Renewable Industrial Process Heat

- About industrial process heat
- How renewable industrial process heat works
- Compatible renewable technologies

About Industrial Process Heat

The United States' industrial sector uses heat for a wide variety of applications, including washing, cooking, sterilizing, drying, preheating of boiler feed water, process heating, and much more. Altogether, the industrial sector uses and estimated 24 quadrillion Btu, or roughly one-third of the nation's delivered energy supply.! Process heating applications alone account for approximately 36 percent of total delivered energy consumption within the manufacturing sector (a subset of the industrial sector).? The vast size and scale of industrial heating energy use represents a unique opportunity for renewable resources.

According to a study of industrial heating in European countries, 30 percent of industrial heating applications require heat below 212^{0}F, another 27 percent can be met with heat between 212 and 750 ^{0}F, and the remaining 43 percent require heat above 750 ^{0}F.[3] Most existing renewable heating technologies can easily and cost-effectively supply heat within the lowest indicated temperature range. Often, the most valuable role that renewable heating technologies can play in industrial applications is to provide "preheating" before an existing conventional energy source is used. Major considerations for industrial renewable heating applications include cost, resource intermittency, and process integration and storage options.

How Renewable Industrial Process Heat Works

Solar, geothermal, or biomass sources can provide heat to support industrial processes that serve wateror air-heating end uses. As described above, more than half of industrial heating is met through temperatures below 750^{0}F, and some industries (agriculture, cooking) have much lower temperature needs. Many renewable heating resources can easily meet the lower temperature requirements. Even if renewable sources cannot support the entire heating load, they can still provide pre-heating to supplement a conventional heating process. Because it takes a relatively large amount of energy to raise the temperature of water (compared with heating air, for example), even a modest amount of pre-heating can reduce a facility's dependence on fossil fuels—and save money in the process.

Compatible Renewable Technologies

Flat-plate solar collectors and ground source heat pumps can support industrial processes requiring warm

to hot water, such as pressurization or pre-heating water. Many agricultural processes also require gentle warming. For example, flat-plate solar collectors and ground source heat pumps can help to warm soil or warm water for fish farming to about 100 ^{0}F.

Chemical processing, kilning, drying, curing, sterilization, and distillation activities requiring higher temperatures can use evacuated tube solar collectors, direct use geothermal water, or biomass furnaces. Concentrating solar thermal technologies and deep geothermal wells can support the highest-temperature applications, such as fuel production, that require pressurized, superheated water or steam above 480 ^{0}F.

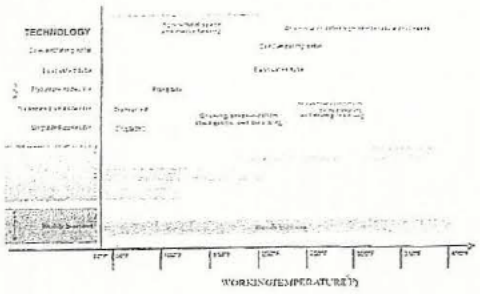
Agricultural and industrial facilities often take advantage of co-location and cogeneration. Waste agricultural products such as rice and corn husks can potentially serve as effective biomass fuels. Similarly, waste heat from a high-temperature industrial process can possibly support another process requiring a lower temperature.

The interactive diagram below shows how industrial processes align with selected renewable technologies. You can click any of the technologies to go to a new page with more detailed information.

Renewable Industrial Process Heat Technologies and Applications

Technologies and Applications

Applications



° View a text version of this diagram o View an expanded version of this diagram to compare industrial process heat with other renewable heating and cooling applications

Understanding the Diagram

The diagram above shows technologies and industrial process applications in terms of the approximate "working temperature" range, which is the required temperature of the heat transfer fluid within the renewable heating system. The working temperature is not necessarily the same as the final temperature of the end product (in this case, the final temperature of the air or water that is being heated).

The diagram above shows approximate working temperature ranges. The exact working temperature requirements for a particular system will depend on factors such as system type, size, and location. The working temperature that a particular renewable technology can supply will also depend on site-

specific factors. For example, the amount of heat that a solar collector system can supply will depend on how much sunlight it receives, and at what angle.

of3

Learn More About Renewable Industrial Process Heat

Key Renewable Technologies	Key End Use Sectors	Technical Resources
Flat-plate solar Evacuated tube solar collector Concentrating solar system Ground source heat Direct use geothermal Deep and enhanced geothermal Woody biomass	Breweries Project development	Industrial Processes tools

[1] U.S. Department of Energy, Energy Information Administration. 2014. Annual Ener Outlook 2014: Industrial Sector Ke Indicators and Consumption.

[2] U.S. Department of Energy, Energy Information Administration. 2006. Best Practices: Process Heating (PDF). (2 pp, 428 K, About PDF).

[3] International Energy Agency, Solar Heating and Cooling Program. 2008. Potential for Solar Heat in Industrial Processes.

EXIT

LAST UPDATED ON OCTOBER 26, 2017

EPA United States Environmental Protection Agency

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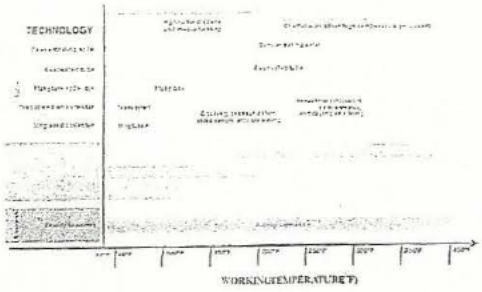

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Flat-plate solar Evacuated tube solar collector Concentrating solar system Ground source heat Direct use geothermal Deep and enhanced geothermal Woody biomass	• Breweries • Project development	• Industrial Processes tools

e,EPA

Solar Heating and Cooling Technologies

Can I use solar thermal technology where I live?

Solar thermal technologies can be used anywhere in the United States. However, some regions naturally receive more intense and more reliable solar energy than others, depending on latitude, typical weather patterns, and other factors. The National Renewable Energy Laboratory provides maps that show the solar energy potential where you live.

Solar thermal technologies absorb the heat of the sun and transfer it to useful applications, such as

heating buildings or water. There are several major types of solar thermal technologies in use:

- Unglazed solar collectors
- Transpired solar air collectors
- Flat-plate solar collectors
- Evacuated tube solar collectors
- Concentrating solar systems

In addition to the solar thermal technologies above, technologies such as solar photovoltaic modules can produce electricity, and buildings can be designed to capture passive solar heat.

Solar energy is considered a renewable resource because it is continuously supplied to the Earth by the sun. Visit EPA's Clean Energy website to learn more about non-thermal solar technologies and the environmental benefits and impacts of solar energy.

Unglazed Solar Collectors

An unglazed solar collector on the roof of a pool and fitness center.
Credit: Albert Nunez, NREL 10651

An unglazed solar collector is one of the simplest forms of solar thermal technology. A heat-conducting material, usually a dark metal or plastic, absorbs sunlight and transfers the energy to a fluid passing through or behind the heat-conducting surface. The process is similar to how a garden hose, laying out in the open, will absorb the sun's energy and heat the water inside the hose.

These collectors are described as "unglazed" because they do not have a glass covering or "glazing" on the collector box to trap heat. The lack of glazing creates a trade-off. Unglazed solar collectors are simple and inexpensive, but without a way to trap heat, they lose heat back to the environment and they operate at relatively low temperatures. Thus, unglazed collectors typically work best with small to moderate heating applications or as a complement to traditional heating systems, where they can reduce fuel burdens by pre-heating water or air.

Solar pool heating collectors are the most commonly used unglazed solar technology in the United States. These devices often use black plastic tubular panels mounted on a roof or other support structure. A water pump circulates pool water directly through the tubular panels, then returns the water to the pool at a higher temperature. Although used primarily for pool heating, these collectors can also pre-heat large volumes of water for other commercial and industrial applications.

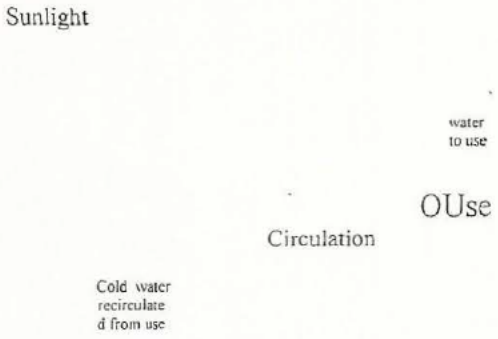
Pool heatin o
Space heating

Single-family homes
Multi-unit housing
Lod in
o Schools
Municipal governments

Project development tools

How It Works

Unglazed Solar Collector



1. Sunlight: Sunlight hits the dark material in the collector, which heats up.
2. Circulation: Cool fluid (water) or air circulates through the collector, absorbing heat.
3. Use: The warmer fluid is used for applications such as pool heating.

Learn More About Unglazed Solar Collectors

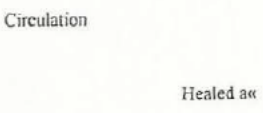
Potential Applications

Key End Use Sectors

Technical Resources

Transpired Solar Air Collectors

Transpired Solar Collector



The south-facing wall of this warehouse is a transpired solar collector.

Sunlight: Sunlight hits the dark perforated metal cladding, which heats up.

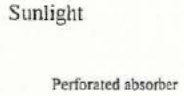
Circulation: A circulation fan pulls air through the perforations behind the metal cladding, heating the air, which is then pulled into the building for distribution.

Credit: DOE Office ofEnerv Efficiency and Renewable Enerv

Transpired solar air collectors typically consist of a dark-colored, perforated metal cladding material mounted on an existing wall on the south side of a building. A fan pulls outside air through the perforations and into the space behind the metal cladding, where the air heats to as much as 30 ^{0}F-100 ^{0}F above the ambient air temperature. The fan then pulls the air into the building, where it is distributed through the building's ventilation system.

The transpired solar collector is a proven but still emerging solar heating technology. This type of technology is best for heating air and ventilating indoor spaces. It can also be applied to several manufacturing and agricultural applications, such as crop drying.

How it works



Learn More About Transpired Solar Air Collectors

Potential Applications	Key End Use Sectors	Technical Resources
o Space heating	Multi-unit housing	Project development
	o Lod in tools	
	Schools	
	o Municipal governments	

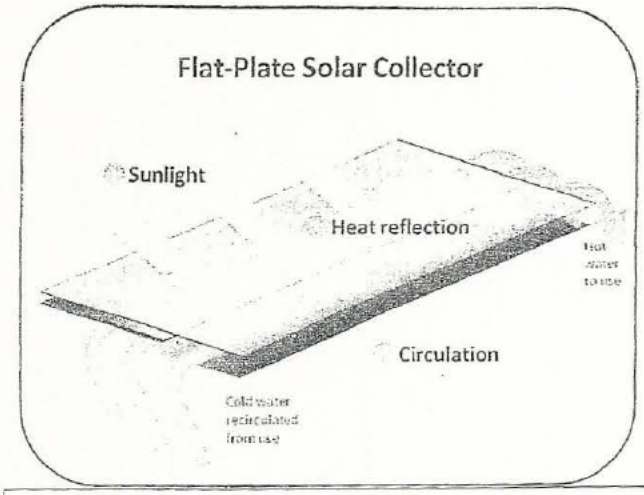
Flat-mate Solar Collectors

An array of flat-plate solar collectors on the roof of a school.
Credit: Joe Ryan, NREL 19690

Most flat-plate collectors consist of copper tubing and other heat-absorbing materials inside an insulated frame or housing, covered with clear glazing (glass). The-heat absorbing materials may have a special coating that absorbs heat more effectively than an uncoated surface.

Glazed flat-plate collectors can operate efficiently at a wider temperature range than unglazed collectors. Flat-plate collectors are often used to complement traditional water boilers, pre-heating water to reduce fuel demand. They can also be effective for space heating. Using a heat exchange system, they can reliably produce hot air for large buildings during daylight hours.

How It Works



1. Sunlight: Sunlight travels through the glass and hits the dark material inside the collector, which heats up.
2. Heat reflection: A clear glass or plastic casing traps heat that would otherwise radiate out. This is similar to the way a greenhouse traps heat inside.
3. Circulation: Cold water or another fluid circulates through the collector, absorbing heat.

Learn More About Flat-Plate Solar Collectors

Potential Applications	Key End Use Sectors	Technical Resources
o Space heating	Single-family homes	o Project development tools
o Hot water heating	Multi-unit housing	
	Lodging	
	Restaurants	
	Schools	
	Municipal governments	

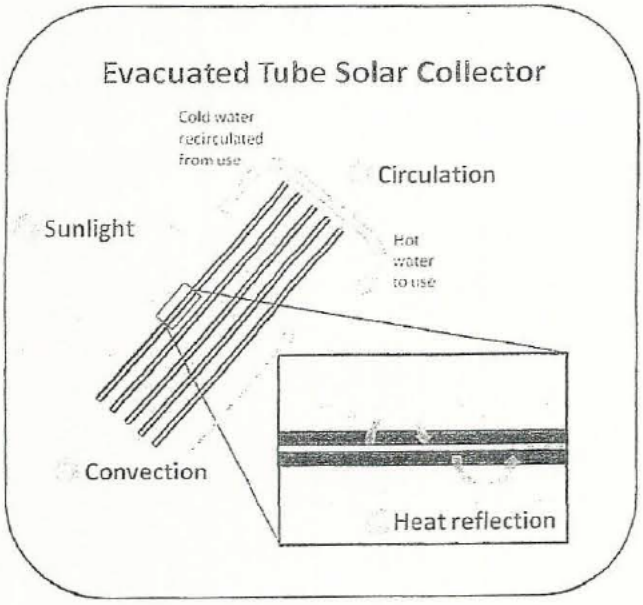
Evacuated Tube Solar Collectors

An evacuated tube solar collector on a roof.
Credit: NREL PIX 09501

Evacuated tube collectors feature thin, copper tubes filled with a fluid, such as water, housed inside larger vacuum-sealed clear glass or plastic tubes.

Evacuated tubes use the sun's energy more efficiently and can produce higher temperatures than flatplate collectors for a few reasons. First, the tube design increases the surface area available to the sun, efficiently absorbing direct sunlight from many different angles. Second, the tubes also have a partial vacuum within the clear glass enclosure, which significantly reduces heat loss to the outside environment.

How It Works



1. Sunlight: Sunlight hits a dark cylinder, efficiently heating it from any angle.
2. Heat reflection: A clear glass or plastic casing traps heat that would otherwise radiate out. This is similar to the wa a greenhouse traps heat inside.
3. Convection: A copper tube running through each cylinder absorbs the cylinder's stored heat, causing fluid inside the tube to heat up and rise to the top of the cylinder.
4. Circulation: Cold water circulates through the tops of the cylinders, absorbing heat.

Evacuated tube systems are typically more expensive than flat-plate collectors, but they are more efficient and can produce higher temperatures. Evacuated tubes can reliably produce very hot water for batch or on-demand water heating and for many industrial processes, and they can produce enough heat to handle almost any space heating or space cooling application.

llectors

Learn More About Evacuated Tube Solar

Potential Applications

- Space heating Single-family homes ' Hot water heating • Multi-unit housing
- Space cooling Lodging
- Industrial process heatBreweries

Key End Use Sectors

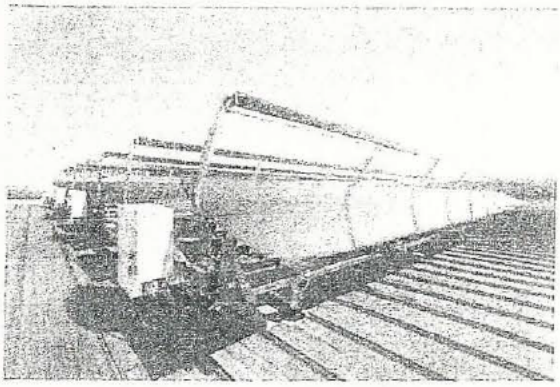
Restaurants
Industrial processes

Technical Resources

Project development tools

- Schools
- Municipal governments

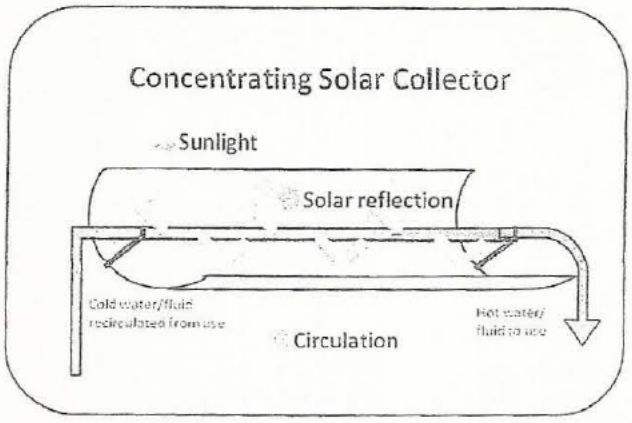
Concentrating Solar Systems



This rooftop array of parabolic trough concentrating solar collectors provides process heat for a winery. These collectors have a unique design that allows them to produce electricity in addition to heat.
Credit: Sun Water Solar

Concentrating solar systems work by reflecting and directing solar energy from a large area onto a small one. Smaller, reflective bowl-shaped arrays can produce water at a few hundred degrees for industrial or agricultural processes or for heating large volumes of water, such as resort swimming pools. Some arrays work with long parabolic troughs that concentrate sunlight onto a pipe running the length of the trough, which carries a heat transfer fluid. Even larger systems use fields of mirrors to reflect sunlight onto a central tower. These types of arrays produce high-pressure steam or other superheated fluids for a range of activities, from heat-intensive chemical processing to electric power generation.

How It Works



1. Sunlight: Sunlight hits a reflective material (i.e., a mirrored surface), usually in the shape of a trough (shown here) or a dish.
2, Solar reflection; The reflective material redirects the sunlight onto to a single point (for a dish) or a pipe (for a trough).
3. Circulation: Cold water or a special heat transfer fluid circulates through the pipe, absorbing heat.

Concentrating systems are capable of producing enormously hot fluids for a variety ofprocesses, and they can produce a relatively large amount of energy for each dollar invested. However, these systems tend to be much larger and more complex than the other types of solar collectors described above, with a higher total price tag. Thus, concentrating solar technology tends to be most effective for large-scale, high-temperature uses, although lower-temperature uses may still be cost-effective under certain circumstances.

Learn More About Concentrating Solar Systems

Potential Applications	Key End Use Sectors	Technical Resources
Pool heating Lod in o	Project development o	Industrial process heat Industrial processes tools

LAST UPDATED ON DECEMBER 19, 2016