SEIA Solar Energy Industries Association®

Solar Heating & Cooling:

Energy for a Secure Future

How smart and effective solar heating and cooling policies can create new American jobs, stimulate the U.S. economy and protect the environment.

Prepared for SEIA by BEAM Engineering

505 9th Street NW | Suite 800 | Washington DC 20004 | 202.862.0556 | www.seia.org

Solar Energy Industries Association

Established in 1974, the Solar Energy Industries Association® is the national trade association of the U.S. solar energy industry. Through advocacy and education, SEIA® and its 1,000 member companies are building a strong solar industry to power America. As the voice of the industry, SEIA works to make solar a mainstream and significant energy source by expanding markets, removing market barriers, strengthening the industry and educating the public on the benefits of solar energy.

For additional information, please visit www.seia.org.

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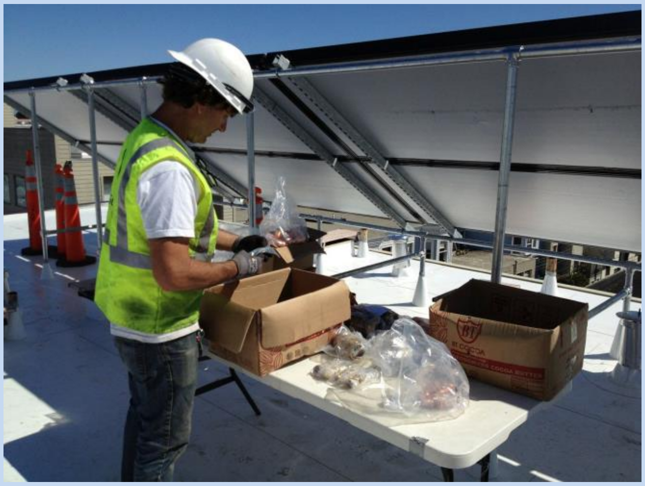

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Solar Heating & Cooling: Energy for a Secure Future

A Message from SEIA President & CEO Rhone Resch

In 1891, inventor Clarence Kemp of Baltimore patented the first commercial solar water heater in America. Kemp enclosed a simple metal tank in a wooden box, creating the so-called "batch" water heater. Looking back, we've certainly come a long way since then!

Today, more than 30,000 solar heating and cooling systems (SHC) are being installed annually in the United States, employing more than 5,000 American workers from coast to coast. That's good – but it can be a lot better. As an organization and as an industry, we're committed to making this happen. It would provide a huge boost for our economy and help the environment, too.

This first-of-its-kind SHC roadmap, developed by a task force made up of SEIA-member companies and BEAM Engineering, lays the groundwork – as well as makes a compelling case – for driving installed SHC capacity from 9 GW thermal to 300 GW thermal by 2050. It's an ambitious goal, but it's doable.

As this new report spells out, in order to reach our target, it will require the installation of 100 million SHC panels over the next 35 years. Admittedly, that's a lot of solar panels. But the payoff would be enormous: stiff competition and economies of scale would drive down system prices nationwide; more than 50,000 good-paying American jobs would be created across the United States; and there would be an estimated $61 billion in annual energy savings for homeowners, businesses, schools and governments.

But just as importantly, there also would be invaluable environmental benefits. This dramatic expansion of SHC systems will allow America to generate nearly 8% of its total heating and cooling needs through clean solar energy, displacing an estimated 226 million tons of carbon emissions annually. That's the equivalent of mothballing 64 coal plants.

Clarence Kemp would be proud – but so are we! Today, innovative solar heating and cooling systems are offering American consumers cost-efficient, effective options for meeting their energy needs, while lowering their utility bills.

So, yes, we're excited about the future. As the voice of solar energy in Washington, D.C. and state capitals around the nation, SEIA's #1 job is the adoption and expansion of smart, forward-looking public policies, which are critically important to the future growth of America's solar energy industry.

Moving forward, we need to do a better job of educating policymakers – at both the state and federal level – about the enormous benefits SHC provides, and why it's so important to have a diversified thermal energy supply in the future.

With the launch of the SHC roadmap, we are now embarking on yet another new, exciting journey. At times, it will be filled with twists and turns – and, yes, we'll hit some speed bumps along the way, too.

But given what's at stake for both the economy and the environment, the destination will be worth the drive!

Executive Summary

The heating and cooling of air and water are essential parts of our everyday lives, supporting our comfort, safety, and productivity. However, these services come at a cost, with approximately 44% of energy consumption in the United States directly attributable to heating and cooling. Solar heating and cooling (SHC) can play a significant role in providing an economically viable and environmentally sustainable long-term solution to these essential needs.

This report seeks to establish:

1. How SHC fits into the current U.S. energy picture
2. Key benefits of the technology
3. The current condition of the SHC market
4. Specific national targets
5. Policies needed to achieve these targets

The current U.S. energy picture

Current dialogue about energy in the United States is centered around electricity and transportation. However, a third element is missing from this discussion: **the thermal energy that is used for all heating and cooling end-use applications**. The residential, commercial, and industrial sectors spend over $270 billion annually on heating and cooling. SHC technologies possess a wide range of applications and proven uses, including domestic water heating, space heating, swimming pool heating, air conditioning, process heating, steam generation, and air heating.

SHC draws from an inexhaustible energy source while displacing fossil fuels and electricity otherwise needed for heating and cooling. This reduces emissions of CO_2 and air pollutants while stimulating local job and economic growth. As a mature, low-risk technology, SHC is deployable throughout the U.S. given our vast solar resources.

Basics and benefits

Solar heating collectors capture the sun's energy and efficiently transfer this heat for heating and cooling applications - easily integrating into most buildings. SHC equipment consists largely of copper, aluminum, steel, or polymers, most of which are easily recyclable and non-toxic. Systems are typically sized to the specific water heating or space conditioning loads of the building.

Residential solar water heating systems typically range between $6,000 to $10,000, while commercial and industrial systems generally fall within the $20,000 to $1,000,000 range per system. Depending on application, location, and financial incentives the payback period can be as little as 4 to 8 years.

Capital expenditures (CAPEX) for SHC systems are often higher than conventional fuel systems, although operational expenses (OPEX) are much lower since the fuel is generated and supplied for free. There is no price volatility with solar energy, so given its lower OPEX it is often easier for businesses and families to budget fuel expenses over the long term with SHC installed.

Employment in the SHC sector currently exceeds 5,000 jobs. Since these positions are largely installation-driven, they cannot be outsourced. These jobs are higher paying, with median wages 13% above those in other U.S. industries. With an increased national emphasis on manufacturing and a growing global need for SHC equipment, the U.S. has the opportunity to invest in and expand its domestic manufacturing base.

The U.S. is the world's second largest emitter of carbon dioxide (CO_2), and as such is a contributor to extreme weather events and health related issues attributable to global warming. SHC technologies emit 0 pounds of CO_2 per MWh_{th} of thermal energy generated, while natural gas - the 'cleanest' option of the fossil fuels - emits 400 pounds of CO_2 per of MWh_{th} of generation. In many circumstances, SHC displaces combustion pollutants generated within our homes or places of business, supporting a reduction in the amount of pollutants we breathe every day.

Current market conditions

Each year approximately 30,000 SHC systems are installed in the U.S., generating an estimated $435 million in annual revenue. There is currently 9 GW_{th} of SHC capacity installed in the U.S., which ranks 36th in the world in installed capacity relative to its population. The vast majority of SHC installations are located in China (152.2 GW_{th}) and Europe (39.3 GW_{th}). The majority of these applications are for water heating, though commercial-scale solar space cooling is already being deployed in Japan, Korea, and China. In developed markets, such as Austria, combination water and space heating systems make up 50% of installations.

The solar heating market saw a period of rapid growth in 1978 when a 40% federal investment tax credit was introduced following the oil crisis. Coupled with additional state tax credits, this caused a dramatic ramp-up of the solar market and drove innovation within the SHC industry. However, the federal tax credit was allowed to expire at the end of 1985, causing the solar heating market to contract sharply. A Congressional Budget Office report noted that from 1916 to the 1970s, federal energy-related tax policy focused almost exclusively on increasing the production of domestic oil and natural gas. An independent analysis has shown that across the period of modern energy infrastructure development, the gas and oil industries have been provided an annual average of $4.86 billion in Federal support. This has created an uneven playing field with other energy technologies, establishing a number of market barriers to SHC adoption that must now be addressed. These barriers include lack of consumer awareness of SHC as a heating and cooling option, high upfront costs due to lack of volume, unclear permitting and building code guidelines, and under-developed industry distribution channels.

National SHC targets

The policy recommendations in this Roadmap target the installation of 300 GW_{th} of SHC capacity by 2050. Without adoption of the *Recommended Policy*, and continuation of *Business-as-Usual*, 75 GW_{th} of capacity is expected to be installed by the same point in time. To reach the more aggressive goal, a deployment of 100 million SHC panels, or in lay terms, about 10ft^2 of solar collector area per person, is required. By achieving this goal, SHC can generate nearly 8% of the total heating and cooling needs in the United States by 2050.

Achieving these targets will produce a number of positive economic and societal impacts. The creation of over 50,000 jobs driving $61 billion in annual energy savings will allow Americans to keep additional money in their pockets while creating long term local jobs. Furthermore, deployment of SHC can avoid at least $19.1 billion in expected transmission and distribution upgrades to the existing electric and natural gas infrastructures.

This deployment will avoid 226 million tons of CO_2 emissions annually, or the equivalent of taking 64 coal plants permanently offline. Distributed SHC generation can also mitigate localized environmental damage through the partial displacement of fossil fuel related drilling, extraction, transportation, and storage.

Policies needed to achieve targets

Renewable heating and cooling standards would strongly complement existing renewable energy policies. The policies required to meet national targets should be long-term oriented and provide financial incentives. Long-term targets with clearly defined goals can take many forms - including Renewable Portfolio Standards (RPS) with SHC eligibility, Renewable Thermal Standards, and building mandates.

The three main types of financial incentives are tax credits, rebate/grant programs, and Renewable Energy Credits (REC). Successful financial incentives allow businesses to make investments under predictable, long-term economic conditions.

Similar to the SunShot Initiative, the Federal government should also take a leadership role in reducing soft costs of SHC to achieve cost competitiveness with conventional fuels.

Other supporting programs include consumer awareness campaigns, research and development for innovation, demonstration projects, and workforce development.

Solar energy is widely supported in the U.S., with both Republicans and Democrats favoring solar above all other forms of energy. Sustained and smart investments in SHC will facilitate a unified transition to clean and low-cost heating and cooling solutions for the United States.

(Photo: SunTrac Solar)

Today, more than 30,000 solar heating and cooling systems (SHC) are being installed annually in the United States, employing over 5,000 American workers from coast to coast.

(Photo: Sunwater Solar)

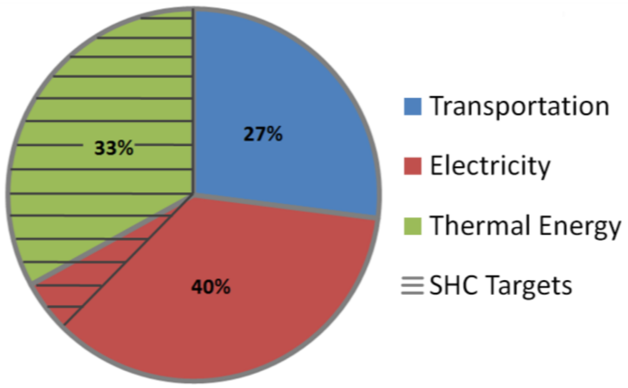
1. The United States Energy Picture

Current dialogue about energy in the United States is centered around electricity and transportation. However, a third element is missing from this discussion: **the thermal energy that is used for all heating and cooling end-use applications**. Any long-term U.S. energy strategy must include thermal energy generation and consumption as part of the "all-of-the-above" energy resource development approach.

DIRECT THERMAL CONSUMPTION & GENERATION

Virtually every home, office building, warehouse, and manufacturing facility in the U.S. uses thermal energy. Thermal energy is used for building space heating, water heating, industrial process heating, and swimming pool heating. It is also possible to shift space cooling to a thermally driven process powered by solar heat.

Thermal energy directly consumed as heat represents 33% of today's U.S. end-use energy, with another 11% of final energy demand used for space cooling.[1]



United States energy loads and target SHC offsets.

Fuels currently used to meet this demand include natural gas, coal, oil, and propane. However, thermal energy can also be generated from renewable sources such as solar, biomass, and geothermal. Collectively, these systems are referred to as renewable heating and cooling technologies. Products that convert sunlight into usable thermal energy are known as solar heating and cooling (SHC) technologies.

Thermal energy is often measured in terms of British Thermal Units (BTUs)—the amount of energy required to raise 1 pound of water 1° Fahrenheit—or 'therms,' both of which can readily be converted into kilowatt-hours (kWhs).[2]

SHC TARGET SECTORS: RESIDENTIAL, COMMERCIAL, & INDUSTRIAL

Today, 27% of U.S. end-use energy is consumed by the transportation sector, 40% is consumed as electricity, and 33% is consumed as thermal energy for heating water, air, and process heating. This consumptive load provides ample opportunity for SHC integration since SHC technologies possess a wide range of applications and proven uses throughout the residential, commercial, and industrial sectors.

Residential Sector: Typical residential SHC applications are domestic water heating, space heating, and space cooling.

Water Heating, Space Heating, and Space Cooling

Over 9 million residential water heaters are replaced annually, creating an excellent opportunity to incorporate solar water heating at a low incremental cost.[3] In the U.S., roughly 80% of the existing SHC market volume is in the small residential sector.[4] Many residential solar water heating projects can be installed in as little as one

[1] www.eia.gov/energyexplained/

[2] 1 therm = 100,000 BTU = 29.3 kWh. See more under Definitions, Terms, and Unit Conversions.

[3] AHRI: Residential Storage Water Heaters Historical Data Report

[4] U.S. Solar Market Insight 2010

day. In some cases, larger combination space and water heating systems are installed to meet more of the energy demand in a residence.

With solar space cooling, often called solar assisted cooling or air conditioning, larger residential systems can be used for space heating in the winter and cooling in the summer.

In the U.S., 115 million homes consume $266 billion of energy annually, of which approximately 72% is related to water heating, space heating, and space cooling.[5] For comparison, this expenditure is equivalent to putting 10 million Americans through college every year.[6]

A residential SHC installation (Photo: Viessmann)

Residential Pool Heating

Solar swimming pool heating is the most widely used application of solar heating technology in the U.S. today. In recent years, over 30,000 solar pool heating systems have been installed annually.[7] Over the last 35 years, significant market penetration has been achieved nationwide for pools located at single-family residential homes due to simple installations and rapid payback periods.

SEIA's goal is to install 100 million SHC panels over the next 35 years.

A residential solar pool heating installation
(Photo: Aquatherm)

Commercial: Typical commercial applications include space heating and cooling and water heating. Building types that are particularly well-suited include military facilities, manufacturing plants, large multi-family residential buildings and affordable housing, municipal facilities, hotels, elderly and student housing, hospitals, sport centers, and agricultural operations. In the U.S. there are 4.8 million commercial buildings which consume $107.9 billion of energy annually, of

[5] http://buildingsdatabook.eren.doe.gov/
[6] At average of 26,600 per year cost for college
[7] http://www.seia.org/cs/research/SolarInsight

which approximately 47% is related to heating and cooling.[8]

Fenway Park's solar hot water system helped power the Boston Red Sox organization as they cruised to their 2007 World Series victory. (Photo: Gro-Solar)

Air Conditioning

Solar space cooling (air conditioning) can be accomplished using thermally activated cooling systems (TACS) driven by solar energy. The two most commonly used types are solar absorption systems and solar desiccant systems.

The use of solar air conditioning is increasing, albeit slowly. The market potential for solar cooling is very significant given the high cost of electric air conditioning. Furthermore, air conditioning demands are a primary contributing factor to strain on electrical grids during hot weather, precisely the same time that solar cooling equipment functions best.

[8] http://buildingsdatabook.eren.doe.gov/

Commercial Pool Heating

Businesses such as hotels, resorts, apartment complexes, health clubs, and schools are perfect candidates for solar pool heating since pools must be maintained at a comfortable temperature. As an example, the amount of energy required to heat a competition-sized outdoor pool located in a warm climate such as California is equivalent to the annual natural gas consumption of approximately 150 single-family homes, so significant energy savings can be achieved in this area.

As of 2008, there were over 186,000 heated commercial pools nationwide. Of these, approximately 62%, or 115,540, were indoors and required year-round heating.[9]

Commercial pool heating installations can extend swimming seasons. (Photo: FAFCO).

Industrial & Warehouse: Typical industrial SHC applications include process water heating, preheating of steam makeup water, air heating, and process cooling. In the U.S. there are 350,000 industrial facilities which consume $94.4 billion worth of energy annually, of which

[9] PK Data, IRL80 2008 U.S. Commercial Pool Market Statistics.

approximately 30% is related to heating and cooling.[10]

Process Water and Steam Heating

Industrial-scale solar heating can be readily applied to hot water and steam applications such as food processing, pasteurization, sterilization, beer and wine production, and water desalination. SHC systems can heat the water directly, or provide a boost to an existing boiler system.

Air Heating

Solar air heating systems can deliver solar heated air up to 180°F, making the systems well-suited for industrial preheating processes, crop drying, laundry drying, or dehumidification applications. The industrial sector has a large potential for space heating with solar air systems proving low-cost energy during all daytime hours.

(Photo: Paradigm Partners)

Solar air heating system vertically installed on exterior wall at Fort Drum, New York
(Photo: Solar Wall).

PLANNING FOR A SECURE THERMAL FUTURE

There are many established targets for renewable transportation fuels at the federal and state levels, as well as for renewable electricity in 37 states.[11] However, there are few targets for renewable heating and cooling or solar heating and cooling specifically, representing a major gap in U.S. energy policy. To date, renewable heating and cooling technologies have mainly been incorporated into policies promoting renewable electricity generation, and market penetration of SHC in the U.S. remains low.

[10] Energy Information Administration. CBECS Data; www.eia.gov/consumption/

[11] http://www.dsireusa.org/rpsdata/

Renewable heating and cooling standards would strongly complement existing renewable energy policies. As such, SHC is a favorable option since it:

- Uses an inexhaustible energy source
- Displaces fossil fuels and electricity otherwise needed for heating and cooling
- Reduces emission of CO_2 and air pollutants
- Stimulates local job and economic growth
- Is a mature and low-risk technology
- Is deployable throughout the U.S. given vast distributed solar resources

In order to take full advantage of these benefits, the U.S. must begin crafting policies that support accelerated deployment of SHC technology.

This SHC Roadmap is designed to help policymakers at the federal, state, and local levels understand the benefits and potential of SHC technology and assist them in crafting successful policies to support the widespread and long term adoption of solar heating and cooling throughout the U.S.

(Photo: Sunwater Solar)

(Photo: Apricus)

An expansion of SHC systems will allow America to generate nearly 8% of its total heating and cooling needs through clean solar energy, displacing an estimated 226 million tons of carbon emissions annually. That's the equivalent of mothballing 64 coal plants.

2. Solar Heating & Cooling: Basics and Benefits

Solar heating systems are based on a simple process everyone is familiar with: things left in the sun tend to heat up. Given modern advances, this energy can be captured more efficiently and safely than at any point in history. Solar heating systems typically produce 45 kWh_{th} to 102 kWh_{th} per square foot of installed collector area per year (or 1.5 to 3.5 therms/ft^2 in equivalent heat units)[12], which is up to 80% of all the available solar energy hitting the surface of the collector.

Enough free energy falls on American roofs each year to meet our heating and cooling demands.[13]

The amount of energy used each year by the average American household for water heating is equivalent to the energy captured by just one or two solar heating collectors occupying about 60 ft^2. In northern states, a substantial portion of home space heating demand can be met by a larger number of collectors, typically occupying up to 400 ft^2. Southern states, which have lower overall heating demands but high cooling costs during summer months, could benefit greatly from solar cooling. Across the entire country, there are many opportunities for SHC to reduce energy costs for homeowners and businesses.

TECHNOLOGY DESCRIPTION

The basic method by which SHC technologies operate is simple: when the sun shines, solar heating and cooling systems capture this energy for use in processes that are essential to our everyday lives.

Solar Heating Collectors

SHC technology utilizes different types of solar collectors based on the specific application, or, in some cases, the preference of the user. Simple unglazed collectors are typically used to heat pool water or preheat large volumes of industrial process water in warm climates. Flat plate, concentrating, and evacuated tube collectors use transparent cover plates or glazing, metal or polymer absorbers, and insulation to efficiently produce heat at higher temperatures. These collectors are often used to provide water and space heating up to 200°F. Concentrating collectors can deliver heat in excess of 300°F-400°F for steam generation in industrial and manufacturing processes. On sunny days, solar heating technologies can also be used to preheat incoming "make-up" air from 30° to 100°F above ambient temperature, thereby reducing the amount of heat required by backup conventional heating systems.[14]

Additional schematics for the collector types described above can be found in the Addendum to this report.

Sizing a System

Systems are typically sized to the hot water or space conditioning loads of the building. For example, a home consuming 50 gallons of hot water per day for showering and laundry could be satisfied by the installation of a two panel system (about 60 ft^2 of collector area).[15] Numerous modeling software options can be used to predict

[12] One therm is equal to 100,000 BTUs. See more under Definitions, Terms, and Unit Conversions.
[13] Total housing rooftop area of 172.4 billion ft^2 in United States
[14] Solar Engineering of Thermal Processes - 3rd edition, John A. Duffie and William A. Beckman
[15] This assumes the incoming water is at a temperature of about 50°F and the set water tank temperature is at 130°F.

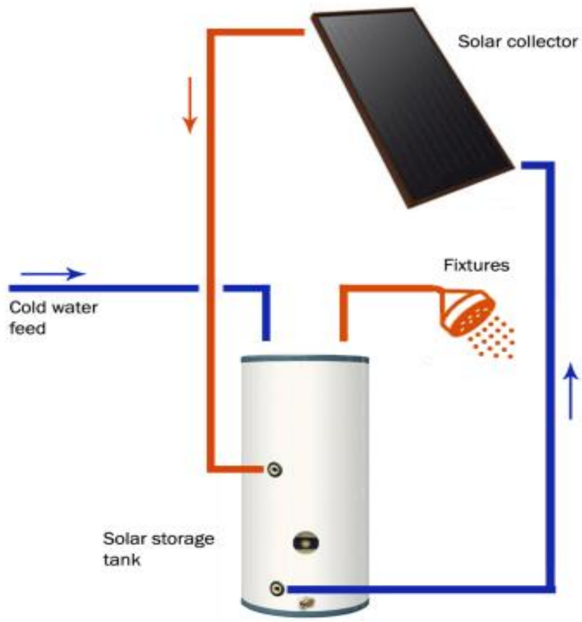
expected energy production and optimize design with great accuracy.

Solar Water Heating Systems

Solar water heating systems are composed of the following main elements: the solar collector, insulated piping, heat transfer fluid, a hot water storage tank, and a system controller. While there are many variations of SHC systems, this figure represents a commonly used domestic hot water heating system. Solar water heating systems operate as follows:

1. The solar collectors absorb sunlight, causing the fluid inside to heat up.
2. A controller senses that the collector fluid is hotter than the storage tank and signals a pump to turn on.
3. The pump circulates heat transfer fluid which carries heat from the collector to the storage tank.
4. The storage tank holds the heated water which is used as necessary. Auxiliary heating remains connected to the storage tank for back-up heating when needed.

(Photo: Cape Fear Solar Systems)



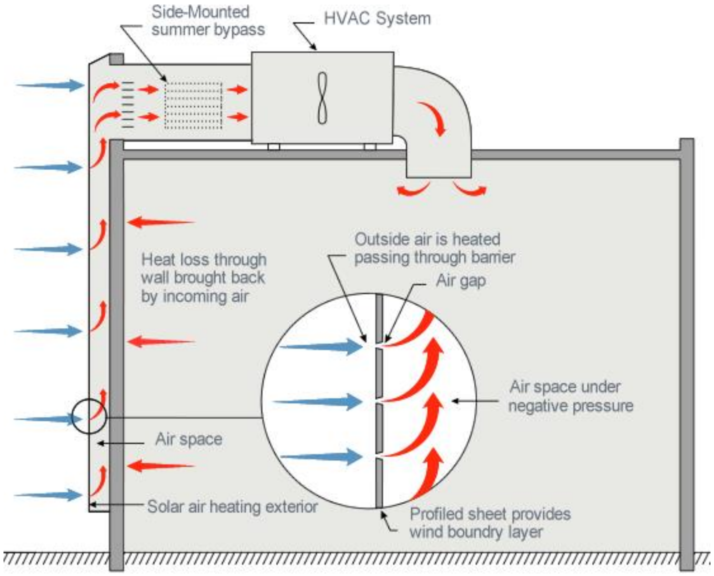
Schematic of a typical solar water heating system

Solar Air Heating Systems

Indoor space heating is the largest single use of energy in most buildings. Solar air heating systems use solar energy to heat indoor spaces in residential and commercial applications, as well as to heat air for manufacturing processes and agricultural crop drying applications. Most solar air heating systems are either wall-mounted or roof-mounted and generally located near the central air intake for the building. Large-scale solar air heating systems operate as follows:

1. Fresh air is drawn through small micro-perforations located in the solar heating collector.
2. The air is preheated by the solar air system anywhere from 30° to 100°F above ambient temperature.
3. The heated fresh air is distributed into the building through the existing HVAC system.

In additional to reducing fossil fuel and electrical demands for heating, solar air heating systems integrate easily into a building's façade.



Schematic of a typical solar air heating system

Solar Cooling Systems

Solar-driven cooling can be accomplished using thermally activated systems driven by solar energy. The two most commonly used types are solar absorption systems and solar desiccant systems. Solar absorption systems use thermal energy to evaporate a refrigerant fluid to cool air. In contrast, solar desiccant systems use thermal energy to regenerate desiccants that dry air, thereby cooling it. When a solar desiccant system is used together with a conventional air conditioner, the conventional unit can typically be set at a higher temperature, thereby using less energy.

Operations and Maintenance

Solar heating and cooling systems can integrate easily with existing heating and cooling systems, acting as a preheat to reduce the amount of fossil fuel or electricity required within the building. Once a SHC system is installed, the only cost is minimal periodic maintenance over its expected 25 to 30-year lifetime.

Recyclability of Materials

SHC equipment consists largely of copper, aluminum, steel, or polymers, most of which are easily recyclable and non-toxic. Therefore, SHC has a minimal impact on the environment and can be repurposed at the end of the collector's life.

QUALITY AND RELIABILITY

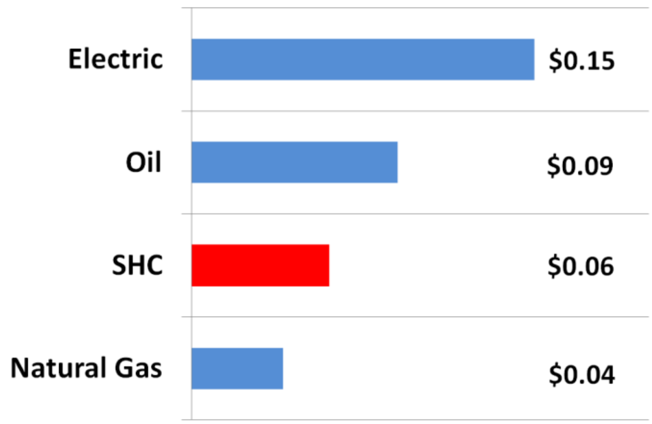
During the past three decades, the SHC industry has made significant advances in quality and reliability of SHC equipment. Most current policies supporting SHC include quality control measures as a prerequisite for participation. Standards for testing individual solar heating collectors include the Solar Rating & Certification Corporation (SRCC™) Standard 100 and the International Organization for Standards (ISO) Standard 9806. Standards for packaged SHC systems include SRCC™'s Standard 300, and other solar heat-related standards are in development. SRCC™ and the International Association of Plumbing and Mechanical Officials (IAPMO) certify collectors and systems to these standards. IAPMO and the International Code Council (ICC) also certify to IAPMO's Uniform Solar Energy Code, an American National Standard.

In order to accurately meter the quantity of thermal energy generated by SHC systems, the American Society of Testing and Materials (ASTM) and IAPMO, supported by the US Environmental Protection Agency (EPA), are developing a heat metering standard for the U.S. which addresses both renewable and non-renewable systems.

ECONOMICS

SHC system costs include the purchase and installation of solar collectors, collector mounting equipment, storage tanks, pumps, controllers, piping, insulation, and connection to HVAC units. While the cost of installation is sometimes higher than for a comparable gas or electric system, operational expenses of SHC systems are typically much lower given that the fuel is free sunlight, and simply requires collection for use.

It is important to note that while point of use costs for natural gas are currently lower than solar heat in most regions, with good policy enactment leading to industry development, solar can provide a low-cost option. Furthermore, externalized costs and future volatility in fuel prices are not represented in current energy prices and must be considered when selecting a fuel.



Levelized fuel costs, \$/kWh$_{th}$ [16]

Additionally, when solar is included in a mortgage or new building financing, the user can often realize an immediate positive cash flow when the fuel cost savings exceed the additional incremental cost or monthly payment of installing the SHC system.

Residential

The out-of-pocket cost of an installed residential solar domestic water heating system typically ranges between $6,000 to $10,000, depending on system type and geographic location.[17] This cost is significantly reduced by the Federal Investment Tax Credit (ITC) and various local, state, and utility incentive programs. Those who install systems typically find these incentives bring the out-of-pocket cost down to $3,000 to $5,000 with a simple payback in the four to eight year range, after factoring in Federal ITC and other state or utility grants.

Today, innovative solar heating and cooling systems are offering American consumers cost-efficient, effective options for meeting their needs, while lowering their utility bills.

Commercial & Industrial

Commercial systems help companies reduce energy bills and manage long-term costs. While fossil fuel and electricity prices are expected to increase over the coming decades, the cost of solar energy will remain the same—free. Commercial system costs can vary widely depending on the heating or cooling load they are sized to, and can range from $20,000 to $1,000,000 per system,[18] with a payback period as short as 4 to 8 years for some systems depending on application, location, and available financial incentives.

[16] http://www.eia.gov/consumption/residential/

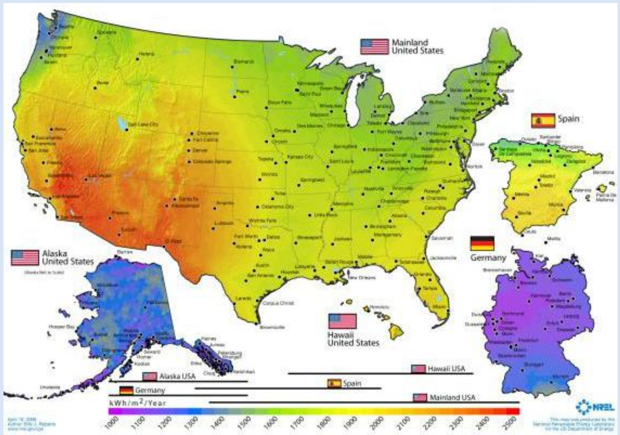
[17] http://www.masscec.com/technology/solar-hot-water, project database

[18] www.csithermal.com, project database

Solar Resource

Though not widely referred to as such, solar energy is our chief domestic energy import and is the foundation of nearly all energy infrastructures worldwide, since it is absorbed into plants, oceans, and land. Over a long enough timeframe, it is responsible for all existing energy sources, including fossil fuels.

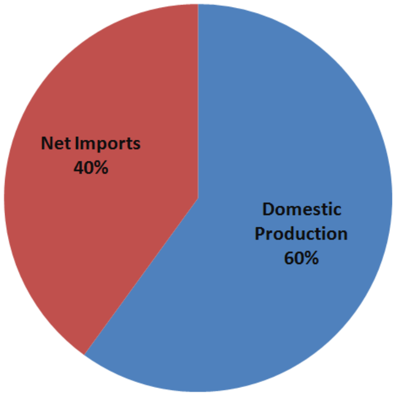
The United States is fortunate to have excellent solar resources. Put in perspective, Germany, a world leader in solar energy production, has solar resources similar to that of Alaska, one of the least sunny U.S. states. Accessible to nearly all citizens, SHC empowers Americans to make their own decisions about their energy supply.



A reliable and stable energy supply is vital to the well-being and security of our society, as history shows that it is unwise to place too much emphasis on a single source of energy, either foreign or domestic. The makeup of the current U.S. energy portfolio renders it highly vulnerable to disruption, particularly from infrastructure failures, natural disasters, or deliberate acts such as terrorism.

SHC is able to circumvent the environmental and security issues typically encountered with the extraction, processing, and distribution of conventional fuels because SHC utilizes sunlight delivered at or near the point of use. In this way SHC mitigates the impacts of supply disruptions by bypassing risky supply and distribution channels. Additionally, serious political and security implications have arisen from US dependence on fuel supplies from volatile regions of the world.

As a country, we spend tens of billions of dollars annually to acquire energy that simple on-site SHC systems can generate. Since solar energy is a domestic energy source, money remains within the country to be reinvested into the economy.



In 2012, net imports provided 40% of the petroleum and other liquid fuels that were consumed in the U.S., which can also be used for heating purposes.[19]

Having realized the security and economic benefits of SHC, numerous countries including China, Turkey, Austria, Germany, Australia, and Israel are aggressively deploying SHC technologies. In Israel today, all new residential buildings are legally required to install solar water heating systems. The fact that 90% of Israeli homes use solar water heating is exemplary of how low-risk, low-cost SHC technology can be

[19] U.S. Energy Information Administration, Monthly Energy Review (April 2013)

pursued as part of a comprehensive national security platform.[20]

Modern Energy Infrastructure

SHC systems can provide strategic value to utilities, including peak load demand reduction, load factor improvement, and increased system reliability.[21] SHC is simple to deploy and is an excellent first-line renewable generation option for utilities looking to strengthen their distribution systems.

Although these positive impacts will vary widely by utility, geography, and climate, demand reduction can be one of the key benefits provided to utilities by SHC. For example, summertime cooling continues to be one of the fastest growing sources of energy consumption in the U.S., requiring new generation plants and transmission infrastructure. Hot and sunny summer days are ideal for solar cooling, which has the potential to reduce peak energy demand and potentially defer the need for utility investments.

In most areas in the U.S., solar heating and cooling can be an effective part of the energy supply equation, providing both heating and cooling to critical infrastructure, such as hospitals and government centers, while simultaneously reducing demands on the electrical grid and natural gas distribution system.

LOCAL JOB CREATION

Employment in the domestic SHC sector currently exceeds 5,000 jobs. Since these positions are largely installation-driven, they cannot be outsourced. With SHC adoption increasing to the target capacity of 300 GW_{th}, employment would reach 50,250 fulltime jobs within the next decade and over 115,000 fulltime jobs by 2050.[22]

The SHC contracting sector employs six major professional trades—plumbing, roofing, siding, HVAC/mechanical, electrical, and engineering. In addition, SHC jobs include positions in manufacturing, sales, project development, distribution, and maintenance. These jobs are typically higher paying, with median wages in the clean energy sector currently 13% higher than those in other U.S. industries.[23]

Copper pipes for circulating heating fluid through a collector are soldered together.
(Photo: New England Solar Hot Water).

Manufacturing

With an increased national emphasis on manufacturing and a growing global need for SHC equipment, the U.S. has the opportunity to invest in and expand its domestic manufacturing base. Increased volumes will lead to greater automation and enable fixed manufacturing costs to be spread out over a greater number of units. SHC products are currently sourced primarily from

[20] Grossman, Gershon. *Renewable Energy Policies in Israel*. In Handbook of Energy Efficiency and Renewable Energy by Frank Kreith and D. Yogi Goswami. 2007
[21] Rethinking Solar Water Heating in an Age of Booming PV.

[22] SHC Alliance
[23] http://www.brookings.edu/research/reports/2011/07/13-clean-economy

manufacturing plants in the U.S., Europe, and Asia. Solar air heating systems are primarily manufactured in the U.S.

Distribution and Sales Channels

Marketing and sales channels for SHC are primarily limited to specialized distributors and contractors, whereas conventional heating and cooling systems are available through big-box retailers and most plumbing or Heating, Ventilation, Air Conditioning (HVAC) wholesalers/distributors. Therefore, sales and marketing costs on a 'per unit' basis for solar heating are very high at this time, but are expected to decrease significantly as the market scales up and distribution channels similar to HVAC emerge.

CLIMATE CHANGE IMPACTS

After China, the U.S. is the world's second largest emitter of greenhouse gases, including carbon dioxide (CO_2). Our high CO_2 emissions are largely correlated with high fossil fuel consumption. These emissions are contributing to rapid climate change and subsequent severe health, environmental, and economic impacts over the short- and long-term. For example, Sandia National Laboratory estimated a net GDP loss of $1.9 trillion dollars to the U.S. between 2010 and 2050 due to climate change-induced drought.[24]

Different fuels emit different amounts of carbon dioxide in relation to the energy they produce. To compare emissions across fuels you must compare the amount of CO_2 emitted per unit of energy output or heat content. [25]

Coal	214
Gasoline	157
Propane	139
Natural gas	117
SHC	0

Pounds of CO_2 emitted per million BTU of energy.

SHC can play a role in reducing and mitigating these impacts by replacing carbon-emitting fossil fuels with solar energy. Installation of a solar water heating system on a single-family home reduces CO_2 generated onsite by 28% on average, and the deployment of a combination space and water heating system can reduce emissions by over 60%.[26] Likewise, solar air heating systems can replace immense amounts of fossil fuels at businesses and manufacturing plants with high makeup air volumes.

Air Quality Improvements

In addition to reduced CO_2 emissions, decreased onsite combustion of fossil fuel translates directly into improved indoor and local air quality. This is greatly beneficial for urban areas which are prone to higher levels of air pollution. By displacing local fossil fuel combustion, SHC can contribute to reduced emissions of particulate matter, ozone, and other hazardous air pollutants defined in the Clean Air Act, such as sulfur dioxide and nitrogen dioxide.

[24] http://prod.sandia.gov/techlib/access-control.cgi/2010/100692.pdf
[25] http://www.eia.gov/tools/faqs/faq.cfm?id=73&t=11

[26] Based upon typical solar fraction and 80% efficiency of existing heating system.

SHC is one of the few technologies that can vastly decrease localized emissions by directly reducing the combustion of carbon emitting fuels on site.

(Photo: Sunwater Solar)

With the expected operational life of solar heating collectors extending up to thirty years, even a small solar heating system has the ability to displace significant quantities of fossil fuels or electricity, thereby avoiding emissions of thousands of pounds of CO_2 and other pollutants into the atmosphere.

Health Impacts

Pollution associated with the burning of fossil fuels costs billions of dollars annually in health costs.[27] A 2012 World Health Organization study found that toxic particulate matter created by fuel combustion can cause diseases such as pneumonia and cancer, and contributes to over six million premature deaths worldwide.[28] Furthermore, the U.S. bears over $50 billion in asthma-related costs each year, which is directly linked to poor air quality, particularly in cities and urban areas.[29] The fuel displaced by SHC is either burned on site or at a regional power plant. Since fossil fuel combustion is reduced with the deployment of SHC, it has the ability to reduce combustion pollution in our homes and neighborhoods.

(Photo: Sunnovations)

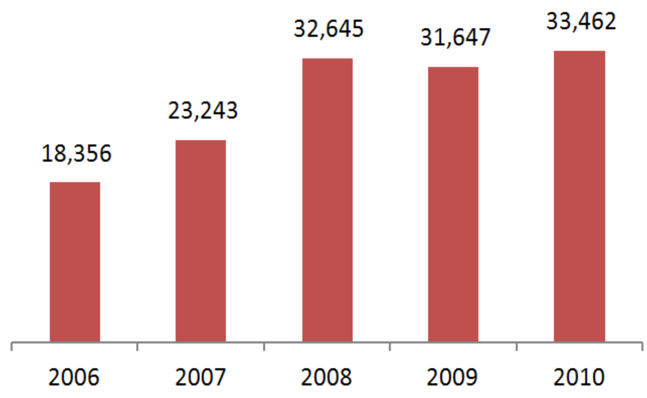
[27]Full cost accounting for the life cycle of coal
[28] Environmental Health and Sustainable Development, Dr. Maria Neira, World Health Organization, 2012
[29] The Economic Affliction of Asthma and Risks of Blocking Air Pollution Safeguards

3. Current Market Conditions

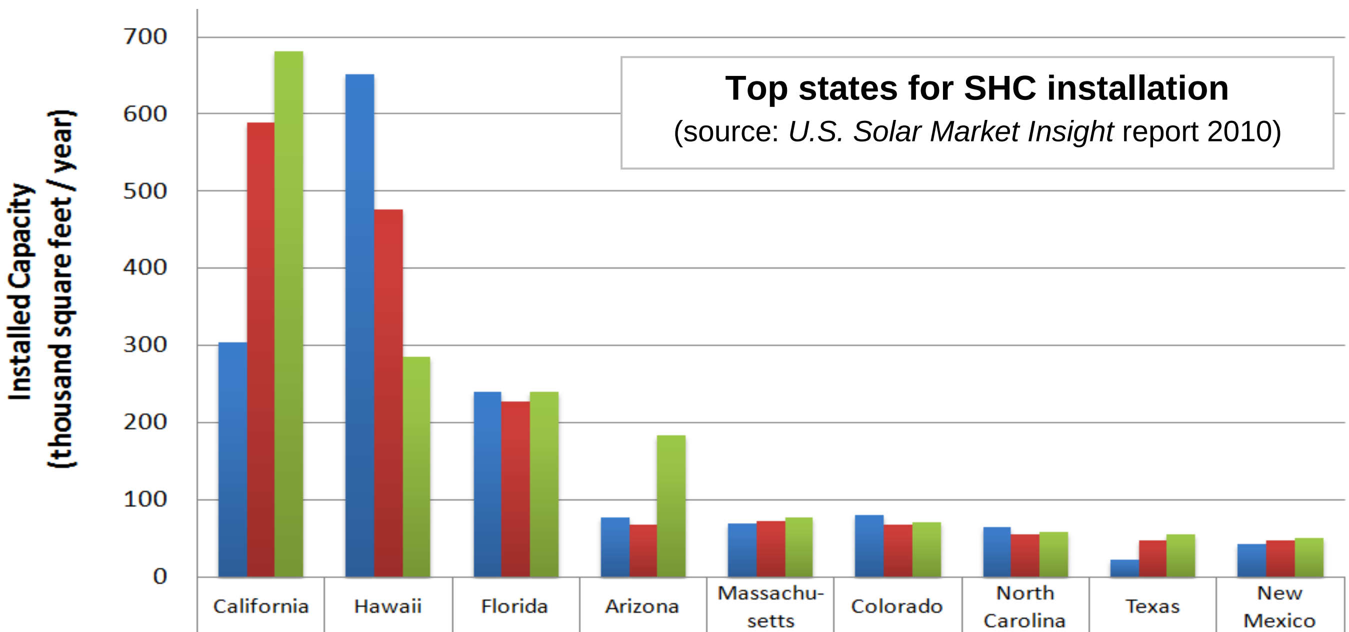
UNITED STATES MARKET

Today the SHC industry provides highly reliable solutions for heating and cooling. Each year approximately 30,000 SWH systems are installed, generating an estimated $435M in revenue.[30] Despite being a mature, low-risk technology, market penetration of SHC in the U.S. is low, with only 9 GW_{th} of installed capacity.[31] For perspective, China is installing systems at a rate approximately 10 times that of the U.S.[32] The U.S. ranks 36th in the world in installed capacity relative to its population.

Installed capacity in states varies widely, with California, Hawaii, Florida, Arizona, Colorado, Massachusetts, North Carolina, and Maryland leading the country. These higher growth rate states are largely driven by effective policy programs. Hawaii now has the highest per capita solar water heating use in the nation, with over 90,000 systems currently installed.[33]



Solar water heating installations in the United States



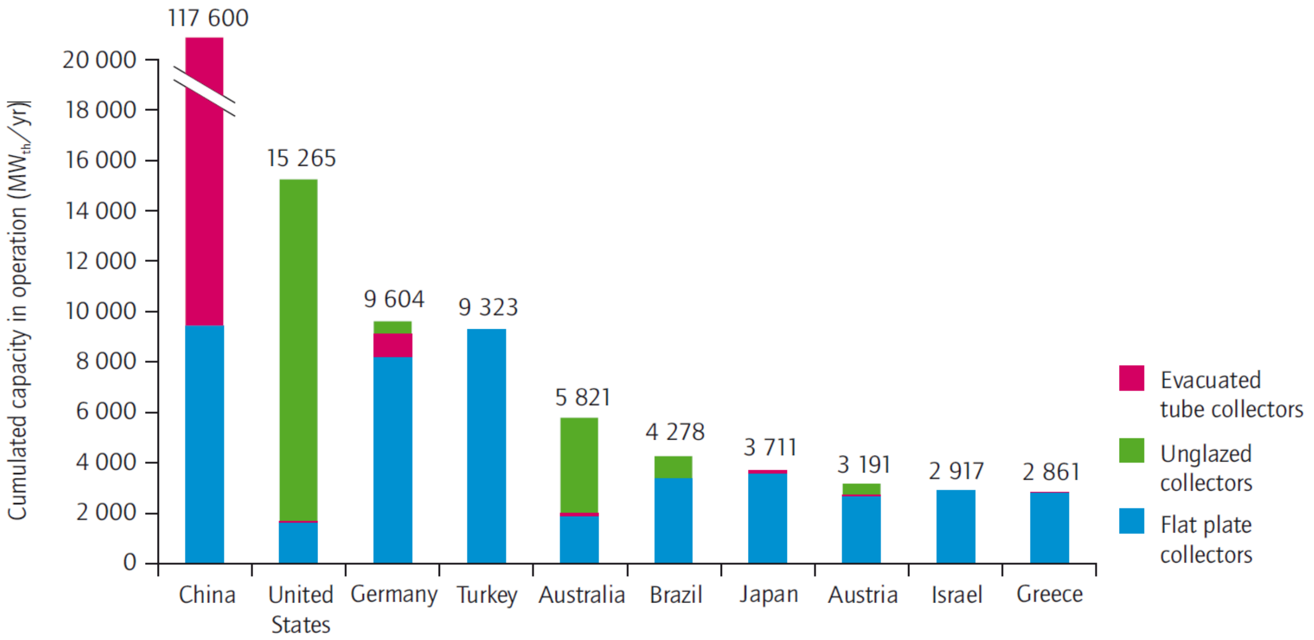
	California	Hawaii	Florida	Arizona	Massachu-setts	Colorado	North Carolina	Texas	New Mexico
2008	304	652	240	77	69	80	64	23	42
2009	589	476	227	68	72	68	56	47	48
2010	681	285	240	183	77	71	59	55	51

[30] U.S. Solar Market Insight Report, 2010
[31] 0.7 kW_{th} of capacity per m^2 of installed collector area
[32] Solar Heat Worldwide 2013
http://www.iea-shc.org/solar-heat-worldwide

[33] http://www.hsea.org/_blog/HSEA_Blog

Total installed capacity of water collectors in operation in 10 leading countries

Source: Weiss and Mauthner, IEA Technology Roadmap, Solar Heating and Cooling, 2012.



The U.S. imported $13.6 million dollars worth of SHC goods in 2010, while exporting $16.3 million for a positive trade balance of $3 million. Further, for every dollar invested in SHC technology, 79 cents stayed in the U.S. to support local economies.[34]

INTERNATIONAL MARKETS

The International Energy Agency Solar Heating & Cooling Program reported that by the end of 2011, an installed capacity of 234.6 GW_{th}, corresponding to a total of 335.1 million square meters of collector area, was in operation with an annual energy yield of 195.5 TWh_{th}. This corresponds to energy savings equivalent to 20.9 million tons of oil per year and emission reductions of 64.1 million tons of CO_2. The number of jobs in the fields of production, installation, and maintenance of SHC systems worldwide was estimated at 420,000 in 2012.[35]

The vast majority of SHC installations are located in China (152.2 GW_{th}) and Europe (39.3 GW_{th}), which together account for 81.6% of the total installed capacity worldwide. In China alone, an estimated 50-60 million households use solar water heating.[36] The remaining installed capacity was split between the U.S. and Canada (16.7 GW_{th}), Asia (excluding China), Latin America, Australia and New Zealand, Israel, Jordan, Lebanon, Morocco, Tunisia, and other Mediterranean and African countries.

Of all solar heating collectors currently in operation worldwide in 2011, 27.9% were glazed flat-plate collectors, 62.3% were evacuated tube collectors (mainly installed in China), 9.2% were

[34] U.S. Solar Energy Trade Assessment, 2011

[35] IEA Solar Heating & Cooling Programme, May 2013

[36] Christopher Flavin, REN21 (2010). Renewables 2010 Global Status Report p. 53.

unglazed flat-plate collectors, and 0.7% were glazed and unglazed air collectors.[37]

As shown in the figure at left, the U.S. is lagging far behind nearly every other region of the world, most notably China, in the deployment of glazed SHC technologies. Commercial-scale solar space cooling is already being deployed in countries such as Japan, Korea, and China; Australia has even published a new solar air conditioning standard. Furthermore, in developed markets, like Austria, combination water heating and space heating systems make up 50% of the market.

HISTORY IN UNITED STATES

The solar water heating market from the late 19th- to mid-20th century was driven by its superior economics. Solar heating provided a competitive alternative to coal and other fuels in warm states such as California and Florida. Between 1920 and 1950, an estimated 50,000 solar water heaters were sold and installed in Florida, and 80% of new homes built in Miami were equipped with solar heating systems.[38]

The shift of government financial support and the introduction of widespread natural gas distribution lines caused the solar heating market to contract significantly in the mid-1980s.

Solar water heating system on a Pomona, CA home circa 1905.

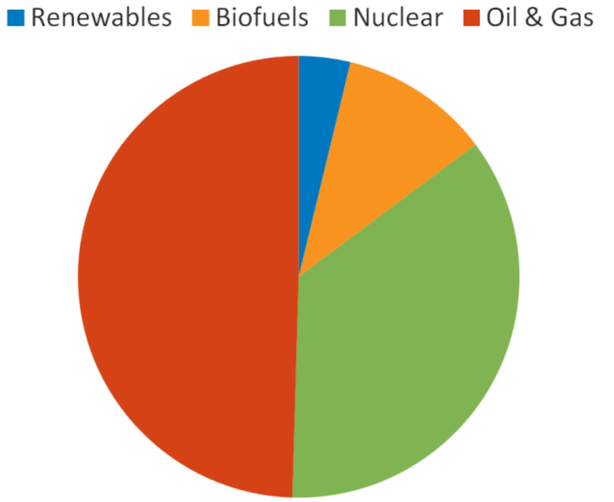
The solar heating market saw a period of rapid growth in 1978 when a 40% federal investment tax credit was introduced following the oil crisis. This federal tax credit was augmented by additional credits at the state level, such as in California where an additional 15% credit was offered. These tax credits caused a dramatic ramp-up of the solar market and drove innovation within the SHC industry.[39] However, the federal tax credit was allowed to expire on December 31, 1985 as part of sweeping tax reforms, causing the solar heating market to contract sharply. The number of solar heating product manufacturers decreased from over 300 to approximately 20, and solar air heating collector manufacturing effectively ceased after most of the 85 manufacturers closed down.[40]

The federal government subsidized traditional energy technologies for more than 60 years before beginning to support renewable energy. A recent Congressional Budget Office report noted that from 1916 to the 1970s, federal energy-

[37] International Energy Agency, Technology Roadmap, Solar Heating and Cooling, 2012
[38] Lane, T. (2011). A brief history of the American solar water heating industry. Ocala, FL:

[39] Government actions and innovation in clean energy technologies: California Public Utilities Commission.
[40] *Solar air systems: A design handbook*. London, UK: James & James (Science Publishers) Ltd.

related tax policy focused almost exclusively on increasing the production of domestic oil and natural gas; there were no tax incentives for promoting renewable energy or increasing energy efficiency.[41]



Levelized historical government support for energy technologies (1900 - 2010).[42]

TODAY'S MARKET BARRIERS

A vast majority of buildings in the U.S. have the necessary roof, wall, or ground space to meet a large percentage of our heating and cooling energy needs with solar. However, the infrastructure for widespread deployment does not yet exist in a national sense, thus creating a number of obstacles to overcome prior to increased adoption rates. It is critical for policymakers and the industry at large to develop innovative solutions to address and deconstruct the following market barriers:

I. **Uneven Playing Field with Other Energy Technologies**: Over the last century there has been a disproportionate policy focus on fossil fuels, electricity, and centralized energy infrastructure in the U.S. The lower-level state policies and incentives for solar heating, in the context of incentives for other solar and renewable energy technologies, have not effectively supported the adoption of solar heating technologies. Natural gas utilities, electric utilities, and state energy offices have not been mandated to develop renewable heating programs. Over the lifetimes of their respective subsidies, the oil, coal, gas, and nuclear industries have received approximately $630 billion in federal subsidies; while wind, solar, biofuels, and other renewable sectors have received a total of roughly $50 billion in government investment.[43]

II. **Lack of Awareness**: Awareness of SHC technology and its benefits among consumers, policymakers, and tradesmen is lacking. Many consumers are not aware that SHC technologies are a viable option, and even those familiar with solar energy are unclear on the difference between SHC technology (heat generation) and solar photovoltaic (electric generation).

III. **Upfront Cost**: SHC systems often cost more to install than conventional fossil fuel and electric heating systems, in large part due to lack of volume. This puts SHC at a competitive disadvantage, even though lifecycle cost assessments often favor SHC. Further, price volatility of competing energy sources such as natural gas makes it difficult to maintain consistent sales of SHC systems as short-term drops in fuel prices delay financial return on investment for customers.

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[41] CBO, http://1.usa.gov/H1XKkB.

[42] DBL Investors, http://bit.ly/uV14lf

[43] DBL Investors, http://bit.ly/uV14lf

IV. **Unclear Permitting and Building Code Guidelines:** The rules for permitting and installing SHC are unclear in many jurisdictions, potentially delaying the project and increasing project cost.

V. **Short-term Policies:** Support policies for SHC have been short-term and have not allowed for the long-term stability investors need to enter a market.

VI. **Industry Channels Still Developing:** SHC is not yet a mainstream technology with established construction, distribution, or financing channels. Therefore, it is often treated as a specialized option, which can increase costs and development time, thereby reducing the likelihood of SHC being deployed.

(Photo: Sunwater Solar)


(Photo: Aztec Solar)

Implementing the SHC Roadmap would create more than 50,000 good-paying American jobs across the United States, and there would be an estimated $61 billion in annual energy savings for homeowners, businesses, schools and governments.

4. National Solar Heating and Cooling Targets

Given its abundance and low cost, SHC will be a primary alternative to finite fossil fuels, though future growth will largely be determined by the amount of regulatory support at all levels of government. Effective market deployment happens when there is cohesive, long-term policy support in place that builds consumer demand, reduces installed costs over time, increases installation efficiencies, and generates marketable results.

The Recommended Policy targets the installation of 300 GW_{th} of SHC capacity by 2050. This target correlates to one SHC panel per American household.

This Roadmap examines two possible scenarios for the future of SHC in the United States — the *Business-as-Usual*[44] scenario and the *Recommended Policy*[45] scenario. Predicted growth patterns under these two scenarios are shown on the following page.

ECONOMIC IMPACTS

If the goals set forth in this policy roadmap are achieved and 300 GW_{th} of installed capacity are realized by 2050, SHC will generate enormous benefits across the range of stakeholders, including homeowners, businesses, and taxpayers.

[44] Assumes a 5% annual growth rate

[45] Assumes that 25% of residences, 15% of commercial buildings, and 10% of manufacturing plants have SHC installed by 2050.

These key benefits include nearly $100 billion per year in positive economic impacts, including:

- $61 billion in annual energy savings resulting in $421 increase in per capita disposable income[46]
- $19.1 billion in deferred electric and natural gas infrastructure expansion and repairs[47]
- $2.1 billion in increased federal tax revenue through job and economic growth[48]
- $1.4 billion increase in annual manufacturing GDP
- Creation of 50,250 jobs corresponding to a $3.8 billion increase in annual wages

SOCIETAL IMPACTS

In addition to the economic benefits, other benefits will accrue to the United States, including:

- Avoidance of 226 million tons of CO_2 emissions annually — the equivalent of taking 64.1 coal-fired power plants offline[49]
- 4.3% national criteria pollutant emissions reduction
- Increased resiliency against natural or man-made disasters through localized energy resources and wireless solar energy distribution
- Reduction/mitigation of climate change impacts
- Avoided local and regional environmental damage through the displacement of fossil fuel related drilling, extraction, transportation and storage
- Unified energy platform — solar energy is supported above all other energy sources by both Republicans and Democrats alike

[46] 1 GW = 1,000,000 kWh; 300 GW; 900,000 GWh production/year; $0.08/kWh average cost

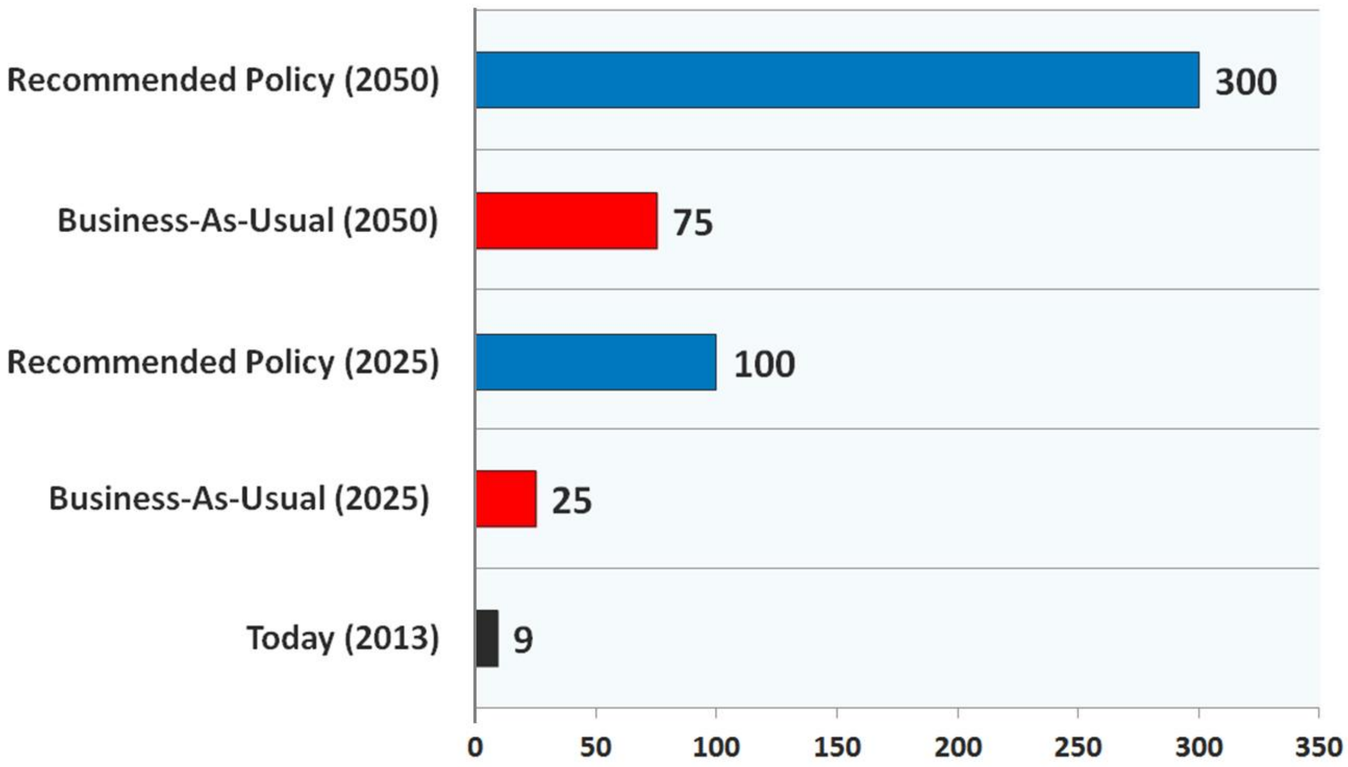
[47] Expect investment in electrical and natural gas infrastructure to meet equal demand.

[48] Average corporate and individual effective tax rates

[49] www.epa.gov/cleanenergy/energy-resources/calculator.html

Action vs. Non-Action

Predicted United States Installed SHC Capacities in **GW_{th}**



Business-As-Usual Scenario

- Consistent annualized growth rates similar to historical levels;
- Continuation of Federal Investment Tax Credit in 2016;
- Moderate state and utility program growth; programs vary substantially between states and/or utility territories thereby hindering national expansion;
- Continued lack of funding for SHC-specific research & development; and
- Continued exclusion of SHC as a central part of federal, state, and utility communication platforms.

Recommended Policy Scenario

- Extension of Federal Investment Tax Credit through at least 2025 with commercial solar pools eligible;
- Unified and well-funded state and utility support programs;
- Integration of renewable heating, with SHC carve-out, into any and all state Renewable Portfolio Standards;
- Widespread building code integration;
- R&D agenda for SHC, awareness raising, workforce development and demonstration projects;
- Commercially competitive solar cooling; and
- Installed system cost reductions of 50%.

5. Policy Needed to Achieve Targets

The goal of this policy support recommendation is to increase the quality and reliability of systems, reduce installation costs, expand the workforce, and foster private investment. Such support is necessary to bridge the gap between early adoption and successful commercialization, and can be a decisive factor for growth when crafted to address the breadth of market barriers over the long term.

The two key policies needed to achieve sustainable market growth and the deployment of 300 GW_{th} SHC capacity by 2050 are:

1. Specific Long-Term Targets
2. Financial Incentives

If policymakers commit to the SHC industry, there are numerous benefits to reap—including low-cost domestic energy, deferred energy infrastructure upgrades, job creation, and protection of the environment.

SPECIFIC LONG-TERM TARGETS

Policies oriented towards long-term targets provide confidence to market actors on both the supply and demand sides. Policies implemented over several years support investment in production capability, training, marketing and distribution, and can mobilize resources for research and development.

SHC policies must be long-term oriented in order to attract private investment and allow for a stable environment for businesses to grow.

There is already widespread constituent support for such policies, with 94% of Democrats, 75% of Republicans, and 89% of Independents ranking solar energy favorably. Furthermore, 78% of Americans support direct federal incentives for solar development.[50]

Given the numerous benefits and widespread support for SHC, government at all levels—local, state, regional, and national—must work to craft specific long-term targets and a stable policy framework to spur investment of private capital and resources.

Targets can take many forms. Some examples include Renewable Portfolio Standards, Renewable Thermal Standards, and building mandates.

Renewable Thermal Portfolio Standards

A Renewable Portfolio Standard (RPS) is a regulation that requires the increased production of energy from renewable energy sources such as wind, solar, biomass, and geothermal. Often, a specific 'carve out' is created in order focus on one particular renewable technology.

There are currently targets for renewable transportation fuels at both the federal and state levels, and thirty-seven states have renewable electricity targets. However, despite the fact that nearly half of the energy consumed in the U.S. is

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[50] Hart & Associates Research, Voters' Perceptions of Solar Energy, September 2012.

in the form of heating or cooling, and there are very few targets for renewable thermal energy or solar heating and cooling.

In order to adequately address the supply of energy used for heating purposes, there must be separate and specific state and utility RPS mandates for SHC.

Whenever RPS policies are planned, established, or updated, proactive efforts to include renewable heat must be applied at the policymaker level.

Maryland requires electricity suppliers to generate 20% of electricity from renewable sources by 2022. Metered solar water heating qualifies as an eligible source to meet the 2% solar carve out.[51]

Building Mandates

As SHC become further integrated with traditional building trades, installation guidelines will become standardized and applied across states. Within the next 10 years, it is likely that state, and potentially Federal, governments will mandate renewable thermal energy supply in a manner similar to how energy efficiency has been mandated. There are several examples of this, both nationally and internationally. In California, the Title 24 building efficiency code has saved Californians more than $74 billion in energy costs since its implementation.[52] To obtain a building permit for a large industrial facility in the United Kingdom, the proposed facility must generate 10% of its energy onsite from renewable sources. In the U.S., Section 523 of the 2007 Energy Act requires that 30% of hot water demand in new federal buildings (and major renovations) be met with solar water heating equipment, provided it is cost-effective.

FINANCIAL INCENTIVES

Financial incentives help offset the higher upfront costs as the SHC industry pursues cost-reduction opportunities. Incentives may be based on the total project cost, the actual or expected energy produced from the system, or the efficiency rating of the SHC equipment.

SHC is fundamentally different than other fuel technologies as it has high a capital expenditure (CAPEX) and low operational expenditures (OPEX), compared with traditional electric and fossil fuel system which have a lower CAPEX but a substantially higher OPEX. Therefore, SHC financial incentives should support higher offset of upfront capital expenditure costs.

Successful financial incentives are long-term and consistent, allowing businesses to make investments under predictable economic conditions. This contributes to:

- Increased contractor experience
- Faster, more efficient project implementation
- Increased volume for manufacturers and subsequent lower per-unit cost
- Decreased permitting and inspection hold-ups due to inspection and building agency exposure to more projects
- Increased consumer confidence and enthusiasm

Over the past five to ten years, states and utilities have again begun to establish various SHC

[51] RPS: Increasing Maryland's In-State Renewable Generation to 20% by 2022, Maryland Energy Administration
[52] California Energy Commission - State of California, www.energy.ca.gov/title24/

incentive programs, the three main types being tax credits, rebates and grant programs, and Renewable Energy Credits. The Federal government has also taken leadership in reducing soft costs for other forms of renewable energy generation.

Tax Credits

The Federal Investment Tax Credit (ITC) is a tax credit equal to 30% of the costs for the solar installation, including design, installation, and equipment. It is available for eligible solar thermal systems placed in service on or before December 31, 2016. Eligible property includes equipment that uses solar energy to generate electricity, heat or cool water for space conditioning, or provide solar process heat. Commercial solar pool heating systems are not currently eligible for the ITC, but this could be changed in future policy.

Under the federal Modified Accelerated Cost-Recovery System (MACRS), businesses may recover investments in certain property through depreciation deductions. Currently, solar technologies such as solar heating and cooling systems are allowed to have equipment depreciation captured over a five-year schedule.[53]

On the state level there is flexibility on how to structure tax benefits. The benefits may exist in tax credits, income tax deductions, and/or property tax exemptions.[54]

Rebate and Grant Programs

Rebate and grant programs, mostly through states and utilities, can support market development given the enhanced flexibility at this level. States that have taken the lead on solar water heating initiatives include California, Hawaii, Florida, Arizona, Massachusetts, North Carolina, and Colorado. Some utilities, such as Lakeland Electric in Florida, offer an on-bill financing option which simplifies the ability to purchase a solar water heating system.[55]

George Washington University

In 2011, solar heating systems were installed at three dorms at GWU. In total, the systems will reduce emissions by 78 tons of carbon annually and support the University's goal of generating 10% of energy from on-campus renewable sources by 2040

"With the completion of this project, GW will have the largest installation producing solar thermal energy on the East Coast," said President Steven Knapp. "By using our campus as a test-bed for renewable energy technologies, we are demonstrating our university's commitment to becoming a model of urban sustainability."

At the state level, California has established an 8-year, $350 million program called the California Solar Initiative - Thermal that uses an online

[53] http://www.irs.gov/publications/p946/ch04.html
[54] www.dsireusa.org/incentives/
[55] www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=FL51F

calculator to quantify incentive amounts, which are up to $2,719 for residential projects and $500,000 for commercial or multifamily projects. Commercial customers may also choose to opt into an incentive structure based on metered energy production.[56]

The California Solar Initiative has supported the installation of $64 million in SHC systems at an investment of only $22 million. These systems heat nearly 1.6 million gallons of water every day.[57]

In Massachusetts, the Commonwealth Solar Hot Water Program includes a performance monitoring feature, financial grants, and a low-income program providing design services and construction oversight.[58]

Renewable Energy Credits

A REC represents the property rights to the environmental, societal, and other non-power qualities of renewable electricity generation. A REC, and its associated attributes and benefits, can be sold separately from the underlying physical electricity associated with a renewable-based generation source.[59]

This flexibility allows organizations to support renewable energy development and protect the environment when green power products, such as SHC, are not always locally available.

[56]www.gosolarcalifornia.org/solarwater/
[57]www.gosolarcalifornia.org/solarwater/
[58] http://www.masscec.com/technology/solar-hot-water
[59] http://www.epa.gov/greenpower/gpmarket/rec.htm

Soft Cost Reductions

Soft costs related to SHC projects incorporate the non-material and non-labor prices of projects, including permitting, inspections, customer acquisition, and financing costs.

The DOE SunShot Initiative is a national collaborative effort to make solar energy cost-competitive by the end of the decade.[60] Though currently only focused on solar photovoltaic (electric), expansion to include SHC would provide an excellent structure to innovate methods to make SHC more cost-competitive with other fuels. For example, inclusion of solar heating technologies in SunShot's permitting cost reduction activities will substantially reduce soft costs.

SUPPORTING PROGRAMS

Financial incentives alone are not enough to build a stable, long-term clean energy solution. To achieve the target 300 GW_{th} of SHC capacity installed by 2050, the approach must incorporate:

- Consumer Awareness
- R&D for Innovation
- Demonstration Projects
- Workforce Development

Consumer Awareness

Though SHC has a long and proven history, many people are unaware or unclear that solar energy can be used directly for heating and cooling. Awareness programs can increase consumer knowledge about the benefits of SHC technology, thereby increasing demand for SHC systems.

[60]http://www1.eere.energy.gov/solar/sunshot/index.html

Reducing Soft Costs and Helping Low-income Families

Demonstration Projects show consumers that the technology is available and dependable to provide heating needs, while building experience and reducing soft costs in the private sector. Action for Boston Community Development (ABCD) and the Low-Income Energy Affordability Network (LEAN) have overseen the construction of 36 solar heating systems at low-income and service facilities throughout Massachusetts. Through this program, the facilities are expected to save nearly $1 million — funds they will be able to reinvest into their core services supporting at-need families and children.(www.bostonabcd.org)

Community Recreational Center – producing heat even in snowfall.

Customer acquisition represent an area of significant cost reduction opportunities, and the industry would benefit substantially from public awareness campaigns. Additionally, innovative community-based programs can be effective means of aggregating buyers, tapping word-of-mouth and grassroots marketing channels, and raising awareness about SHC options.

R&D for Innovation

Though SHC is a mature technology, further opportunities exist to provide cost reductions through additional research and development (R&D). The federal R&D budget for SHC technology has historically been less than other energy technologies and virtually non-existent since the mid-2000s, significantly impacting growth of the industry. In order to support a range of R&D priorities, equitable R&D funding must be provided to the SHC industry.

Opportunities for hardware-based research and development include:

- Solar cooling
- Improved thermal energy storage
- Building-integrated and plug-and-play components

Workforce Development

Additional workforce development is key to widespread SHC deployment. Workforce development programs typically involve subsidized training positions where an individual looking to gain experience in the industry can work with a SHC company. This serves to soften the risk of adding payroll to the company while providing an entry point for individuals seeking to enter the industry.

SHC installation work draws from well-developed construction trades such as plumbing, electrical, HVAC, and roofing, and should therefore be included in standard training programs throughout the country.

Additionally, the engagement of architects and engineers is necessary to increase the inclusion of SHC in new and existing projects and to support high quality design, construction, and performance verification of SHC systems.

The Massachusetts Commonwealth Solar Hot Water Program has generated $2.63 in wages for every $1.00 invested in the program.[61]

Recent studies have found that the labor and permitting costs of solar heating and cooling systems comprise a larger proportion of installed costs than material costs do.[62] Significant opportunities exist to reduce these non-hardware costs through increased professional education. Innovative education models should include:

- Online courses aimed at large-scale participation and open access via the Internet
- Educational partnerships with universities and community colleges
- On-the-job training
- Support for engineering evaluations

Certain industry and trade organizations have taken the lead on developing workforce programs. The North American Board of Certified Energy Practitioners (NABCEP) administers entry-level solar heating and cooling tests for community and other colleges around the U.S., and provides free access to its *Solar Heating Installer Resource Guide.*[63] The International Pipe Trades distributes "*Solar Water Heating Systems: Fundamentals and Installation*" to journey workers and apprentices around the U.S., and provides training based on the document. The Iron Workers Union of America has developed a course for installing solar air heating systems on industrial buildings.

Get Involved!

For the most up-to-date Solar Heating and Cooling policy initiatives, visit www.seia.org/SHCA.

U.S. Solar Heating & Cooling Alliance - a Division of SEIA Solar Energy Industries Association®

[61] www.masscec.com/technology/solar-hot-water
[62] Itron 2011
[63] http://www.nabcep.org/resources

Definitions, Terms, and Unit Conversions

BTU: British Thermal Unit. A traditional unit of energy signifying the amount of energy required to heat 1 pound of water 1 degree Fahrenheit. 3,413 BTUs are equivalent to one kilowatt hour (kWh).

CCF: A unit of volume in the U.S. to represent one hundred cubic feet. Typically used to measure the volume of a gas, such as natural gas. 1 CCF is approximately equivalent to 1 therm.

Heat Exchanger: A device which transfers heat from solar collectors to heat storage without mixing heat transfer fluids. Heat exchangers are necessary where freezing conditions require the use of non-toxic antifreeze heat transfer fluids.

HVAC: Heating, ventilation and air conditioning equipment.

kWh: Kilowatt Hour. A unit of energy representing 1000 watt hours. Typically used by electric utilities as a billing unit to consumers. If a device consumes one kilowatt of power to operate, and it operates for one hour, it will use one kWh.

Renewable Thermal Technologies: Technologies that produce useful thermal energy using sunlight, biomass, biofuels, and temperature differences in the ground and air.

SHC: Solar Heating and Cooling.

Solar Heating System: A system that uses the sun's heat to provide useful thermal energy, usually in the form of heated water. Synonymous with solar thermal system.

Solar Thermal System: Synonymous with solar heating system, but can also refer to large-scale solar electric generating technologies.

SWH: Solar water heating.

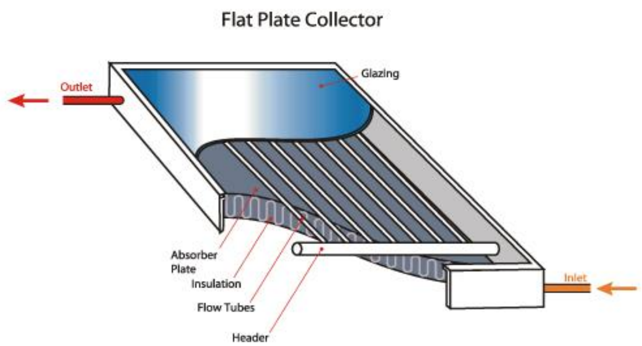
Therm: A unit used to measure large amounts of gas. Typically used to measure natural gas. 1 therm is equivalent to 1 CCF.

(Photo: Skyline Innovations)

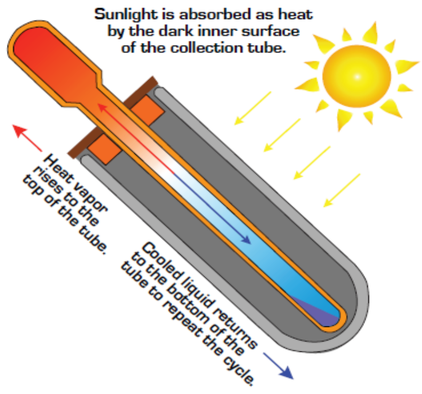
(Photo: Heliodyne)

Collector Schematics

A flat plate glazed collector consists of an absorber plate, typically constructed of copper, aluminum, or polymer tubes and plate, which forms the absorptive surface for sunlight. This absorber plate assembly is contained in an insulated box covered with a tempered glass or a polymer cover plate. Fluid flowing through the absorber plate assembly removes heat from the solar collector and transfers it to the building, pool, or other end-use application.

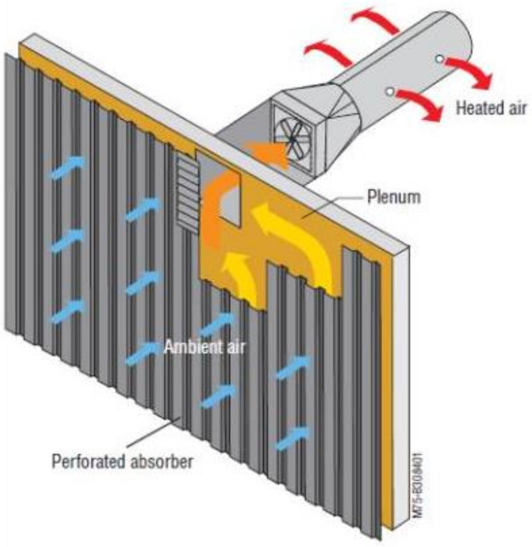


Evacuated Tube collectors consist of a row of several parallel, transparent glass tube assemblies that have been "evacuated" of air, creating a highly efficient heat insulator (similar to a thermos) for the fluid that flows through absorbers running inside the length of the tube.



Solar Pool Heating collectors typically are constructed of extruded polymer material, where swimming pool water is pumped through an array of panels on a roof or adjoining structure such as a trellis.

Transpired solar air heating systems draw air in through perforated metal absorbers, preheating it for distribution into the HVAC system.



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