Energy Efficient Buildings for a Sustainable Future

By Roshni Udyavar (The author is Head, Rachana Sansad's Institute of Environmental Architecture)

As we take stock of our balance-sheet with Planet Earth eight years into the third millennium, we are dismayed that our solitary home in this Universe is under siege by one species – *Homo sapiens*. Since the beginning of the industrial revolution when we began to exploit fossil fuels – oil, coal, gas - stored during the earth's evolution, we have indiscriminately exploited it as if these resources were infinite. And now, we have realized that we will soon be running out of fuel and perhaps facing a future with sea-level rise, unpredictable weather conditions, extreme heat and cold, and all the grim possibilities that scientists studying global warming have predicted.

Buildings consume energy not only during construction, but throughout their life cycle. The Sustainable Buildings and Construction Initiative of the United Nations in a report[1] released in 2006 stated that building construction activity constituted 40% of energy use, 30% of raw materials, 20% of water and 10 % of land use while contributing to 40% of CO_2 emissions, 30% of solid waste generation and 20% of effluents. Most of the energy use – almost 80% - is consumed during the operation of the building, according to a report by The Energy Resources Institute[2].

India is a growing and emerging economy. Despite the slump in the market, there is a trend towards urbanization and growth in the commercial sector through IT Parks, SEZs and the like, all of which will require energy. According to the Eleventh Five year Plan of the Government[3], India is the world's seventh largest energy producer, accounting for about 2.49% of the world's total annual energy production, as well as the world's fifth largest energy consumer, accounting for about 3.45% of the world's total annual energy consumption in 2004. However, India's per capita energy consumption is one of the lowest in the world. India consumed 455 kilogram of oil equivalent (kgoe) per person of primary energy in 2004, which is around 26% of world average of 1750 kgoe in that year. Compared to this, per capita energy consumption in China and Brazil was 1147 kgoe and 1232 kgoe, respectively. Despite an envisaged growth rate of 9% in the latest five year plan ending 2012, over half of the country's population does not have access to electricity or any other form of commercial energy. Bridging this gap by increase in the supply chain – adding thermal plants, nuclear plants, hydro plants as well as opting for renewable resources such as solar photovoltaic, solar thermal and wind – is an uphill task, one which will take a prolonged period of time if it has to meet the demands of India's growing population. In the nearly 70,000 villages in India not covered by an electrical grid, it is evident that the quality of life is below par as women spend several hours each day collecting water and fire-wood.

On the other hand, demand-side management through passive solar design and energy conservation measures in buildings has immense potential. The potential of saving energy in residential buildings is 20%, in industrial buildings it is 25% while that in commercial buildings it is as much as 30% according to a research by the Environmental Management Center, New Delhi. It is important to realize that conserving energy in buildings is equivalent to generating electricity in a power plant, every kwh of which produces 3015KCal of waste heat and 1 kg of CO_2 – a greenhouse gas.

Further, the MEDA (Mahaharshtra Energy Development Agency) states that every MW of energy generated from a conventional unit requires more than Rs. 5 crores of investment in addition to what is required in the transmission and distribution network.

Energy conservation in buildings can be achieved by the following methods:

- **Solar Passive or bioclimatic architecture: designing building envelope with a thorough understanding of climate and building physics; to maximize day-lighting and thermal comfort**
- **Using renewable sources of energy**
- **Using energy-efficient appliances**
- **Using local, durable, flexible and energy efficient materials and design of spaces**
- **Applying energy conservation measures at the personal/ consumer level**

Solar Passive or bioclimatic Architecture: According to the Center for Monitoring Indian Economy (CMIE), 2001, in the residential sector, 34% of the energy consumed is accounted to fans, 28% to lighting, 13% to refrigeration, and 7% to air-conditioning. While in the commercial sector, nearly 60% of the energy consumed is due to lighting, 34% to HVAC and 6% to fans. This clearly indicates the flaw in the building design. Through the use of glass envelopes, for example, which obstruct natural light within the building but allow heat gain, buildings are transformed to energy guzzling machines. These glass houses are carelessly replicated in different climatic zones without due consideration to energy consumption and thermal comfort.

Passive solar architecture is the science of designing buildings which breathe and provide comfort to inhabitants with least energy input. The vernacular even post-modern architecture of India with features such as balconies, verandahs, courtyards and sloping roofs exemplify passive design.

Modern tools such as energy simulation software are now available to do this job with ease and must be used by all architects. The best known example of passive solar architecture, the 540,000 sq. ft headquarters of the ING Bank in Amsterdam is a series of interconnected towers which do not use conventional air-conditioning. It relies primarily on passive cooling with back-up absorption chillers. The building uses less than a tenth the energy of its predecessor and a fifth that of a conventional new office building in Amsterdam. The annual energy savings are approximately $2.9 million from features that added roughly $700,000 to the construction cost of the building—and were paid back in three months.

Using renewable energy sources: India is bestowed with abundant solar radiation. It receives about 320 days of clear sunshine / year (2900hrs/day) and has a potential of 5.2-5.6 kWh /m2/ day. Solar thermal for water heating has been found to be feasible for India which with a pay-back period of about 1.5 to 2 years. Several brands and options such as thermo-syphon system, forced pump system and heat-exchanger system are available for different requirements. Solar photovoltaic and wind energy are still associated with high initial cost with a pay-back of nearly 20 years. But they can be considered for communities, townships and SEZs which have no grid connection. Geothermal energy for heating or cooling is another less explored option for renewable energy. Building Integrated Photovoltaic (BIPV), is another emerging trend where solar cells become part of the building envelope.

Using energy efficient appliances: The use of Compact Fluoroscent Lamps instead of standard incandescent bulbs or conventional tube lights has a potential to save nearly 60% energy. A change from electromagnetic ballast to electronic ballast can save ballast losses of nearly 15%. The following checklist can be useful in energy efficient design of buildings:

- Follow NBC-2005 for appropriate Lux levels required for various tasks.
- Select lamps on their efficacy values (lumens/Watt), Rendering Index (Ra) & Color temperature (CCT) values
- Use lighting software tools for lighting design analysis
- Try design alternatives to fulfill both lighting levels and lighting power density requirements. Spaces are often illuminated with no concept of lighting power density – or the exact number of lights required to provide sufficient light for the task in the space. An uniformity ratio (ratio of lowest to average lux level in a room) of >0.3 should be maintained.
- Finalize design based on life cycle cost analysis; for example the life cycle cost of an incandescent bulb is Rs. 1500 while that of a CFL is Rs. 650 even though the initial cost of the CFL is 10 times that of the bulb.
- Incorporate automatic lighting controls; this includes the use of timers, occupancy sensors and photocells.

Using local, durable, flexible and energy efficient materials and design of spaces: This implies the use of materials which have low embodied energy or the life-cycle of which does not involve the pollution and overuse of our natural resources.

Applying energy conservation measures at the personal/ consumer level: Although this measure has least inputs from the architect or designer, it can make a world of difference to energy consumption. The simplest measure that can be taken by every user is to switch off fans and lights when not in use. For offices using AC or HVAC system, it is advisable to conduct an energy audit of the premises. It is important to maintain a power factor greater than 0.9. Today, a number of ESCOs or Energy Service Companies are available who conduct energy audit and charge their fees from the amount of energy they conserve.

Conforming to the measures stated above is much in compliance with the Eleventh Five Year Plan of the Planning Commission of India. Every attempt must be made by professionals and educational institutions to apply these measures in building design.

Richard Crowther stated in an article on Habitability: “Design is the key in our worldly realm of energy and matter. Nature has no sacred vow or responsibility to preserve us above all other species, nor to preserve us at all. To save ourselves from ourselves may yet be possible. [4]

References:

1. Sustainable Buildings and Construction Initiative – Information Note; United Nations Environment Program, 2006
2. Managing Power Demand: A Case Study of the Residential Sector in New Delhi by Manisha Jain, Vikas Gaba and Leena Srivastava, published by the British High Commission, New Delhi and TERI, 2007
3. Eleventh Five Year Plan: 2007 – 2012, Vol III, Agriculture, Rural Development, Industry, Services and Physical Infrastructure, Planning Commission Government of India, Oxford University Press, 2008, pg 342
4. Ecologic Architecture by Richard Crowther, Butterworth Heinmann, 1992