

SOLAR ENERGY, PROBLEMS AND PROSPECTS

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Solar energy, radiant light and heat from the sun, has been harnessed by humans since ancient times using a range of ever-evolving technologies. Solar radiation, along with secondary solar-powered resources such as wind and wave power, hydroelectricity and biomass, account for most of the available renewable energy on earth. Only a minuscule fraction of the available solar energy is used.

Solar powered electrical generation relies on heat engines and photovoltaics. Solar energy uses are limited only by human ingenuity. A partial list of solar applications includes space heating and cooling through solar architecture, potable water via distillation and disinfection, daylighting, solar hot water, solar cooking, and high temperature process heat for industrial purposes. To harvest the solar energy, the most common way is to use solar panels.

Solar technologies are broadly characterized as either passive solar or active solar depending on the way they capture, convert and distribute solar energy. Active solar techniques include the use of photovoltaic panels and solar thermal collectors to harness the energy. Passive solar techniques include orienting a building to the Sun, selecting materials with favorable thermal mass or light dispersing properties, and designing spaces that naturally circulate air.

Energy from the Sun

The Earth receives 174 petawatts (PW) of incoming solar radiation (insolation) at the upper atmosphere. Approximately 30% is reflected back to space while the rest is absorbed by clouds, oceans and land masses. The spectrum of solar light at the Earth's surface is mostly spread across the visible and near-infrared ranges with a small part in the near-ultraviolet.

Earth's land surface, oceans and atmosphere absorb solar radiation, and this raises their temperature. Warm air containing evaporated water from the oceans rises, causing atmospheric circulation or convection. When the air reaches a high altitude, where the temperature is low, water vapor condenses into clouds, which rain onto the Earth's surface, completing the water cycle. The latent heat of water condensation amplifies convection, producing atmospheric phenomena such as wind, cyclones and anti-cyclones. Sunlight absorbed by the oceans and land masses keeps the surface at an average temperature of 14 °C. By photosynthesis green plants convert solar energy into chemical energy, which produces food, wood and the biomass from which fossil fuels are derived.

The total solar energy absorbed by Earth's atmosphere, oceans and land masses is approximately 3,850,000 exajoules (EJ) per year. [In 2002, this was more energy in one hour than the world used in one year.] Photosynthesis captures approximately 3,000 EJ per year in biomass. The amount of solar energy reaching the surface of the planet is so vast that in one year it is about twice as much as will ever be obtained from all of the Earth's non-renewable resources of coal, oil, natural gas, and mined uranium combined.

From the table of resources it would appear that solar, wind or biomass would be sufficient to supply all of our energy needs, however, the increased use of biomass has had a negative effect on global warming and dramatically increased food prices by diverting forests and crops into biofuel production. As intermittent resources, solar and wind raise other issues.

Solar energy can be harnessed in different levels around the world. Depending on a geographical location the closer to the equator the more "potential" solar energy is available.

Applications of solar technology

Solar energy refers primarily to the use of solar radiation for practical ends. However, all renewable energies, other than geothermal and tidal, derive their energy from the sun.

Solar technologies are broadly characterized as either passive or active depending on the way they capture, convert and distribute sunlight. Active solar techniques use photovoltaic panels, pumps, and fans to convert sunlight into useful outputs. Passive solar techniques include selecting materials with favorable thermal properties, designing spaces that naturally circulate air, and referencing the position of a building to the Sun. Active solar technologies increase the supply of energy and are considered supply side technologies, while passive solar technologies reduce the need for alternate resources and are generally considered demand side technologies.

Architecture and urban planning

Sunlight has influenced building design since the beginning of architectural history. Advanced solar architecture and urban planning methods were first employed by the Greeks and Chinese, who oriented their buildings toward the south to provide light and warmth.

The common features of passive solar architecture are orientation relative to the Sun, compact proportion (a low surface area to volume ratio), selective shading (overhangs) and thermal mass. When these features are tailored to the local climate and environment they can produce well-lit spaces that stay in a comfortable temperature range. Socrates' Megaron House is a classic example of passive solar design. The most recent approaches to solar design use computer modeling tying together solar lighting, heating and ventilation systems in an integrated solar design package. Active solar equipment such as pumps, fans and switchable windows can complement passive design and improve system performance.

Urban heat islands (UHI) are metropolitan areas with higher temperatures than that of the surrounding environment. The higher temperatures are a result of increased absorption of the Solar light by urban materials such as asphalt and concrete, which have lower albedos and higher heat capacities than those in the natural environment. A straightforward method of counteracting the UHI effect is to paint buildings and roads white and plant trees. Using these methods, a hypothetical "cool communities" program in Los Angeles has projected that urban temperatures could be reduced by approximately 3 °C at an estimated cost of US\$1 billion, giving estimated total annual benefits of US\$530 million from reduced air-conditioning costs and healthcare savings.

Electrical generation

Sunlight can be converted into electricity using photovoltaics (PV), concentrating solar power (CSP), and various experimental technologies. PV has mainly been used to power small and medium-sized applications, from the calculator powered by a single solar cell to off-grid homes powered by a photovoltaic array. For large-scale generation, CSP plants like SEGS have been the norm but recently multi-megawatt PV plants are becoming common. Completed in 2007, the 14 MW power station in Clark County, Nevada, United States and the 20 MW site in Beneixama, Spain are characteristic of the trend toward larger photovoltaic power stations in the United States and Europe.[68] As an intermittent power source, solar power requires a backup supply, which can partially be complemented with wind power. Local backup usually is done with batteries, while utilities normally use pumped-hydro storage. The Institute for Solar Energy Supply Technology of the University of Kassel in Germany pilot-tested a combined power plant linking solar, wind, biogas and hydrostorage to provide load-following power around the clock, entirely from renewable sources. This is a good idea for other countries.

Energy storage methods

Solar energy is not available at night, and energy storage is an important issue because modern energy systems usually assume continuous availability of energy. Thermal mass systems can store solar energy in the form of heat at domestically useful temperatures for daily or

seasonal durations. Thermal storage systems generally use readily available materials with high specific heat capacities such as water, earth and stone. Well-designed systems can lower peak demand, shift time-of-use to off-peak hours and reduce overall heating and cooling requirements.

Phase change materials such as paraffin wax and Glauber's salt are another thermal storage media. These materials are inexpensive, readily available, and can deliver domestically useful temperatures (approximately 64 °C). The "Dover House" (in Dover, Massachusetts) was the first to use a Glauber's salt heating system, in 1948.

Solar energy can be stored at high temperatures using molten salts. Salts are an effective storage medium because they are low-cost, have a high specific heat capacity and can deliver heat at temperatures compatible with conventional power systems. The Solar Two used this method of energy storage, allowing it to store 1.44 TJ in its 68 m³ storage tank with an annual storage efficiency of about 99%. Off-grid PV systems have traditionally used rechargeable batteries to store excess electricity. With grid-tied systems, excess electricity can be sent to the transmission grid. Net metering programs give these systems a credit for the electricity they deliver to the grid. This credit offsets electricity provided from the grid when the system cannot meet demand, effectively using the grid as a storage mechanism.[101]

Pumped-storage hydroelectricity stores energy in the form of water pumped when energy is available from a lower elevation reservoir to a higher elevation one. The energy is recovered when demand is high by releasing the water to run through a hydroelectric power generator.

Development, deployment and economics

Beginning with the surge in coal use which accompanied the Industrial Revolution, energy consumption has steadily transitioned from wood and biomass to fossil fuels. The early development of solar technologies starting in the 1860s was driven by an expectation that coal would soon become scarce. However development of solar technologies stagnated in the early 20th century in the face of the increasing availability, economy, and utility of coal and petroleum.

The 1973 oil embargo and 1979 energy crisis caused a reorganization of energy policies around the world and brought renewed attention to developing solar technologies. Deployment strategies focused on incentive programs such as the Federal Photovoltaic Utilization Program in the US and the Sunshine Program in Japan. Other efforts included the formation of research facilities in the US (SERI, now NREL), Japan (NEDO), and Germany (Fraunhofer Institute for Solar Energy Systems ISE).

Commercial solar water heaters began appearing in the United States in the 1890s. These systems saw increasing use until the 1920s but were gradually replaced by cheaper and more reliable heating fuels. As with photovoltaics, solar water heating attracted renewed attention as a result of the oil crises in the 1970s but interest subsided in the 1980s due to falling petroleum prices. Development in the solar water heating sector progressed steadily throughout the 1990s and growth rates have averaged 20% per year since 1999. Although generally underestimated, solar water heating is by far the most widely deployed solar technology with an estimated capacity of 154 GW as of 2007.

Solar energy is not so widely used for electricity generation in our country, but using the experience of other countries, it becomes clear that such source of energy as solar power will be increasingly used in future. It is practically an inexhaustible source of energy. Scientific research is carried out by our scientists in this field of knowledge and it surely result in application of new technologies of energy production.

ISO Standards. The International Organization for Standardization has established a number of standards relating to solar energy equipment. For example, ISO 9050 relates to glass in building while ISO 10217 relates to the materials used in solar water heaters.