Solar Energy

Sunlight can be viewed as the ultimate renewable resource. It is the fundamental energy source for most forms of life (except some deep-ocean dwellers whose metabolisms are driven by chemosynthesis), and most forms of energy used in human society (except nuclear energy) are derived from solar energy in some form (photosynthesis drives biomass production; biomass is either used to create energy directly or converted to fossil fuels over time).

Today, the technologies most commonly used to convert sunlight into useful energy fall into two categories: **solar photovoltaic** and **solar thermal**.

Solar Photovoltaic

Solar photovoltaic (PV) cells directly convert the energy from sunlight into electrical current. PV cells are made of semiconductor materials that release electrons and create electrical current when excited by sunlight. PV systems are made up of multiple panels, which in turn are composed of a number of small PV cells. They can range in size from the miniscule panel of cells found in watches and calculators to multi-panel residential arrays to grid-level solar farms with hundreds of panels. Commercial PV technologies are currently available in varying degrees of sophistication: some are stationary; some move throughout the day, tracking the sun as it progresses across the sky; others use optics and mirrors to focus sunlight on a single cell for maximum effect.

The current generated by PV systems is known as direct current (DC). It is the same type of current that is used in car batteries. However, the electric grid distributes, and appliances consume, electricity in the form of alternating current (AC), which means that an inverter must be installed along with any PV system. When installing a PV system, owners can choose whether or not to interconnect with the grid. Grid-tied systems are easier to install and maintain, have the benefit of receiving power from the grid on cloudy days, and are cheaper, since instead of purchasing an expensive battery to store excess power generated during peak hours, power can simply be diverted onto the grid.. However, they usually won't provide power if the grid goes down, making them a less desirable option for system owners interested in self-sustainability.

Historically, the greatest barrier to solar PV development has been its high cost of power, which has exceeded that of both fossil fuel-based electricity and other renewable power sources. However, standard cost analysis of PV systems tends to exclude many of its peripheral benefits,

such as lower transmission and distribution costs associated with on-site power generation and a higher value of electricity resulting from production curves that correspond with average hourly demand profiles. Coupled with the ability to install systems on or near existing structures, which reduces land use constraints common to other renewable energy projects, this continues to create appeal for the development of solar PV.

What is the status of PV in Massachusetts?

The Commonwealth of Massachusetts has long demonstrated a commitment to encouraging the maturation of the solar energy market. A renewable energy charge (known as the systems benefit charge, or SBC) on electric bills began funding PV rebates and partnerships in 2001. In 2008, a Commonwealth solar program was established to award rebates through the Massachusetts Clean Energy Center (MassCEC). The current program is the Commonwealth Solar II Program, which offers incentives of $0.40/watt, with additional possible adders. These programs have provided millions of dollars in funding for commercial, industrial, residential, institutional, and public PV projects. For the most recent program, these rebates have represented approximately 10% of costs. Federal grants and rebates also contribute to project funding in some instances.

According to the Solar Energy Industries Association, there are currently more than 286 solar companies in Massachusetts, with a total installed base of 464 MW. This is more than Governor Patrick's original goal of 250 MW and ranks the Commonwealth fifth in the nation in installed generation. Massachusetts' new goal is 1600 MW by 2020.

One initiative promoting solar development in the Commonwealth is the Solar Carve-Out program, which was established through the Green Communities Act and became effective in 2008. The Solar Carve-Out mandates that certain percentage of compliance for the Renewable Portfolio Standard (RPS) program be met with solar energy through the purchase of Solar Renewable Energy Certificates (SRECs).

How do I become an SREC generator?

To be eligible, generators must:

- Have a capacity of less than 6 MW
- Be located in Massachusetts
- Use some of its generation on-site and be connected to the utility grid
- Have a Commercial Operation Date of January 1, 2008 or later

The Solar Carve-Out works in complement with the Commonwealth Solar II Program. However, projects that received substantial funding from ARRA or the Renewable Energy Trust prior to the start date of the Solar Carve-Out program (January 1, 2010) are not eligible to participate.

Although SREC generators may apply individually (there is a basic application on the DOER website), small-scale residential and commercial operators are encouraged to apply as members of an aggregation of generators, as it will be easier to negotiate contracts with buyers looking to purchase large quantities of SRECs. A list of aggregators and brokers can be found on the Massachusetts RPS website.

Each applicant or aggregate participant must first establish a trading account at NEPOOL GIS and submit a Statement of Qualification Application to DOER (which can be found on the DOER website). DOER will then tell MassCEC to put the qualified system in their Production Tracking System (PTS). At the end of each month, data from the PV system's production meter will have to be uploaded into the PTS. MassCEC will then send this information on to NEPOOL GIS, where it will be given an electronic certificate and become an SREC. When it shows up in the NEPOOL GIS system, it can be sold in the electricity market.

For local government entities that want to show their commitment to solar power but lack the resources to procure systems outright, a Power Purchase Agreement (PPA) may be a better option.

Solar Thermal

Solar thermal energy (STE) technology converts the energy from sunlight into heat energy (as opposed to photovoltaic technology, which converts it directly into electrical current).

Low- to medium-temperature solar collectors tend to be a cheaper alternative for communities or households that lack the upfront capital to install more costly photovoltaic systems, but still want to find a way to take advantage of the free, abundant resource of solar energy. These can be used to keep swimming pools warm or in place of a hot water heater or central heating system. They can provide up to 80% of a building's hot water needs.

Solar water heaters can be either active (with circulating pumps and controls) or passive (without). They have two main components: a storage tank for heated water, and the collector, which is generally installed on the roof.

These collectors have an average life span of 30-40 years and can sometimes outlive the roof itself. Most solar water heaters also come with a backup tank to provide for cloudy days or times of unusually high demand.

High temperature solar collectors use mirrors and optics to cause solar rays to converge on a certain point and generate electricity, usually by heating a conventional boiler to drive a steam-powered turbine. High temperature solar collectors, or concentrated solar power (CSP), can be

constructed to generate commercial scale amounts of power. The world's largest, Ivanpah, is currently located in California' Mojave Desert.

There are currently no CSP plants operating in Massachusetts, although in May of 2010 the federal Department of Energy announced a grant of up to $3.7 million to a CSP manufacturer with a novel design in Woburn.

Federal and state incentives make solar thermal systems relatively easy to purchase, and tend to have a payback time between 5 and 10 years. MassCEC's Commonwealth Solar Hot Water program offers incentives for solar thermal systems, and Mass Save's HEAT Loan Program provides low-interest financing for loans up to $25,000.