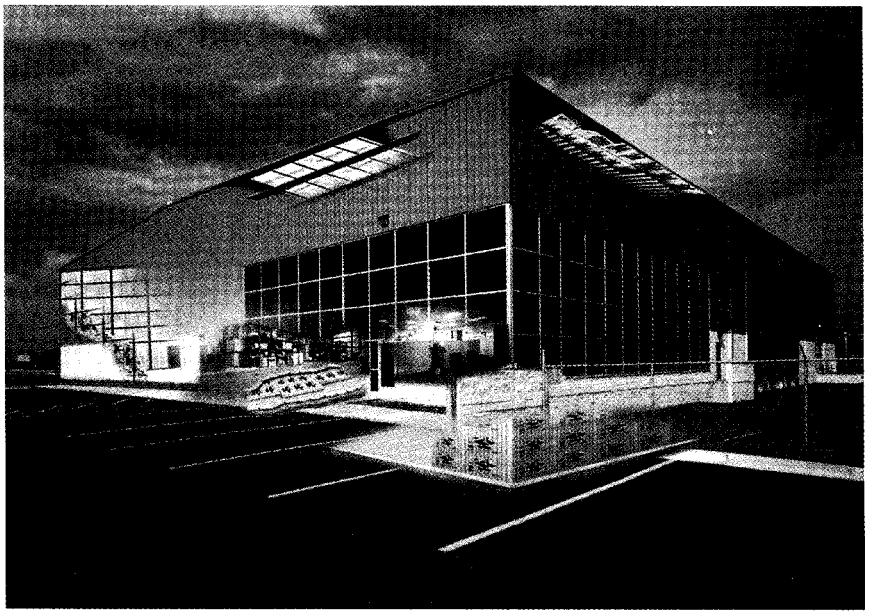
An initiative for energy efficient buildings

One of the most energy intensive sectors in India is the building sector. Consumption of energy is likely to rise even further due to the increase in urbanization, industrialization and living standards. Fuel price has been rising constantly. In a scenario like this reduction in the use of energy can be achieved significantly by applying various energy efficient techniques when constructing a building and even on existing buildings.

The importance of energy conservation and increasing use of renewable sources of energy in the transition to a sustainable development has already been recognized in the country. During the past quarter of a century, a significant thrust has been given to the development, trial and inclusion of a variety of technologies which can meet our energy needs on a sustainable basis and are environmentally acceptable. This paper presents one such initiative by the Ministry of New and Renewable Energy.



Introduction

The building sector in our country is one of the largest energy consuming sectors. In modern buildings significant amount of energy is consumed to keep the built environment comfortable. Energy consumption for production of building materials and construction of buildings is also significant. The purpose of constructing a building is to provide a shelter - an artificial environment, which is more conducive for human occupancy than the natural environment. It is also expected to be aesthetically appealing. Modern architecture with its many significant achievements is, however, more inclined to energy intensive solutions to achieve these objectives.

Energy consumption in the building sector has been progressively increasing in India with increasing standards of living, like in any other developing economy. As population grows and becomes more urbanized, there would be increasing activities in the building sector for construction and also for adequate arrangements for comfort of the built environment. This would demand larger share of energy in an already strained energy supply scenario of the country.

Since the required energy is mainly derived from fossil fuels, the building sector has become a major perturbing factor to the environment. The energy related perturbation is contributed by green house gas (GHG) emissions and emissions of acid rain precursors like sulphur dioxides and nitrogen oxides. The environmental impact resulting from the energy consumption in the building sector has, of late, become a global concern.

In this scenario introduction of energy efficient building design concept has become critical for achieving the collective objectives of energy security and environmental protection which in turn can ensure economic and social development.

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Energy Efficient Building Design Concept

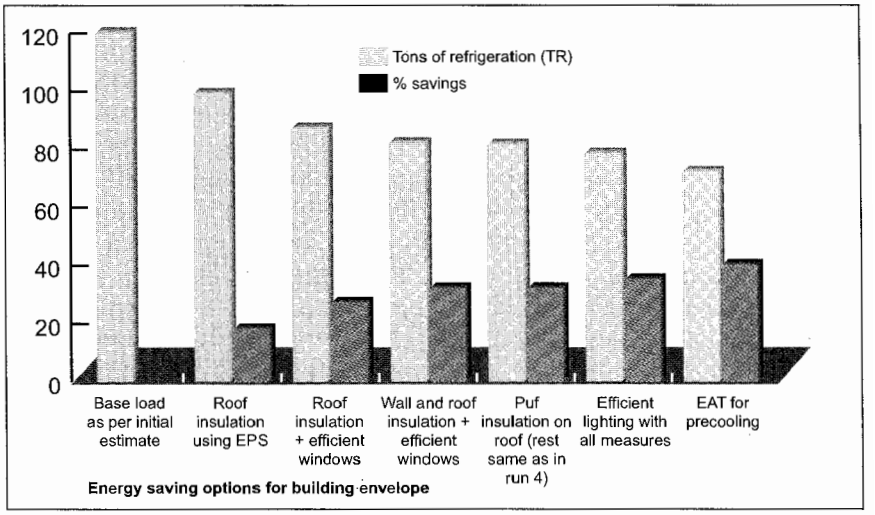
Energy efficient building design is essentially an integrated approach. The available options in architectural intervention, building materials, available technologies and design methodologies are required to be

carefully evaluated to minimize energy usage and provide cost effective solutions. The purpose is to achieve total comfort with the least amount of conventional energy input. This would save scarce fossil resources and result in concomitant environmental benefits. Not only the new building stock can be targeted, but also retrofitting of the existing buildings with newer technologies can result reduction of energy consumption in large number of cases. Various options that are available for achieving the above objectives are as follows:

Passive solar techniques

Passive solar techniques capture adequate solar energy for heating the building during the winter and provide for shading from the sun during the summer. The initial approach is to provide a suitable orientation with respect to the sun. Optimum solar designs are accomplished by vegetation, overhangs, awnings or sunscreen. To reject heat in a hot climate, natural sinks are used and ventilation wherever required is maximized. The useful daylight is harnessed through appropriate windows and skylights and also through light shelves.

Many of the solar passive techniques based on traditional wisdom date back to ancient times. Over hundreds of years in various geographical regions of the world, many of these techniques have progressively got refined. This traditional architectural concept offers a more comfortable built environment compared to conventional structures. With recent advances in computational aids, more accurate and site specific designs are now possible. As a result of efforts made in many countries of the world including ours to promote this technology, a host of new techniques and materials (advanced glazing, storage materials, light pipes, fiber optics etc.) are now available, expanding the opportunities for wider applications of the technology.



Source: Mili Mijundar (TERI)

Figure 1: Reduction in cooling load for an institutional building by incoporation of energy efficiency measures

Energy efficiency

Increasing insulation levels in conditioned buildings is regarded as the most cost effective investment in energy efficiency. Thermal insulation of external walls, roof and floor and double pane windows can reduce energy consumption for space heating by lowering heat losses through the envelope of the building. Energy consumption for cooling can also get reduced because of lesser heat gains from outside, through the envelope.

For cold climate a newer development is *'transparent insulation material'* (TIM). As the name suggests TIMs are characterized by their ability to transmit solar radiation while providing sufficient insulation against heat losses.

■ *Air conditioning (AC) and refrigeration* technology is undergoing major changes because of increasing environmental consciousness and decreasing energy availability. The change is towards higher efficiency and better environmental acceptability. Efficient AC system and strategic energy conservation measures must be adopted to reduce energy consumption of air-conditioned buildings. Solar cooling systems based on vapor absorption refrigeration is technically feasible, but so far has failed to achieve economic competitiveness. Further R&D is in progress.

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Figure 1 highlights the actual energy reduction that may be achieved in the heating load requirements in properly designed energy efficient buildings.

■ *Energy efficient light* consume considerably less electricity than an incandescent lamp for producing the same light. Its initial cost is high but it lasts for longer duration and the running cost is less. Such lamps are now available in variety of wattages. As electricity is efficiently being converted to light in these energy efficient lamps, the amount of heat generated is significantly less.

■ *Energy efficient glazing (insulating glasses, solar controlled glazing, low-e glazing etc.)* can contribute for efficient utilization of energy in three ways - by reducing the capacity of installed air conditioning system, by lowering the electricity consumption for its operation and by reducing the

electricity consumption due to lighting by the optimal use of natural daylight in buildings during daytime.

Specifications of the glazing, however, are required to be defined and matched to the particular requirements and environmental strategy of each building. Above mentioned energy management techniques are often more cost effective in providing a given level of energy services than any energy supply strategy [1].

Renewable energy technologies

- *Solar water heaters* currently available in the market can generate hot water at 60-80 °C and can be conveniently installed. The technology is fairly mature and economically viable. It can affect considerable saving of electricity. The technology has already found success in market penetration in western and southern parts of the country.
- *Solar air heaters* can supplement heating requirement of a building during daytime. In cold and sunny climate, these can be used extensively to reduce demand of electricity and firewood for space heating. Old buildings can also be retrofitted with solar air panels very easily.
- *Solar electricity* can be generated by integrating solar cells in buildings, on roofs and facades, or by installing grid connected photovoltaic (PV) power plants. It is an expensive proposition where grid connected electricity is available. However, for locations where conventional electricity is not available or the grid is far away, it makes an ideal alternative [2]. PV power plant offers a number of advantages compared to conventional electricity. It provides the energy security. Inclined roofs if oriented in the right direction, for instance, are an ideal support structure for PV modules, and construction costs can be minimized. Grid connected plants offer the possibility of supplying surplus amounts of PV electricity to the national grid.

Low energy materials and methods for building construction

An analysis of the 'embodied energy' from a range of different building materials, construction methodologies and building type suggests that the energy requirement for constructing a building can represent many times the energy used by the building in a single year of operation [3]. For an energy efficient structure, it is therefore necessary to closely examine the issue of building materials and to take an appropriate decision. The rules for decision making for selecting materials for construction in energy efficient way as suggested by Robert Vale [3] are given in Box 1.

Solar Buildings Program of MNRE

The concern for energy scarcity and the environmental problems associated with consumption of energy in the building sector have resulted in continued interest in energy efficient building design. For about two decades, the Ministry of New and Renewable Energy (MNRE) has been working on the possibility of using solar energy in the building sector for reducing energy consumption in buildings through climate responsive designs and providing clean renewable energy sources to meet part of the energy loads of buildings. Since 1994, through a comprehensive Solar Passive Architecture Program, MNRE

Box 1

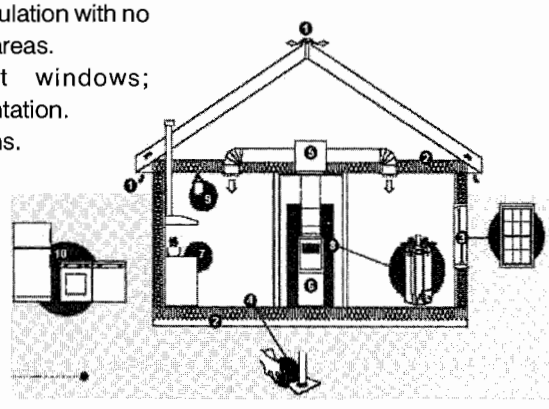
Selecting materials for construction – Rules for decision making

- Where two materials exist that will perform the same function for the same price, choose the less toxic of the two.
- Wherever practicable choose materials that are unrefined and as close as possible to their natural state.
- Use local materials wherever possible; the heaviest materials should be obtained from the closest sources.
- Design for minimum energy consumption and maximum longevity.

Improve energy efficiency throughout the house

The figure below suggests some measures that can be incorporated at the design stage of any home or other building. These measures will help save substantial amount of energy, over the life of the building.

1. Provide roof/attic ventilation.
2. Install adequate insulation with no gaps or compressed areas.
3. Specify efficient windows; consider window orientation.
4. Seal all penetrations.
5. Locate all ducts within conditioned space; ensure all ducts are sealed with mastic.
6. Choose efficient modesl and right size heating and cooling equipment.
7. Provide controlled ventilation.
8. Install efficient water heating.
9. Specify efficient lighting for fixtures used more than 4 hours per day.
10. Choose efficient appliances.



Courtesy of Southface Institute; developed with funding from the U.S. Department of Energy

has undertaken several activities to promote energy efficient building design concept in the country. The program is currently known as the Solar Buildings Program.

The primary objective of the Solar Buildings Program is to promote energy efficient building designs, through optimum use of available solar and other forms of ambient energy in building energy management. The program has several components namely Research & Development, Training & Education, Awareness creation and Demonstration [4].

Research and Development

R&D projects are sponsored by the Ministry at universities, national laboratories and other research institutions, with the objective of developing suitable design techniques and concepts, software packages, architectural instruments, materials, thumb rules etc. for solar efficient buildings.

An important requirement for designing an energy efficient building is to have adequate knowledge of the climatic conditions of the given location. In order to provide this information to the building designers, through a sponsored research project, the information on climatic parameters collected by the meteorological stations of the India Meteorological Department (IMD) over the years was analyzed and presented in a concise form. In the study, on the basis of monthly mean data recorded in 233 stations located in different parts of India, the country has been classified into six climatic zones[5]. This classification has further been used to evolve suitable design guidelines for buildings in different climatic zones [6]. Computer softwares have also been developed to help design a building in harmony with the nature. R&D is also being carried out to make low energy consuming buildings by optimizing use of the available solar and other ambient forms of energy.

Through another sponsored project, ambient design conditions have been developed for 52 stations in India as per ASHRAE (1997) format [7]. Weather data base for different climatic regions in the country has also been developed in standard formats acceptable to most applications.

Training and Education

Under this program workshops and seminars are being organized throughout the country for creating awareness, generating public interest and providing inputs about the technology to engineers, academicians, scientists, planners, builders, students and potential house owners. Orientation courses are regularly being organized for architects to make them familiar with the new developments and to motivate them for adopting solar efficient building design concepts.

Training & education is one of the major actions to disseminate the available knowledge on the subject. Since the inception of the program, more than 70 such training programs have been organized in different parts of the country. Every year around 10 such programs are targeted. The programs include one-day workshops or Seminars and orientation courses of 3-5 days duration. These programs are normally being organized by research institutes, universities, colleges of architecture, engineering colleges, state nodal agencies and other professional organizations. Necessary financial support for organizing these programs/courses is provided by the Ministry. Some of these programs are general in nature while others are focused. The programs with general contents impart basic understanding, highlight benefits and encourage the general public, while the more focused programs help in educating professionals and also crystallize their knowledge base in the area [8].

One of the objectives of this program is also to develop a suitable curriculum to be introduced in the schools of architecture.

Demonstration

To demonstrate the concept of solar buildings, the Ministry is promoting design and construction of solar buildings in government and semi government sectors. Under the

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Box 2

MNRE supported Energy Efficient Buildings

Cold & Cloudy Climate

- State Bank of Patiala, Shimla
- Minister's residence, Shimla
- Judges' Houses, Shimla
- MLA Hostel, Shimla
- 200 Bed Hospital at Khaneri
- HP Cooperative Bank, Shimla
- Nirman Bhavan, Shimla
- Himurja building, Shimla
- Nirman Bhavan, Shimla (under construction)
- HPWD Rest house, Kotgarh (under construction)

Composite Climate

- Urja Bhavan, Bhopal
- School of Energy & Environmental Studies, DAV, Indore
- Solar Energy Centre, Gwalpahari
- RETREAT Building, TERI, Gwalpahari
- PEDA building, Chandigarh (under construction)

Warm & Humid Climate

- WBREDA Building, Calcutta

Hot & Dry Climate

- Solar Passive Hostel, Jodhpur