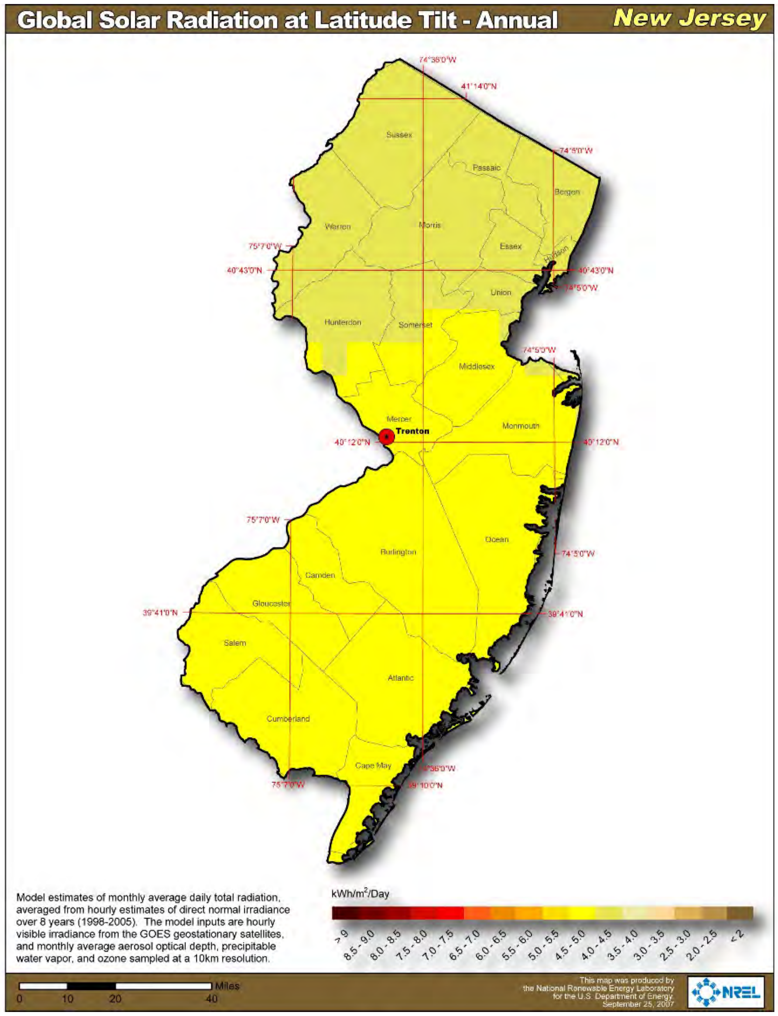


Figure 27: New Jersey Annual Solar Radiation at Latitude.
Source: (NREL, 2013).

5.7.2 Rules and Regulations

Solar Energy Option Requirements for Residential Development

A law enacted in 2009, requires new residential developments with 25 or more dwelling units to offer to install or arrange for the installation of solar energy systems (including solar thermal) at the request of the purchaser before the completion of construction, where it is “technically feasible”. Under the technical feasibility standards, developers are required to provide information concerning applicable incentives that may be available for the installation of solar energy systems, and general information on the environmental benefits, and potential energy cost savings associated with solar energy systems (N.J. Stat. § 52:27D-141.1 et seq.).

5.7.3 Impacts of Policies

New Jersey has aggressively pursued policies in support of distributed solar photovoltaic (PV) systems, first through a state rebate program and then a market-based mechanism via its RPS. For a number of years, New Jersey has been second (behind, California) in the per-capita installation of PV. On the other hand, its policies to enhance development of solar thermal systems have been more limited has not exhibited as much success in expanding solar hot water, space heat, and other thermal systems. Because New Jersey has not explicitly focused on solar thermal technologies except for a brief pilot rebate program in 2009, it does not report incentive dollars or other resources devoted to promoting solar thermal systems. Neither dollars nor number of projects are reported by the state energy authority. However, as seen below, the number of solar domestic water heaters per year has fallen drastically over the past ten years.

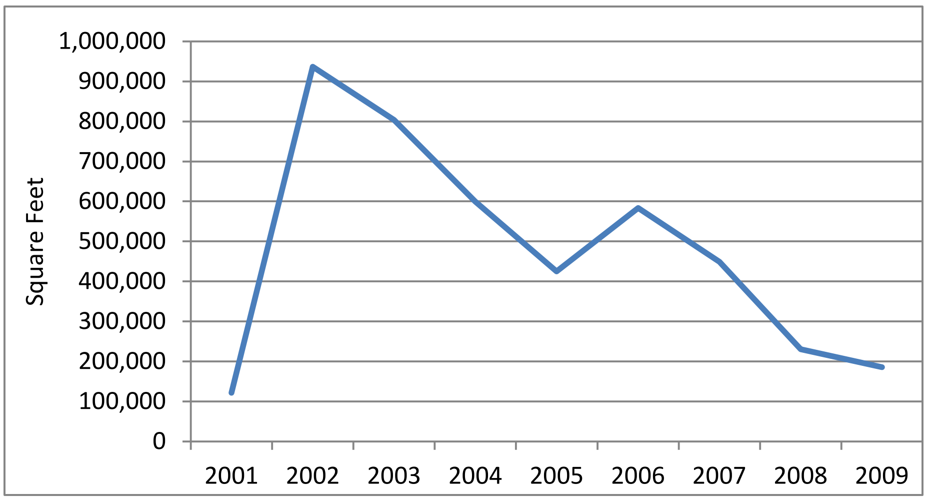


Figure 28: New Jersey Destination of Solar Thermal Collectors.
Source: (US EIA, 2012).

5.8 OREGON

The average state irradiation is approximately 3.9 kWh/m2/day (Marion & Wilcox, 1994). Cities in Oregon experience between 240 and 315 cloudy and partly cloudy days each year depending on their location, with cities in the southern half of the state typically seeing fewer cloudy days each year. Despite the region's reputation as being a cool and rainy northwestern state, many parts of Oregon receive satisfactory amounts of solar radiation six to eight months of the year.

5.8.1 Financial Incentives

Tax Exemption for Renewable Energy Systems

Enacted in 1976, the Tax Exemption for Renewable Energy Systems act exempts from the property tax value assessments, any change in the real market value of a property that results from the installation of a qualifying renewable energy system, including solar thermal.

Residential Energy Tax Credit

Enacted in 1977, state law allows taxpayers to take a credit on state taxes, based on the savings estimated relative to a conventional system for a typical four-person household. Currently, the credit equals $0.60/kWh saved, up to a maximum of $1,500 or 100% of the cost of the system. The amount of the tax credit is established through an on-site inspection by a tax-credit professional who evaluates the output, shading loss, tilt, orientation, etc. The law also allows third-party entities (e.g., in lease arrangements or purchased power agreements) to take the tax credit (Oregon Department of Energy (ODOE), 2013a).

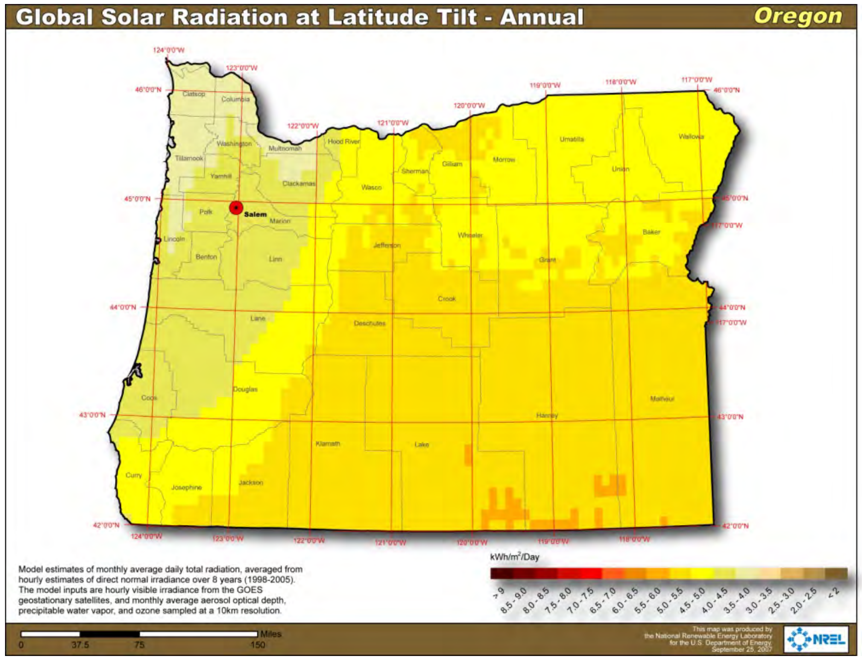


Figure 29: Oregon Annual Solar Radiation at Latitude.
Source: (NREL, 2013).

Energy Conservation Tax Credits

These tax credit programs, created in 2011 to replace an earlier Business Energy Tax Credit Program, offer competitive grants to energy conservation and renewable energy (including solar thermal) projects for homes or businesses. Projects with a total cost of less than $20,000 may be eligible for the Small Premium Projects program and larger projects may be eligible for the Competitively-Selected Projects program. The ODOE evaluates each project on a point system based on the number of new jobs created by the project, the project's internal rate of return, the amount and end use of energy generated, the geographic diversity and technological diversity of proposals submitted, and how the project meets the state's environmental and energy goals (ODOE, 2013b).

Community Renewable Energy Feasibility Fund

This program, funded with a $1 million settlement payment, provides grants to fund feasibility studies for renewable energy, heat, and fuel projects in Oregon. The Fund is a revolving loan fund, — awardees that construct projects are required to repay the cost of the grant back to the Fund. The Fund is currently inactive and not providing grant until current awardees repay grants (ODOE, 2013c).

Solar Water Heating Incentive Program

Funded by 3% public-purpose surcharge from customers of Pacific Power and Portland General Electric, a 1.25% surcharge from customers of Northwest Natural Gas, and 1.5% surcharge from customers of Cascade Natural Gas, the Energy Trust of Oregon is an independent, non-profit organization similar to Delaware's Sustainable Energy Utility (SEU). Since 2003, the Energy Trust has offered incentives to switch from natural gas to solar thermal water and pool heating systems through its Solar Water Heating Incentive Program. Customers of the above utilities who install eligible systems on their homes, office buildings, community or municipal buildings, or agricultural facilities can qualify for a "buy down" incentive, calculated by multiplying an incentive rate by the estimated annual kWh savings in heating. The maximum allowable is $1,500 for residential applications and up to 35% of the system cost for commercial applications (Energy Trust of Oregon, 2013).

Small Scale Energy Loan Program and Other Loan Programs

The Small Scale Energy Loan Program, funded from the sale of bonds, provides low-interest loans to small scale energy projects including solar thermal. The loans can range in size from $20,000 to over $20 million. Over 850 applications for $594 million in small scale loans have been approved (ODOE, 2013d). The Energy Trust of Oregon offers financing for homeowners and small businesses for the installation of solar thermal (Energy Trust of Oregon, 2013a). In lieu of a rebate for the installation of a solar water heating system, Ashland Electric Utility, Eugene Water & Electric Board, and Salem Electric offer loans with low or no interest and/or other favorable terms (DSIRE Solar Oregon, 2013).

Utility Rebate Programs

Ashland Electric Utility, Central Lincoln People's Utility District, Consumers Power, and Salem Electric all offer rebates for the installation of solar water heating systems ranging from $500 to $1,000 (DSIRE Solar Oregon, 2013).

5.8.2 Rules and Regulations

Green Energy Technology for Public Buildings

A law enacted in 2007 requires passive solar, solar thermal, or solar electric systems to be incorporated into all new public buildings for which the total contract price is $1 million or more. This was later expanded to other all green technologies like geothermal heat pumps. The policy applies to renovation projects costing at least $1 million and 50% of the insured value of the building. If a contractor determines solar can be appropriate for a particular project, solar systems with a value of at least 1.5% of the expected contract value must be installed. When solar is not deemed appropriate for a project, that 1.5% will be put into a reserve account for use on a future public building project (ORS § 279C.527 et seq. and OAR 330-135-0010 to 330-135-0055).

Solar Permitting

To help streamline the process for complying with laws requiring the incorporation of solar thermal technologies, the State of Oregon implemented a solar permitting law in 2011. Permitting has been streamlined for projects that do not expand the footprint or peak height of the structure and that lie parallel to the slope of the roof. The City of Portland developed an electronic permitting process for residential solar systems. Trained contractors may submit project plans and the permit application on-line instead of filing in-person. Turnaround for permits is expected to be about 24 hours. Reducing these time-consuming steps in the process can help speed solar thermal projects from design to operation (ORS § 215.439).

Solar Contractor Licensing

In an effort to standardize training and ensure the quality of solar contractors, Oregon requires contractors who install solar thermal equipment to obtain either a Plumbing Journeyman's License or a Solar Heating and Cooling System Installer License. The Journeymen take part in 8,000 hours of on-the-job training and can then perform necessary solar plumbing work. System installers participate in 2,000 hours of solar-specific on-the-job training. Their work is limited to the non-potable side of solar thermal systems (ORS § 447.065 and ORS § 479.630).

5.8.3 Impacts of Policies

In the five-year period from 2008 to 2012, the Energy Trust of Oregon provided rebates to an average of 124 residential and 20 commercial installations per year. The Energy Trust lowered incentives in 2012 to manage an increased customer demand in 2011, and saw the number of installations drop by 50% (Energy Trust of Oregon, 2013b). Figure 4 shows a large increase in domestic shipments of solar thermal starting in 2004, the same year that the Energy Trust started providing rebates. Since other incentives such as subsidized financing and tax credits had been in place prior to 2004, the role of the rebates in jump starting Oregon's solar thermal market are clear.

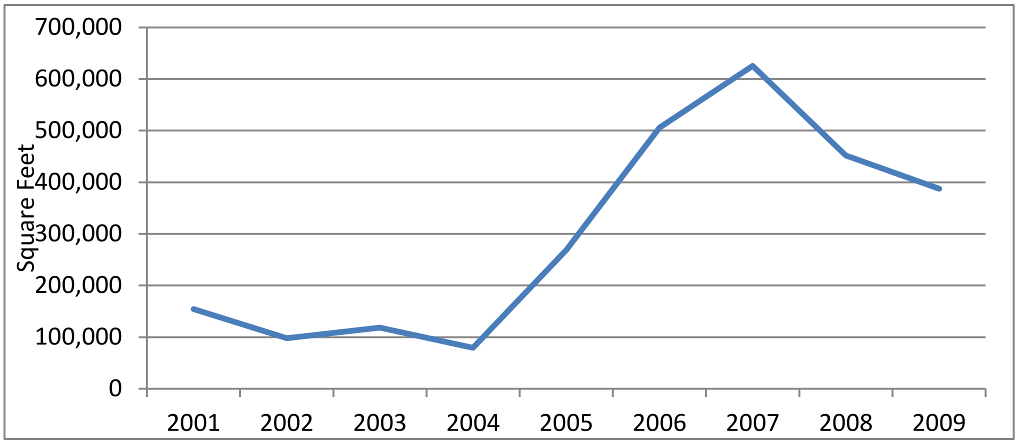


Figure 30: Oregon Destination of Solar Thermal Collectors.
Source: (US EIA, 2012).

5.9 VERMONT

Vermont's annual average solar insolation throughout the state is 4.0-4.5 kWh/m^2/day. In the winter, insolation can be as low as 3.0 kWh/m^2/day (Marion & Wilcox, 1994). Like Connecticut, Vermont has a fairly large number of cloudy days, with an average of only 58 days per year classified as "clear" (NOAA, 2013).

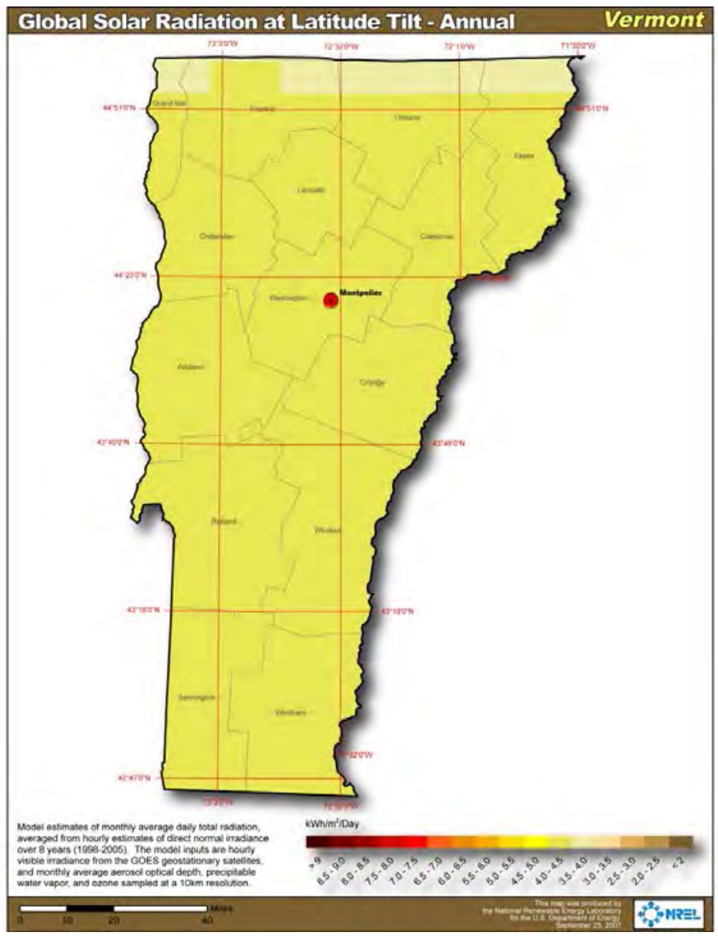


Figure 31: Vermont Annual Solar Radiation at Latitude.
Source: (NREL, 2013).

5.9.1 Financial Incentives

Corporate Investment Tax Credit

The corporate investment tax credit available to businesses in Vermont that own solar thermal systems is effectively a 7.2% credit on state taxes. After December 31, 2016, this tax credit will drop to 2.4% (32 V.S.A. § 5822).

Property Tax Exemption

State law allows municipalities the option of offering an exemption for solar thermal equipment from the property taxes. Although adoption of this exemption varies by municipality, the exemption generally applies to the total value of the solar thermal system (32 V.S.A. § 3845).

Renewable Energy Systems Sales Tax Exemption

State law provides a sales tax exemption for the purchases of a solar thermal system up to a size equivalent to 250 kW in capacity (32 V.S.A. § 9741(46)).

Small-Scale Renewable Energy Incentive Program

The Clean Energy Development Fund (CEDF), established in 2005 and primarily funded from a settlement with Entergy in connection with Vermont Yankee nuclear power plant, funds the Small-Scale Renewable Energy Incentive Program. Incentives are available only for solar water heating systems, not space heating systems. For 2014, the available funding for solar water heating systems is $250,000. The incentive is determined by the system's rated kBTU x 10 $1.50 and is capped at $3,000 for residential and $16,000 for commercial systems (Renewable Energy Resource Center, 2013).

PACE Financing

PACE financing in Vermont was authorized by state law in 2009 (24 V.S.A. § 3251 et seq.). Unlike most other states, Vermont updated its law in 2011 to make it more acceptable to the Federal Housing Financing Agency and the development of PACE programs is proceeding in Vermont. To date, 30 towns have created PACE districts. PACE programs are authorized to finance up to $30,000 or 15% of the assessed property value, whichever is lower. The amount borrowed is typically repaid via a special assessment on the property over a period of up to 20 years. Currently, PACE is only authorized for residential properties (Efficiency Vermont, 2013).

5.9.2 Impacts of Policies

In the last several years, funding for CEDF and solar thermal were elevated due to the infusion of dollars from the American Resource and Recovery Act. In 2011, 159 solar thermal systems were provided rebates, totaling $297,000. In 2012, 353 solar thermal systems were provided rebates, totaling $631,000. The return to a more normal budget of $250,000 should result in a more modest, but still substantial funding of solar thermal systems. The figure below illustrates the destination of solar thermal shipments to Vermont. Similar to Oregon, the impact of the start up of the rebates in Small-Scale Renewable Energy Incentive Program can be seen in increase in shipments starting in 2005.

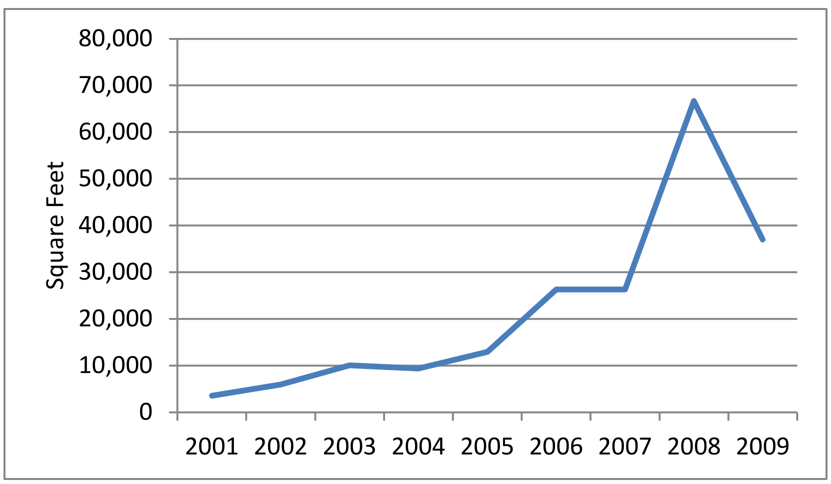


Figure 32: Vermont Destination of Solar Thermal Collectors.
Source: (US EIA, 2012).

5.10 DELAWARE

Delaware has a moderate solar resource, with average irradiation in Wilmington of 4.1 kWh/m2/day (Marion & Wilcox, 1994). Delaware experiences, on average, 201 cloudy and partly cloudy days each year.

5.10.1 Financial Incentives

Green Energy Fund

A public benefits fund — the Green Energy Fund — was established in 1999 as part of the electric utility restructuring law enacted that year. Collected from the customers of Delmarva Power, the initial \$0.000178/kWh charge collected about \$1.5 million per year. In 2007, the charge was increased to \$0.000356/kWh, collecting about \$3.2 million per year. Separate public benefit funds exist for the Delaware Electric Cooperative (DEC) and the state's municipal utilities through the Delaware Municipal Electric Corporation (DEMEC). Under the initial incentive program under the Green Energy Fund — the Energy Alternatives Program — solar thermal projects were eligible to receive a grant of 35% of the cost of the system, capped at \$1,500 for residential and \$250,000 for commercial projects (5 DE Reg. 1529 - 1538 (01/01/02)). Due to a law enacted in 2003, grant amounts were increased to 50% of project costs with caps of \$5,000 for residential and remaining at \$250,000 for commercial projects and the name of the program was changed to the Green Energy Program (8 DE Reg. 114 - 126 (07/01/04)). Further changes to law in 2010 allowed the Delaware Energy Office/DNREC Division of Energy and Climate to have more flexibility to make changes to the incentive levels and the current incentives are set at \$1.00 per calculated annual kWh saved up to a cap of \$5,000 for residential and \$10,000 for non-residential systems for both domestic hot water and radiant heating systems. Non-profit organizations are provided grants at a rate of \$2.00 per annual kWh saved up to a maximum of \$10,000 (DNREC, 2013a). The Green Energy Program regulations are currently under revision to clarify program requirements and streamline the

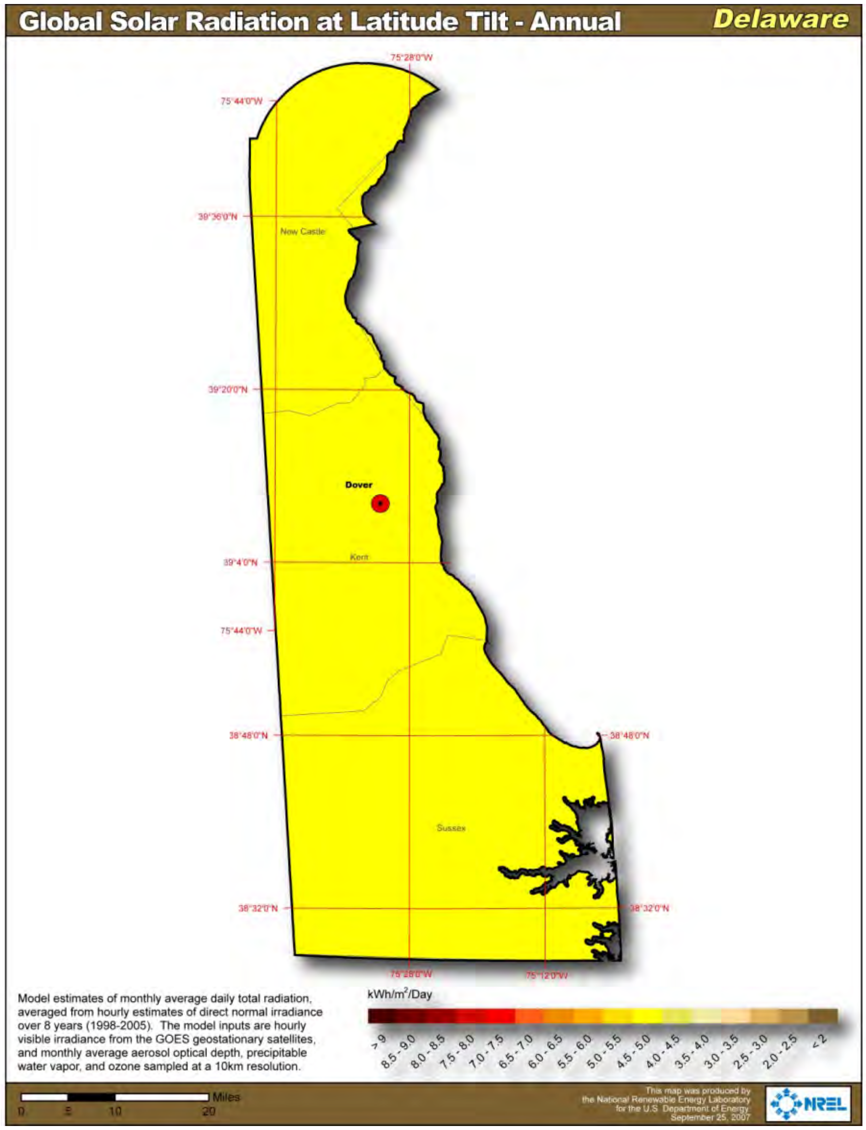


Figure 33: Delaware Annual Solar Radiation at Latitude.
Source: (NREL, 2013).

application process. Since 2005, 60 grants have been awarded to residential and non-residential solar water heating projects through the Green Energy Program for over $177,000 (DNREC, 2012).

Delaware Electric Cooperative Green Energy Fund

DEC started their green energy program in 2007 which offers incentives to members who install solar water heating and solar space heating systems. Grants are awarded to cover up to 20% of the total installed cost, with a maximum of $3,000 for Class A solar water heating systems and $7,500 for Class B solar water heating systems. Class A systems are defined as systems installed to meet average monthly peak demands of less than 50kW, with Class B systems being defined as those intended to meet average monthly peak demands of 50kW or greater. Solar water heating systems integrated into a radiant heating application are also eligible for up to 20% of total installed costs, with the maximum being slightly higher for Class A systems at $5,000 (DNREC, 2013b). Unfortunately, due to the limited funding for this program, applicants can expect to wait three to four years for grant funding after their application has been approved. Since the program began in 2007, eleven projects have been approved for funding for a total of $33,000 (DNREC, 2012).

Delaware Municipal Corporation Green Energy Program

DEMEC member utilities administer the incentives within their municipalities and each has their own requirements and incentives structures. While all municipal utilities initially offered individual grants, some of the municipalities have chosen to discontinue individual grant funding in favor of funding projects of a community nature. Solar thermal systems used for domestic water heating or in radiant heating are eligible for grants under this program only if they reduce or eliminate the need for electric or gas water heaters. All municipal utilities have suspended grant programs. Dover used the incentive levels in the Green Energy Program for Delmarva Power customers. Milford and Newark were offering incentives of up to 50% of the installed costs of all solar thermal systems. For solar water heating systems, the maximum grant available is $3,000 for residential systems and $10,000 for non-residential systems. For systems using solar energy for radiant heating, the maximum grant funding available is $5,000 for residential systems and $10,000 for non-residential systems (DNREC, 2013c). Newark and Middletown have each awarded a single grant for a solar water heating project with a grant of approximately $3,000 each. Seaford has awarded two grants for solar water heating projects for a total of $20,163 (DNREC, 2012).

5.10.2 Rules and Regulations

Renewable Portfolio Standard

Solar thermal systems that displace electricity are an eligible energy resource to create renewable energy credits (RECs) to meet the requirements of the RPS. However, only one solar thermal system has registered with PJM-EIS' Generation Attribute Tracking System (GATS) and only one REC derived from that system has been retired to comply with the RPS (PJM-EIS, 2013). The RPS has a solar PV carve-out with a minimum of 0.8% PV by 2015 and 3.5% by 2026. The solar PV carve-out has been a major driver for the growth of the PV market in Delaware. The RPS does not have a similar carve-out for solar thermal energy systems (26 Del. C. § 351 et seq.).

Participating Contractors

In order for a solar thermal system to receive a grant from the Green Energy Program, the installation of the system must be by a Participating Contractor. The Green Energy Program regulations require that a Participating Contractor have a professional plumbing license and have taken training courses on solar thermal. A certification from the North American Board of Certified Energy Practitioners (NABCEP) is a preferred demonstration of appropriate knowledge and training (DNREC, 2013a).

5.10.3 Impacts of Policies

Since 2005, the green energy programs for Delmarva Power, DEC, and DEMEC have awarded over $225,000 in grants to about 80 solar thermal projects, representing over 4,300 ft^2 of solar thermal panels. Figure 34 shows the solar thermal installations for 2005 to 2011, with average system costs and average grant investment for each year. Figure 35 shows solar thermal shipments to Delaware, and since 2006, there has been a significant increase in solar thermal shipments to the state. However, this increase is from a baseline of almost zero.

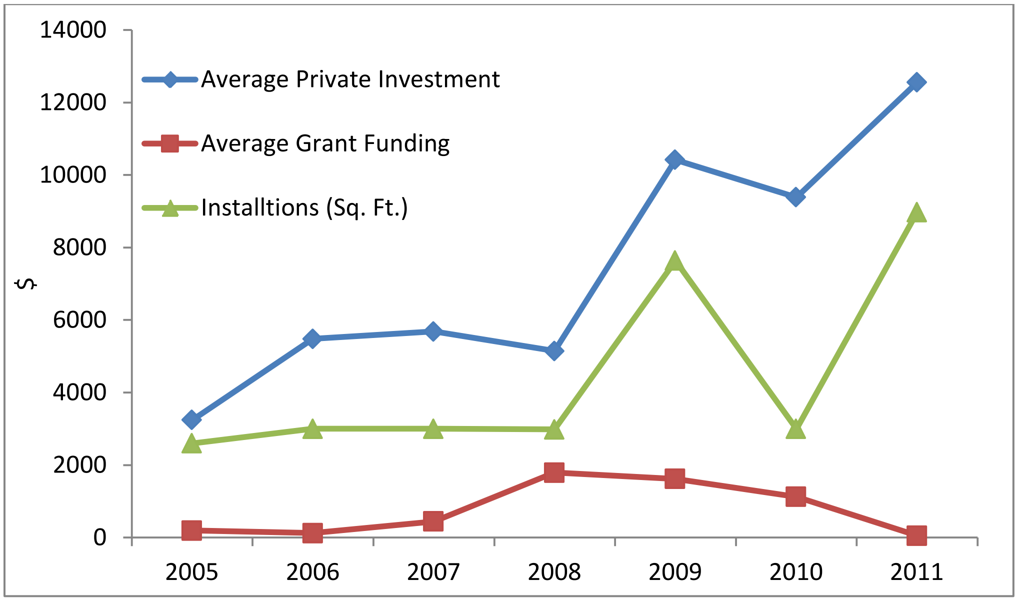


Figure 34: Grant Funding, Area of Installations, and System Investment in Delaware.
Source: (DNREC, 2012).

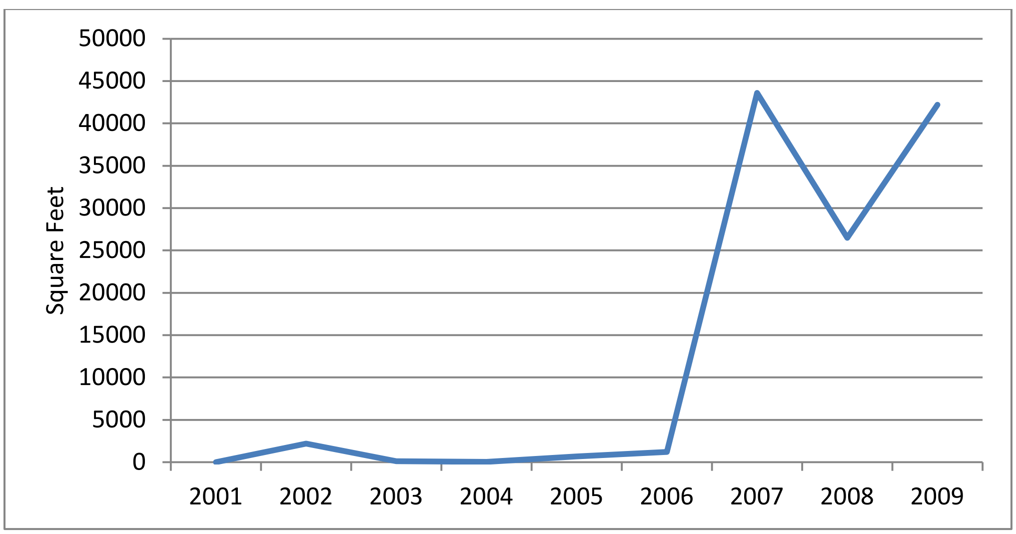


Figure 35: Delaware Destination of Solar Thermal Collectors.
Source: (U.S. EIA, 2012).

Chapter 6: Conclusion and Recommendations

Delaware has a sizeable mix of policy support for renewable energy, including the Green Energy Funds, the Sustainable Energy Utility (SEU), and the RPS. The state's support of PV has been considerable — for a number of years, Delaware has ranked in the top ten, and often the top five, in PV-installed per-capita. In contrast, Delaware has been only moderately successful in supporting solar thermal, with over $225,000 granted in support of 80 solar thermal systems. So while not neglected —according to an analysis in this study, Delaware ranks 16th in shipments of solar thermal panels — solar thermal energy has not received the same level of policy attention that PV and other renewable energy technologies have. In addition, Delaware is lagging behind other states not known for their renewable energy policies, for example Virginia, and northern states with only a moderate solar resource, for example Maine. In short, there is room for improvement in the solar thermal market in Delaware and in the state's policy support of solar thermal energy.

Based on the analysis in this report, several best practices are evident. First, policies that specifically target solar thermal technology are more suited to enhance deployment and for promoting the technology. Programs that lump solar thermal in with other renewable or clean energy technologies tend to overlook solar thermal systems in favor of larger-scale solar PV, wind, or energy efficiency projects. The California Solar Initiative (CSI)-Thermal program and Hawaii's rebate program are examples of programs that have achieved some success in solar thermal system deployment. Second, incentives that provide a direct upfront rebate or grant are more successful at driving deployment than loan or financing policies. California, Oregon, and Vermont all saw substantial increases in solar thermal shipments with the start of rebate programs. While useful in a more robust market, loan and financing programs like PACE haven't demonstrated the ability to drive market transformation and jumpstart a state solar thermal market like rebates can.

In Delaware, the installation of residential solar thermal systems has not gained sufficient traction to create a robust market, even with the long-standing grants available from the Green Energy Program. One issue has been the low natural gas prices which have made the cost-effectiveness of solar thermal applications more challenging. Solar thermal also has not held the appeal to homeowners that PV has had — with a PV system, a homeowner is a power generator. Whereas with a solar water heating system, the homeowner is simply displacing energy usage. While the non-residential market also seems to be more drawn to PV, individual customers in the non-residential market have thermal demands that far exceed residential domestic uses and thus enable installations to be more cost-effective. Solar thermal companies in recent years have been successful in marketing to certain segments of the non-residential market with high thermal demands such as multi-tenant buildings, hotels, food-processors, and breweries.

An advantage of rebate and grant programs is that such incentives are more conducive to third-party financing arrangements like power purchase agreements (PPA) and leases. In the PV market, the creation of PPA model by Sun Edison enabled the installation of large commercial PV systems with no money down by host customers and led to an explosion in growth for the PV market. Similarly, in the solar thermal market, the emergence of the PPA model has been driver of growth in the market, primarily in commercial installations. An enhancement to the Green Energy Program that would make this emerging solar thermal business model more viable in Delaware would be to raise the grant cap on non-residential systems to a higher amount, e.g., $25,000 or $100,000.

Another enhancement to the current solar thermal incentives in Delaware would be to dedicate a portion of some funding source — the Green Energy Fund, the SEU, or other funding source — to solar thermal incentives. Emerging markets like the solar thermal market in Delaware are able to scale up when there is a stable and known amount of funding on an annual basis. In addition, a program that has predictable step-declines in grant or rebate levels provides an emerging industry with an incentive to lower installations costs and to fund more installations. The CSI-Thermal program is a good example of a program with predictable, declining incentives over a multi-year period. This model worked well for PV, so California applied the same policy model to solar thermal.

Rules and regulations establish guidelines that shape markets, ensure high quality systems and services, protect access to resources, and enhance deployment through standards and mandates. The Green Energy Program's regulations for Participating Contractors establish a fairly rigorous set of standards for contractors. Requiring contractors to become NABCEP-certified within one year after becoming a Participating Contractor would further establish the professionalism and competency of solar thermal contractors. Another regulation that could be tweaked is the RPS. Currently, only solar thermal systems that offset electricity use are eligible for the RPS. Changing the RPS to allow all solar thermal systems to be an eligible energy resource in the RPS would provide another source of potential revenue for solar thermal systems that offset natural gas, oil, or propane.

While the recommendations above represent specific actions that should be considered to enhance Delaware's current policy regime in support of solar thermal technology, they do not represent an exhaustive list of policy options.

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