Research on

Solar Electric Power Systems (PV)

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Solar electric power systems transform sunlight into electricity. Sunlight is an abundant resource. Every minute the sun bathes the Earth in as much energy as the world consumes in an entire year.

Solar cells employ special materials called semiconductors that create electricity when exposed to light. Solar electric systems are quiet and easy to use, and they require no fuel other than sunlight. Because they contain no moving parts, they are durable, reliable, and easy to maintain.

How It Works

Solar cells, also known as photovoltaic (PV) cells, do the work of making electricity. Several types of solar electric technology are under development, but four—crystalline silicon (a form of refined beach sand), thin films, concentrators, and thermophotovoltaics—are illustrative of the range of technologies. Solar cells are connected to a variety of other components to

Crystalline Silicon

Crystalline silicon solar cells are used in more than half of all solar electric devices. Like most semiconductor devices, they include a positive layer (on the bottom) and a negative layer (on the top) that create an electrical field inside the cell. When a photon of light strikes a semiconductor, it releases electrons (see animation). The free electrons flow through the solar cell's bottom layer to a connecting wire as direct current (DC) electricity.

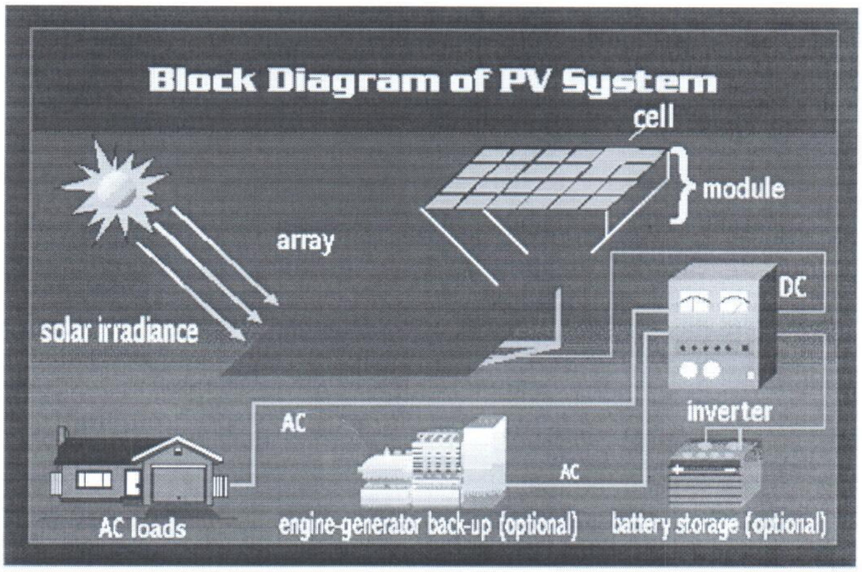
Some solar cells are made from polycrystalline silicon, which consists of several small silicon crystals. Polycrystalline silicon solar cells are cheaper to produce but somewhat less efficient than single-crystal silicon.

A simple silicon solar cell can power a watch or calculator. However, it produces only a tiny amount of electricity. Connected together, solar cells form modules that can generate substantial amounts of power. Modules are the building blocks of solar electric systems, which can produce enough power for a house, a rural medical clinic, or an entire village. Large arrays of solar electric modules can power satellites or provide electricity for utilities.

Solar Electric Power System Components

In addition to modules, several components are needed to complete a solar electric power system.

Many systems include batteries, battery chargers, a backup generator, and a controller so that people in solar-powered homes and buildings can turn on the lights at night or run televisions or appliances on cloudy days. Grid-connected systems don't require batteries or backup generators because they use the grid for backup power. Some remote system applications, such as those used to pump water, do not require a backup power source.



Components of a typical standalone PV system using crystalline silicon technology. (Source: Solar Electric Power Association)

Solar electric power systems can incorporate inverters or power control units to transform the DC electricity produced by the solar cells into alternating current (AC) to run AC appliances or sell to a utility grid. Complete systems usually include safety disconnects, fuses, and a grounding circuit as well.

Thin Films

Solar electric thin films are lighter, more resilient, and easier to manufacture than crystalline silicon modules. The best-developed thin-film technology uses amorphous silicon, in which the atoms are not arranged in any particular order as they would be in a crystal. An amorphous silicon film only one micron thick can absorb 90% of the usable solar energy falling on it. Other thin-film materials include cadmium telluride and copper indium diselenide. Substantial cost savings are possible with this technology because thin films require relatively little semiconductor materials.

Thin films are produced as large, complete modules, not as individual cells that must be mounted in frames and wired together. They are manufactured by applying extremely thin layers of semiconductor material to a low-cost backing such as glass or plastic. Electrical contacts, antireflective coatings, and protective layers are also applied directly to the backing material. Thin films conform to the shape of the backing, a feature that allows them to be used in such innovative products as flexible solar electric roofing shingles.

Concentrators

Concentrators use optical lenses (similar to plastic magnifying glasses) or mirrors to concentrate the sunlight that falls on a solar cell. With a concentrator to magnify the light intensity, the solar cell produces more electricity. Today, most solar cells in concentrators are made from crystalline silicon. However, materials such as gallium arsenide and gallium indium phosphide are more efficient than silicon in solar electric concentrators and will likely see more use in the future. These materials are now used in communications satellites and other space applications.

Concentrators produce more electricity using less of the expensive semiconductor material than other solar electric systems. A basic concentrator unit consists of a lens to focus the light, a solar cell assembly, a housing element, a secondary concentrator to reflect off-center light rays onto the cell, a mechanism to dissipate excess heat, and various contacts and adhesives. The basic unit can be combined into modules of varying sizes and shapes. Concentrators only work with direct sunlight and operate most effectively in sunny, dry climates. They must be used with tracking systems to keep them pointed toward the sun.

Thermophotovoltaics

Thermophotovoltaic (TPV) devices convert heat into electricity in much the same way that other PV devices convert light into electricity. The difference is that TPV technology uses semiconductors "tuned" to the longer-wavelength, invisible infrared radiation emitted by warm objects. This technology is cleaner, quieter, and simpler than conventional power generation using steam turbines and generators.

TPV converters are relatively maintenance-free because they contain no moving parts. In addition to using solar energy, they can convert heat from any high-temperature heat source, including combustion of a fuel such as natural gas or propane, into electricity. TPV converters produce virtually no carbon monoxide and few emissions. They may be used in the future in gas furnaces that generate their own electricity for self-ignition (during power outages) and in portable generators and battery chargers.

Advantages

Solar electric systems offer many advantages. Standalone systems can eliminate the need to build expensive new power lines to remote locations. For rural and remote applications, solar electricity can cost less than any other means of producing electricity. Solar electric systems can also connect to existing power lines to boost electricity output during times of high demand such as on hot, sunny days when air conditioners are on.

Solar electric systems are flexible. Solar electric modules can stand on the ground or be mounted on rooftops. They can also be built into glass skylights and walls. They can be made to look like roof shingles and can even come equipped with devices to turn their DC output into the same AC utilities deliver to wall sockets. These advances mean individual homeowners and businesses can relieve pressure on local utilities struggling to meet the increasing demand for electricity.

More than 30 states offer grid-connected solar electric system owners the chance to save money on their energy bills by feeding any excess power their solar electric system produces into the utility grid—an arrangement called net metering.

Solar power systems require minimal maintenance. They run quietly and efficiently without polluting. They are easy to combine with other types of electric generators such as wind, hydro, or natural gas turbines. They can charge batteries to make solar electricity continuously available.

For utilities, large-scale solar electric power plants can help meet demand for new power generation, especially in distributed applications. A solar electric power plant is created from multiple arrays that are interconnected electronically. Solar electric plants are easier to site and are quicker to build than conventional power plants. They are also easy to expand incrementally—by adding more modules—as power demand increases.

Solar electric power systems are good for the environment. When solar electric technologies displace fossil fuels for pumping water, lighting homes, or running appliances, they reduce the greenhouse gases and pollutants emitted into the atmosphere. The use of solar electric systems is particularly important in developing nations because it can help avert the expected increases in emissions of greenhouse gases caused by the growing demand for electricity in those countries.

Solar electric technologies also benefit the U.S. economy by creating jobs in U.S. companies. Exporting solar electric technologies to developing nations expands U.S. markets while protecting the global environment.

Disadvantages

Although solar electric systems make financial sense in remote areas that lack access to power lines, they are usually more expensive than fossil fuels for grid-connected applications.

This disadvantage is significant for utilities considering large-scale solar electric power plants. Although solar electricity costs considerably more than electricity generated by conventional plants, regulatory agencies often require utilities to supply electricity for the lowest cash cost.

Utilities view solar electric power plants differently than they view conventional power plants. Solar electric modules produce electricity intermittently—only when the sun shines. Their output varies with the weather and disappears altogether at night. Integrating solar electricity absorbent mixtures used in absorption chillers are water/lithium bromide and ammonia/water.

Compared with mechanical chillers, absorption chillers have a low coefficient of performance (COP = chiller load/heat input). However, absorption chillers can substantially reduce operating costs because they are powered by low-grade waste heat. Vapor compression chillers, by contrast, must be motor- or engine-driven.

Low-pressure, steam-driven absorption chillers are available in capacities ranging from 100 to 1,500 tons. Absorption chillers come in two commercially available designs: single-effect and double-effect. Single-effect machines provide a thermal COP of 0.7 and require about 18 pounds of 15-pound-per-square-inch-gauge (psig) steam per ton-hour of cooling. Double-effect machines are about 40% more efficient, but require a higher grade of thermal input, using about 10 pounds of 100- to 150-psig steam per ton-hour.

A single-effect absorption machine means all condensing heat cools and condenses in the condenser. From there it is released to the cooling water. A double-effect machine adopts a higher heat efficiency of condensation and divides the generator into a high-temperature and a low-temperature generator.

Is It Right for You?

Absorption cooling may be worth considering if your site requires cooling, and if at least one of the following applies:

- You have a combined heat and power CHP) unit and cannot use all of the available heat, or if you are considering a new CHP plant
- Waste heat is available
- A low-cost source of fuels is available
- Your boiler efficiency is low due to a poor load factor
- Your site has an electrical load limit that will be expensive to upgrade
- Your site needs more cooling, but has an electrical load limitation that is expensive to overcome, and you have an adequate supply of heat.

In short, absorption cooling may fit when a source of free or low-cost heat is available, or if objections exist to using conventional refrigeration. Essentially, the low-cost heat source displaces higher-cost electricity in a conventional chiller.

In Practice

In a plant where low-pressure steam is currently being vented to the atmosphere, a mechanical chiller with a COP of 4.0 is used 4,000 hours a year to produce an average 300 tons of refrigeration. The plant's cost of electricity is $0.05 a kilowatt-hour.

An absorption unit requiring 5,400 lbs/hr of 15-psig steam could replace the mechanical chiller, providing annual electrical cost savings of:
Annual Savings = 300 tons x (12,000 Btu/ton / 4.0) x 4,000 hrs/yr x $0.05/kWh x kWh/3,413 Btu = $52,740

Actions You Can Take

Determine the cost-effectiveness of displacing a portion of your cooling load with a waste steam absorption chiller by taking the following steps:

- Conduct a plant survey to identify sources and availability of waste steam
- Determine cooling load requirements and the cost of meeting those requirements with existing mechanical chillers or new installations
- Obtain installed cost quotes for a waste steam absorption chiller
- Conduct a life cycle cost analysis to determine if the waste steam absorption chiller meets your company's cost-effectiveness criteria.

Absorption Chiller Refrigeration Cycle

The basic cooling cycle is the same for the absorption and electric chillers. Both systems use a low-temperature liquid refrigerant that absorbs heat from the water to be cooled and converts to a vapor phase (in the evaporator section). The refrigerant vapors are then compressed to a higher pressure (by a compressor or a generator), converted back into a liquid by rejecting heat to the external surroundings (in the condenser section), and then expanded to a low- pressure mixture of liquid and vapor (in the expander section) that goes back to the evaporator section and the cycle is repeated.

The basic difference between the electric chillers and absorption chillers is that an electric chiller uses an electric motor for operating a compressor used for raising the pressure of refrigerant vapors and an absorption chiller uses heat for compressing refrigerant vapors to a high-pressure. The rejected heat from the power-generation equipment (e.g. turbines, microturbines, and engines) may be used with an absorption chiller to provide the cooling in a CHP system.

The basic absorption cycle employs two fluids, the absorbate or refrigerant, and the absorbent. The most commonly fluids are water as the refrigerant and lithium bromide as the absorbent. These fluids are separated and recombined in the absorption cycle. In the absorption cycle the low-pressure refrigerant vapor is absorbed into the absorbent releasing a large amount of heat. The liquid refrigerant/absorbent solution is pumped to a high-operating pressure generator using significantly less electricity than that for compressing the refrigerant for an electric chiller. Heat is added at the high-pressure generator from a gas burner, steam, hot water or hot gases. The added heat causes the refrigerant to desorb from the absorbent and vaporize. The vapors flow to a condenser, where heat is rejected and condense to a high-pressure liquid. The liquid is then throttled though an expansion valve to the lower pressure in the evaporator where it evaporates by absorbing heat and provides useful cooling. The remaining liquid absorbent, in the generator passes through a valve, where its pressure is reduced, and then is recombined with the low-pressure refrigerant vapors returning from the evaporator so the cycle can be repeated.

Absorption chillers are used to generate cold water (44°F) that is circulated to air handlers in the distribution system for air conditioning.

"Indirect-fired" absorption chillers use steam, hot water or hot gases steam from a boiler, turbine or engine generator, or fuel cell as their primary power input. Theses chillers can be well suited for integration into a CHP system for buildings by utilizing the rejected heat from the electric generation process, thereby providing high operating efficiencies through use of otherwise wasted energy.

"Direct-fired" systems contain natural gas burners; rejected heat from these chillers can be used to regenerate desiccant dehumidifiers or provide hot water.

Commercially absorption chillers can be single-effect or multiple-effect. The above schematic refers to a single-effect absorption chiller. Multiple-effect absorption chillers are more efficient and discussed below.

Multiple-Effect Absorption Chillers

In a single-effect absorption chiller, the heat released during the chemical process of absorbing refrigerant vapor into the liquid stream, rich in absorbent, is rejected to the environment. In a multiple-effect absorption chiller, some of this energy is used as the driving force to generate more refrigerant vapor. The more vapor generated per unit of heat or fuel input, the greater the cooling capacity and the higher the overall operating efficiency.

A double-effect chiller uses two generators paired with a single condenser, absorber, and evaporator. It requires a higher temperature heat input to operate and therefore they are limited in the type of electrical generation equipment they can be paired with when used in a CHP System.

Triple-effect chillers can achieve even higher efficiencies than the double-effect chillers. These chillers require still higher elevated operating temperatures that can limit choices in materials and refrigerant/absorbent pairs. Triple-effect chillers are under development by manufacturers working in cooperation with the U.S. Department of Energy.

* Geothermal Energy... Power from the Depths

The Earth's crust is a bountiful source of energy—and fossil fuels are only part of the story. Heat or thermal energy is by far the more abundant resource. To put it in perspective, the thermal energy in the uppermost six miles of the Earth's crust amounts to 50,000 times the energy of all oil and gas resources in the world!

The word "geothermal" literally means "Earth" plus "heat." The geothermal resource is the world's largest energy resource and has been used by people for centuries. In addition, it is environmentally friendly. It is a renewable resource and can be used in ways that respect rather than upset our planet's delicate environmental balance.

Geothermal power plants operating around the world are proof that the Earth's thermal energy is readily converted to electricity in geologically active areas. Many communities, commercial enterprises, universities, and public facilities in the western United States are heated directly with the water from underground reservoirs. For the homeowner or building owner anywhere in the United States, the emergence of geothermal heat pumps brings the benefits of geothermal energy to everyone's doorstep.

The Basics

There's a relatively simple concept underlying all the ways geothermal energy is used: The flow of thermal energy is available from beneath the surface of the Earth and especially from subterranean reservoirs of hot water. Over the years, technologies have evolved that allow us to take advantage of this heat.

In fact, electric power plants driven by geothermal energy provide over 44 billion kilowatt hours of electricity worldwide per year, and world capacity is growing at approximately 9% per year. To produce electric power from geothermal resources, underground reservoirs of steam or hot water are tapped by wells and the steam rotates turbines that generate electricity. Typically, water is then returned to the ground to recharge the reservoir and complete the renewable energy cycle.

Underground reservoirs are also tapped for "direct-use" applications. In these instances, hot water is channeled to greenhouses, spas, fish farms, and homes to fill space heating and hot water needs.

Geothermal energy use extends beyond underground reservoirs. The soil and near-surface rocks, from 5 to 50 feet deep, have a nearly constant temperature from geothermal heating. As a homeowner or business owner, you can use the Earth as a heat source or heat sink with geothermal heat pumps. According to the U.S. Environmental Protection Agency (EPA), geothermal heat pumps are one of the nation's most efficient—and therefore least polluting—heating, cooling, and water-heating systems available. In winter, these systems draw on "earth heat" to warm the house, and in summer they transfer heat from the house to the earth, which ranges in temperature from 50° to 70°F (10° to 21°C) depending on latitude.

A Clear Advantage

Geothermal energy delivers some powerful environmental and economic benefits. If you live in an area that uses geothermal resources for electricity production, you're quite fortunate. Consider Lake County, California, which is home to many of the geothermal power plants at our nation's best-developed geothermal resource, The Geysers. It's no coincidence that the Lake County air basin is the first and only one in compliance with all of California's stringent air quality regulations.

Perhaps you own a greenhouse and need to cut exorbitant energy bills in order to stay in business. If you are located near a geothermal resource, you should know that most greenhouse growers estimate that direct use of geothermal resources instead of traditional energy sources reduces heating costs by up to 80%. This can save about 5% to 8% in total operating cost.

Assume you're a home or business owner who has installed

a geothermal heat pump. You're not only doing your part to help make the world a cleaner place to live and breathe, you're rewarded with low operating and maintenance costs, and, usually, lowest life-cycle costs. (Life-cycle cost is the total cost of the equipment spread over the useful life of the equipment.) In practical terms, your heat pump investment may cost you $15 per month more in mortgage payments, but it may save you $30 per month on your electric bill.

In all three of these cases, domestic, not foreign, resources are being used—a practice that has merits all its own. Nearly half of our nation's annual trade deficit would be obliterated if we could displace imported oil with domestic energy resources. A nation's trade deficit represents a permanent loss of wealth for the citizens of that nation. Keeping the wealth at home translates to more jobs and a robust economy. And not only does our national economic and employment picture improve, but a vital measure of national security is gained when we control our own energy supplies.

Types of Geothermal Resources

The center of the Earth is 4000 miles (6400 kilometers) deep. How hot is this region? Our best guess is 7200°F (4000°C) or higher. Partially molten rock, at temperatures between 1200° and 2200°F (650° to 1200°C), is believed to exist at depths of 50 to 60 miles (80 to 100 kilometers).

Heat is constantly flowing from the Earth's interior to the surface. Most types of geothermal resources—hydrothermal, geopressured, hot dry rock, and magma—result from concentration of Earth's thermal energy within certain discrete regions of the subsurface.

Hydrothermal resources are reservoirs of steam or hot water, which are formed by water seeping into the earth and collecting in, and being heated by fractured or porous hot rock. These reservoirs are tapped by drilling wells to deliver hot water to the surface for generation of electricity or direct use. Hot water resources exist in abundance around the world. In the United States, the hottest (and currently most valuable) resources are located in the western states, and Alaska and Hawaii. Technologies to tap hydrothermal resources are proven commercial processes.

Geopressured resources are deeply buried waters at moderate temperature that contain dissolved methane. While technologies are available to tap geopressured resources, they are not currently economically competitive. In the United States, this resource base is located in the Gulf coast regions of Texas and Louisiana.

Hot dry rock resources occur at depths of 5 to 10 miles (8 to 16 kilometers) everywhere beneath the Earth's surface, and at shallower depths in certain areas. Access to these resources involves injecting cold water down one well, circulating it through hot fractured rock, and drawing off the now hot water from another well. This promising technology has been proven feasible, but no commercial applications are in use at this time.

Magma (or molten rock) resources offer extremely high-temperature geothermal opportunities, but existing technology does not allow recovery of heat from these resources.

Earth energy is the heat contained in soil and rocks at shallow depths. This resource is tapped by geothermal heat pumps.

Geothermal Power Plants—from Water to Light

Flip a switch and light up a room—what could be easier? Push a button on the TV remote control and be entertained. It all seems so simple that we are often unaware of the true environmental and social cost of these conveniences—and who would want to give them up even if we had to account for every penny?

But rather than thinking in terms of giving things up, let's think positively: in the United States, right now, the installed generating capacity for geothermal stands at about 2700 megawatts. That's the equivalent of about 58 million barrels of oil, and provides enough electricity for 3.7 million people. The cost of producing this power ranges from 4¢ to 8¢ per kilowatt hour. The geothermal industry is working to achieve a geothermal life-cycle energy cost of 3¢ per kilowatt hour. And remember, this is clean energy produced from domestic resources.

How clean? In terms of air emissions, geothermal power plants have an inherent advantage over fossil fuel plants because no combustion takes place. Geothermal plants emit no nitrogen oxides and very low amounts of sulfur dioxide—allowing them to easily meet the most stringent clean air standards. The steam at some steam plants contains hydrogen sulfide, but treatment processes remove more than 99.9% of those emissions. Typical emissions of hydrogen sulfide from geothermal plants are less than 1 part per billion—well below what people can smell. The low levels of air emissions produced are mostly carbon dioxide, which many people believe acts as a greenhouse gas to trap heat within Earth's atmosphere. Even so, geothermal plants emit minimal amounts of carbon dioxide—1/1000 to 1/2000 of the amount produced by fossil-fuel plants.

Geothermal water sometimes contains salts and dissolved minerals. In the United States, the geothermal water is usually injected back into the reservoir from where it came, at a depth well below groundwater aquifers, after its heat energy has been extracted. This recycles the geothermal water and replenishes the reservoir. However, some geothermal plants also produce some solid materials, or sludges, that require disposal in approved sites.

All U.S. geothermal power plants are located in the states of California, Nevada, Utah, and Hawaii—home to some of the most majestic scenery on Earth. It's fortunate, then, that these plants consume only a small amount of land, and can coexist with numerous other land uses, including agriculture, with minimal impact on the surrounding beauty.

They're reliable and efficient, too. Taken as a group, geothermal power plants are available to generate power 95% or more of the time; they are seldom off-line for maintenance or repair. And, they have the highest capacity factors of all types of power plants. Capacity factor is the ratio of the amount of electricity a plant produces to how much electricity it is capable of producing.

Dry Steam Power Plants were the first type of geothermal power plant (in Italy in 1904). The Geysers in northern California, which is the world's largest single source of geothermal power, is also home to this type of plant. These plants use the steam as it comes from wells in the ground, and direct it into the turbine/generator unit to produce power.

Flash Steam Power Plants, which are the most common, use water with temperatures greater than 360°F (182°C). This very hot water is pumped under high pressure to equipment on the surface, where the pressure is suddenly dropped, allowing some of the hot water to "flash" into steam. The steam is then used to power the turbine/generator. The remaining hot water and condensed steam are injected back into the reservoir.

Binary Cycle Power Plants operate on the lower-temperature waters, 225° to 360°F (107° to 182°C). These plants use the heat of the hot water to boil a "working fluid," usually an organic compound with a low boiling point. This working fluid is then vaporized in a heat exchanger and used to turn a turbine. The geothermal water and the working fluid are confined to separate closed loops, so there are no emissions into the air.

Because these lower-temperature waters are much more plentiful than high-temperature waters, binary cycle systems will be the dominant geothermal power plants of the future.

Developing and commercializing geothermal power technologies contributes not only to a cleaner environment, but to a healthy U.S. industrial base, as well. Around the developing countries of the world, demand for electric power is burgeoning—and nearly half of these countries have geothermal resources. These markets have proven particularly receptive to clean energy produced with indigenous resources, creating attractive export options for geothermal technologies and expertise. In fact, U.S. geothermal companies have signed contracts worth more than $6 billion in the past few years to build geothermal power plants in some of these developing countries.

Direct Use of Geothermal Energy

If you've ever soaked in water from a natural hot spring, you're one of the millions of people around the world who has enjoyed the direct use of geothermal energy. And while this naturally occurring hot water may be the perfect tonic for frayed nerves and sore muscles, it's capable of much more. In the United States alone, direct geothermal applications (not including geothermal heat pumps) have an installed capacity of 500 thermal megawatts, which is roughly equivalent to saving half a million barrels of oil per year. This includes approximately 40 greenhouses, 30 fish farms, 190 resorts and spas, 125 space and district heating projects, and 10 industrial projects.

The resource required for these applications is widespread across the western third of the United States. This is water in an underground reservoir, at low-to-moderate temperatures usually ranging from 68° to 302°F (20° to 150°C). The consumer of direct-use geothermal energy can count on savings in energy costs—as much as an 80% reduction from traditional fuel costs, depending on the application and the industry. Direct-use systems typically require a larger initial investment, but have lower operating costs and no need for ongoing fuel purchases, therefore reducing life-cycle costs.

In a typical application, a well brings heated water to the surface; a mechanical system—piping, heat exchanger, controls—delivers the heat to the space or process; and a disposal system either injects the cooled geothermal fluid underground or disposes of it on the surface.

The direct use of geothermal energy offers some heartening possibilities. Imagine an entire community of people having their homes heated geothermally. Sound like something way off in the future? Not at all. In 1893, the citizens of Boise, Idaho, put their pioneering spirit to work and built the world's first geothermal district heating system by piping water from a nearby hot spring. Within a few years, the system was providing heat to 200 homes and 40 downtown businesses—and the system continues to flourish today.

There are now 18 district heating systems in the United States (including one in Klamath Falls, Oregon, that melts snow from the city's downtown sidewalks), and the potential for more is tremendous. A recently updated resource inventory of 10 western states identified 271 communities located within 5 miles (8 kilometers) of a geothermal resource.

Greenhouse operators are taking advantage of geothermal direct use in growing numbers, with nearly 40 greenhouses (many of which are several acres in size) producing vegetables, flowers, houseplants, and tree seedlings in eight western states. Operators of fish farms are profiting from the lower energy costs and improved fish growth rates that geothermal energy delivers. Other industrial and commercial applications that match well with geothermal direct use include food dehydration, laundries, gold processing, milk pasteurizing, and swimming pools and spas.

The Heat Pump Solution

The geothermal heat pump doesn't create electricity—but it greatly reduces consumption of it. If you would like to reduce the cost of heating and cooling your home, you might want to consider installing a geothermal heat pump, an economical and energy-efficient technology for space heating and cooling and water heating. Nationwide, more than 350,000 of these systems are in operation in homes, schools, and businesses. And the geothermal heat pump industry expects to be installing 40,000 systems per year by 2000.

In winter, heat pump systems draw thermal energy from the ambient temperature of the shallow ground, which ranges between 50° and 70°F (10° to 21°C) depending on latitude. In summer, the process is reversed to a cooling mode, using the ground as a sink for the heat contained within the building. The system does not convert electricity to heat; rather, it uses electricity to move thermal energy between the building and the ground and condition it to a higher or lower temperature according to the heating or cooling requirements. Consumption of electricity is reduced 30% to 60% compared to traditional heating and cooling systems, allowing a payback of system installation in 2 to 10 years. And these low-maintenance systems have long lives of 30 years or more. Some systems are also capable of producing domestic hot water at no cost in summer and at small cost in winter.

An analysis by the EPA found these systems to be among the most efficient space-conditioning technologies available—with the lowest environmental cost of all that were analyzed. But this might be the most compelling statistic: Surveys show that the number of satisfied geothermal heat pump customers stands at 95% or higher.

About Solar Heating and Cooling

It is possible to use solar thermal energy or solar electricity to operate or power an HVAC or heating and cooling system. The following is a brief description of "active" solar cooling and refrigeration technologies. Active solar energy systems use a mechanical or electrical device to transfer solar energy absorbed in a solar collector to another component in the "system." It is possible to also cool a building or structure by using the natural processes of solar heat transfer (conduction, convection, and radiation). This is often referred to as "passive solar cooling," and is primarily an architectural technique. This brief focuses on active solar cooling systems. The American Solar Energy Society (ASES, see

Source List below) is one source of information on passive solar cooling techniques.

Absorption Cooling and Refrigeration

Absorption cooling is the first and oldest form of air conditioning and refrigeration. An absorption air conditioner or refrigerator does not use an electric compressor to mechanically pressurize the refrigerant. Instead, the absorption device uses a heat source, such as natural gas or a large solar collector, to evaporate the already-pressurized refrigerant from an absorbent/refrigerant mixture. This takes place in a device called the vapor generator. Although absorption coolers require electricity for pumping the refrigerant, the amount is small compared to that consumed by a compressor in a conventional electric air conditioner or refrigerator. When used with solar thermal energy systems, absorption coolers must be adapted to operate at the normal working temperatures for solar collectors: 180° to 250°F (82° to 121°C). It is also possible to produce ice with a solar powered absorption device, which can be used for cooling or refrigeration.

How Does an Engine Driven Chiller Work?

Packaged natural gas engine-driven water chillers and direct expansion (DX) units are now available. Commercially proven custom and packaged engine-driven refrigeration units offer excellent reliability and economic advantages for ice rinks, refrigerated warehouses and other applications. The industry is also focusing on developing small, engine-driven heating and cooling systems suitable for small commercial applications.

Operation: Engine-driven cooling systems employ a conventional vapor compression cycle. Their main components are the compressor, condenser, expansion valve and evaporator.

Advantages: The main difference between a natural gas and conventional electric system is the replacement of the electric motor with a gas engine. This change results in variable-speed operation capability; higher part-load efficiency; efficient high-temperature waste-heat recovery for water heating, process heating, or steam generation; and an overall reduction in operating expenses.

* Requires no more room than conventional electric chillers

* Lowest operating cost of any available chiller

* Depending on electric rates and natural gas rates, an engine driven chiller may operate at up to 1/2 of the cost of direct-fired absorption chillers

* Like absorption chillers, engine driven chillers reduce on-peak electric demand charges.

* Depending on your electric and/or natural gas supplier, there may be rebates available for purchasing a new absorption chiller or engine driven chiller from your utility supplier.

* Environmentally friendly.

Solar Cooling

Solar cooling employs heat driven chillers to provide cold water to condition air through fan coil units or under floor heat transfer systems. Heat driven cooling technology relies on commercially and proven heat driven chillers that have been deployed globally, utilizing less than 0.1% of the electricity that the traditional compressor system utilizes. Despite this, solar cooling is in its infancy with approximately 1000 installations, primarily pilot projects that have successfully leveraged. More than 200 solar cooling systems have been installed in Europe.

The application of solar cooling is economical, especially when the solar collector field is also available during the winter for heating purposes.

Millennium has extensive HVAC and solar cooling systems experience.

Millennium is currently agent for SorTech adsorption chillers for cooling and air-conditioning applications in the small and medium scale performance range from 7.5 kW to 60 kW cooling capacity utilizing heat as primary energy for cold production instead of electricity.

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