Environmental Design+ Construction

Web Exclusive: Solar Energy and Architecture

by Luis J. Roges
February 1, 2008

Making greater use of solar energy through viable, sustainable design.

What happens when one flips on a light switch? We all expect a light or many lights to come on somewhere in the room. Sounds simple, but few of us think about this unless no light turns on.

In the United States, electric power has been present for generations and is used by just about everyone alive today. Electric utilities have expanded their networks to cover our territory enabling from turning a light bulb tc powering vey complex manufacturing processes. The power distributed through this apparently seamless and quiet process originates at generation stations that are neither quiet nor simple. Electricity provides the most economical way to transport energy over long distances and to remote locations where it has brought progress and better quality of life to every community it has reached.

Electric-power generating facilities ere installations — plants — thet produce electric power from other forms or sources of power. The most common sources are fossil fuel (oil, coal and natural gas), nuclear power, dammed rivers or other bodies of water, geothermal, solar thermal, wind (eolian), and chemical energy (from fuel cells and batteries).

Fossil Fuels

Fossil fuels are being consumed faster than they regenerate and not only fossil fuels are being consumed faster than they are regenerated, but their available reserves are finite. Additionally, the generating process from fossil fuels (the kind most commonly used in the united States and throughout the world) produces emissions that contribute to the greenhouse effect and to global warming. For years engineers and scientists have been seeking of alternate sources of power to generate electricity in a quest for sustainable, natural, clean fuels.

Hydraulic Power

Hydraulic power is the conversion of the potential energy from falling water through a hydroelectric facility into electric power. These systems have been widely used and provide a clean and fairly inexpensive source of energy but they are predetermined by geographlcal conditions which are not available everywhere.

Wind Power

Wind energy continues to be developed, providing a clean source of power but it is limited to areas of high winds usually distant from urban developments. Wind farms require large areas for the installation of the wind power towers (turbines) and many communities oppose their use because of aesthetics. One example, which has been delayed for years, is the Cape Wind project in Nantucket Sound, R.I., that will have more than 130 wind turbines.

Nuclear Power

At its birth, nuclear power brought great hopes to the engineering community that it had found “the solution” to the ever-growing electric power needs of the world. Beginning in the 1960s here and in Europe many nuclear plants were designed and built. Later, in the 1980s, Asia began to build nuclear plants to meet its incipient power needs. However, this •great solution” brought along a new problem: nuclear waste. We in the AEC community are generally aware of the great problem waste disposal presents, the NIMBY syndrome end other societal concerns around nuclear waste management and disposal. Add radioactivity to the waste and the problem becomes almost insurmountable. The LIS Nuclear Regulatory Commission (NRC) 2006-2007 Information Digest reports that in 2004, 10 percent of the LIS electric power generating capability was from nuclear energy. The growth of nuclear power has been impaired by the enormously difficult social and political problem that nuclear waste represents — a problem that, to date, remains unsustainable and unresolved.

Without the sun, life as we understand it on our planet would not be possible. We ell take for granted that there will be a sunrise the next day, and it has been so since humans first appeared on Earth. What if we were to harness and harvest the sun's almost infinite source of clean, sustainable and perceivably inexpensive power? Architects, as form- givers and designers, bear great responsibility — even, I would venture, bear the duty — to integrate design, sustainability, power availability/consumption and conservation together in a continuum toward a clean and efficient way of life. Sunlight and its power renew life ever,' day. This basic concept has driven my approach to design since day one: We must use it. Solar power offers feasible solutions (at the residential level) to both heating water (SWH) and to local generation of electric power.

Harnessing the Sun

Photovoltaic (PV) cells offer, what perhaps is, the single most valuable "tool" supporting sustainable design as they present an actual alternatlve to carbon-based energy sources. Today, there are photovoltaic cells units of up to nearly 200 watts per panel. This concept is not limited to the residential level. Soulder City, 20 miles (SE) from Las Vegas, is the site of the most recent large-scale renewable power source project, Nevada Solar One. This 64 megawatts solar power plant is a 300-acre facility. The scale of Nevada Solar One and its influence across the natlon'5 Sun Belt are remarkable contributions to sustainable design.

PV cells would become our rooftops and parts of our windows on buildings that are designed seriously to take on solar-power generation. Environmentally-conscious architects will integrate PV use through appropriate building shapes and orientations, including the proper treatment of areas of south glass.

Cost Benefits

One trend in the U.S. is that of power utilities allowing users to "sell power back to the grid." Through renewable energy credits (RECs), which are part of a program in many states where electric utilities are required by law to invest in renewable energy, utilities buy tradable certificates from consumers who have green/renewable power-generating systems (mostly solar) so that they Can sell power back to the grid. Sy way of net-metering, a customer (consumer) produces energy and feeds it back into the grid to get credit for the amount of energy produced. This complex process requires simplification. Parallel to an ever-increasing cost of oil, we anticipate that smart and environmentally-conscious entrepreneurs will become more interested in this segment of power-generation and distribution, helping the public to become aware of and take advantage of these technologies.

Some states offer income tax credits for passave solar residential design and have issued design guidelines that define the requirements for earning the tax credit. Some of them are:

- Building layout must maximize passive solar gain (less-used areas On north side, etc.)
- At least half of the window area must face within 30 degrees of due south.
- South window area should be greater than 7 to 9 percent of total floor area.
- Average windo U-factor (U factor measures heat loss prevention of a product. The rete Of heat loss is indicated in terms Of the U-factor Of a window assembly. It is expressed in atu/hr ft2 OF) may not be greater than 0.35 (area weighted).
- South window solar heat gain coefficient (SHGC; Soler Heat Gain Coefficient measures how we," window blocks heat from sunlight. The SHGC is the fraction of the heat from the sun that enters through s window. SHGC is expressed as a number between O and The lower a window's SHGC, the less solar heat it transmits) must be at least 0.55.
- Thermal storage (expressed in diurnal heat capacity) must be equal to 30 times the area of south-facing windows.
- The building needs to have adequate overhangs.
- Shading of the south face should be less than S percent.
- North windows must be less than 2 percent of floor area.

- Skylights must be tinted and have an SHGC of no more than 0.30.
- Skylights may be no more than 1 percent of roof area.
- West window SHGC must be less than 0.40.
- The house should have a whole-house fan or an operable window or skylight near the highest point in the roof.

Sunlight should be looked at as a kind of "Dr. Jekyll & Mr. Hyde," because while the heat can be used for solar water heaters, it is desirable to restrict the heat component through windows facing directions other than south; and even windows facing south need summer shading. This opens opportunities to use RVs as electricity-generating shades. In colder climates zones, however, south glass should embrace winter sun as it is a major contributor to the heating of the building.

Technological Advances

In this context of sustainable, energy-efficient design, the lighting industry is offering increasingly better technologies. Compact fluorescent bulbs, as substitutes for incandescent bulbs, have decreased the lighting heat-load in buildings, and LED lighting is the next big move. For the same light emission (lumens), LED bulbs use 2-10 watts Of electricity (1/3 to 1/30 Of incandescent or compact fluorescent), emit little heat compered to standard bulbs, work in cold weather and are dimmable. The electric load from lighting will decrease with designs using these technologies, making the use of PV to service smaller power loads even more feasible.

Architects are knowledgeable about the interconnections that link solar heating, use Of daylight, passive cooling and consen'ation. Allowing daylight inside for illumination and passive heating during winter months favors bigger windows. At the same time, passive cooling calls for smaller windows that minimize direct sunlight without sacrificing natural ventilation or requiring lights during daytime. Smart analysis and design with a combination of building orientation, window openings and sizes, proper insulation, use of sustainable materials and integrated use of solar power are not only socially and environmentally responsible, but they are concepts that we all Ought to embrace.

Luis J. Roges

Luis Roges is a vice president at Meridian Design Associates, Architects, P.C., (www.meridiandesign.com), a global architectural firm committed to green issues and sustainable commercial and residential designs.