Zero Energy Building- An energy efficient *approach*

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Abstract: The concept of Zero Energy Building (ZEB) has gained wide international attention during last few years and is now seen as the future target for the design of buildings.. In UK, buildings are responsible for 46% of national energy consumption .Researchers are continuously trying to find out the way of reducing the emission of carbon dioxide and implementations of the renewable energies technologies. The zero energy building concept is a realistic solution for the CO_2 emission and reduction of energy demand in the building sector. Zero energy building design has become a high priority for architects and multi-disciplinary researchers related to architectural engineering and building physics. A zero energy building refers to a building with a net energy consumption of zero over a typical year. It implies that the energy demand for heat and electrical power is reduced, and this reduced demand is met on an annual basis from renewable energy supply. The renewable energy supply can either be integrated into the building design or it can be specifically provided for the building.

Keywords: Renewable energy, Climate changes, Zero energy buildings, Global warming.

1.INTRODUCTION

Buildings have a significant impact on energy use and the environment. Commercial and residential buildings use almost 40% of the primary energy and approximately 70% of the electricity in the United States. The energy used by the building sector continues to increase, primarily because new buildings are constructed faster than old ones are retired. So the role of various renewable energy sources in buildings has been getting full attention around the world. The scientific evidences for climate changes and the associated impacts of greenhouse gas emissions are becoming increasingly obvious. Scientists and built environment professionals are trying to find advanced technologies, renewable energies, and useful strategies to reduce carbon dioxide emission. Zero energy building design has become a high priority for architects and multi-disciplinary researchers related to architectural engineering and building physics. A zero energy building refers to a building with a net energy consumption of zero over a typical year. It implies that the energy demand for heat and electrical power is reduced, and this reduced demand is met on an annual basis from renewable energy supply. The renewable energy supply can either be integrated into the building design or it can be specifically provided for the building, for example as part of a community renewable energy supply system. It also normally implies that the grid is used to supply electrical power when there is no renewable power available, and the building will export power back to the grid when it has excess power generation. This 'two way' flow should result in a net positive or zero export of power from the building to the grid. The zero energy building design concept is a progression from passive sustainable design. The object of a zero energy building is not only to minimize the energy consumption of the building with passive design methods, but also to design a building that balances energy requirements with active techniques and renewable technologies (for example, solar photovoltaic's, solar thermal or wind turbines). It can be measured in terms of primary energy consumption or carbon emissions.

Fig. 1 Zero Energy Building

2. LITERATURE REVIEW

Biaou et al. [2] simulated a zero net energy home in Montreal with TRNSYS. Photovoltaic (PV) panels and a geothermal heat pump for heating and cooling has been installed in the home. The results shows that it is possible to achieve a zero net energy for a R-2000 type home with PV and geothermal heat pump. Clarke et al. [3] applied an established integrated software environment, with building simulation software ESP-r, a RE modeling and matching tool Merit and a fuel use information management program EnTrak, for a case study of hybrid renewable energy systems for residential building in Korea to evaluate the feasibility of new technologies using a simulation based decision support system. The integrated software environment can help to identify suitable technology types and capacities at an early design stage. Norton and Christensen [4] presented the full year of energy performance data on the 3-bedroom Denver zero energy home combining envelope efficiency, efficient equipment, appliances and lighting, a photovoltaic system, passive and active solar thermal features. This case study demonstrates that it is possible to build efficient affordable zero energy homes in cold climates. Bolling and Mathias [5] compared four heating and cooling systems in the aspects of the entire life cost, energy usage, exergetic efficiency and exergy destruction for the same residential house located in four different cities in America. The four systems include a high efficiency furnace and electric air conditioner, a ground source heat pump, an absorption air conditioner and direct heating and a thermally driven heat pump; the last two systems use solar thermal energy and backup non-renewable energy. The results showed that vertical ground source heat pump paid back in the shortest time.

3. METHODOLOGY

The construction and laboratory experiments on zero energy houses are a costly method to explore potential variations in building designs. Computer simulations of building systems can provide convenient and quick prediction for zero energy house design and avoid large costs due to building construction and experiments. Energy Plus and TRNSYS 16.0 are used in the study. Energy Plus models hourly energy consumption in multi-zone buildings based on detailed designs and weather data, while TRNSYS has been widely applied for both energy efficiency and renewable energy analyses. The latter models each component in the system as a module and allows access to the source code for appropriate adaptation. In this study, Energy Plus simulations are used for building envelope design and TRANSYS is used for building systems and renewable energy systems design.

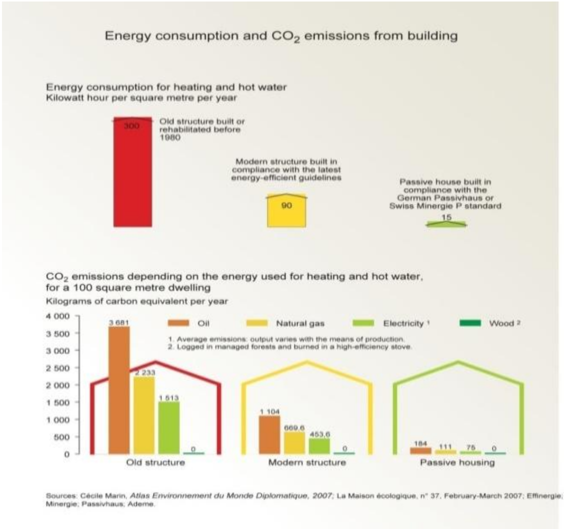

Fig. 2. Energy Consumption and CO_2 Emission from Building

4. LIST OF ENERGY EFFICIENT BUILDINGS IN INDIA

In India, the concern for energy scarcity and the environmental problems associated with the consumption of energy in the building sector has resulted in continued interest in energy efficient building design.

The Ministry of Non-Conventional Energy Sources (MNES), of the Government of India has undertaken several initiatives to promote solar efficient building design in the country TERI (The Energy and Resources Institute) took a major step in the green building sector in India in1997 by designing and constructing the RETREAT (Resource Efficient TERI Retreat for Environmental Awareness and Training) complex at Gurgaon (35 km from New Delhi). The RETREAT, built as a model training complex with a built-up area of 3000 sq meters, demonstrates efficient utilization of energy, sustainable and integrated use of both natural resources and clean energy technologies, and efficient waste management systems [TERI 2000; TERI 2001]. It has established that 'zero energy in - zero waste out' buildings could be created and run efficiently in the country. The building has been designed as south-facing for the winter heat gains. Deciduous trees have been planted on the southern side of the complex which protects the building from the summer sun, and in winter, by shedding their leaves, the trees brighten up the rooms and provide the required heating. The south side of the structure is partially sunk into the ground to reduce heat gains and losses. Instead of the conventional grid electricity, the complex has a PV-Gasifier hybrid power plant. The biomass gasifier generates 50 kW power by burning twigs, branches, straw and crop residue and a 10 kW roof integrated PV system generates power from solar energy. To avoid conventional air conditioning methods, an earth tunnel system has been constructed that collects atmospheric air, cools it under the earth, and then pumps it to the residential rooms to maintain a steady temperature. The air conditioning of the conference hall and other common facilities is achieved by using gas-fired ammonia absorption chillers, which consume 75 percent less electrical energy than a conventional system, as well as being cleaner and CFC (chlorofluorocarbon) free.

Cold and Sunny

- Degree College and Hill Council Complex, Leh
- LEDeG Trainee's Hostel, Leh
- Sarai for Tabo Gompa, Spiti

Cold and Cloudy

- State Bank of Patiala, Shimla
- Himurja building, Shimla
- HP state Cooperative Bank, Shimla
- Nirman Bhavan, Shimla
- MLA Hostel, Shimla
- 200 Bed Hospital, Khaneri
- HPWD Rest house, Kotgarh

Hot & Humid

- WBREDA Building, Kolkata
- WBPCB building, Kolkata
- CMC House, Mumbai
- Vikas Apartment, Auroville
- La Cuisine Solaire, Auroville

Hot & Dry

- Solar Passive Hostel, Jodhpur
- Torrent Research Centre, Ahmedabad
- Indian Institute of Health Management Research, Jaipur

Mixed Climate

- RETREAT Building, TERI, Gurgaon
- Urja Bhavan, Bhopal
- Water and Land Management Institute, Bhopal
- School of Energy & Environmental Studies, DAV, Indore
- Solar Energy Centre, Gurgaon
- American Institute of Indian Studies, Gurgaon
- SOS Tibetan Children's Village, Dehradun
- Bidani House, Faridabad
- Transport Corporation of India building, Faridabad
- PEDA building, Chandigarh
- IREP Training Centre, Bakholi

Moderate

- TERI SRC office building, Bangalore

Source: TERI 2001.

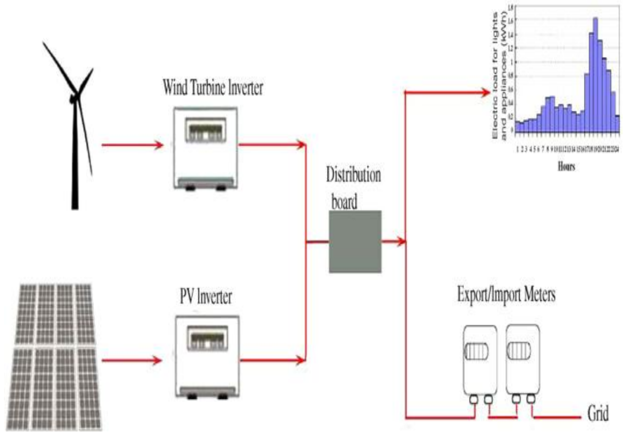

Fig. 3. Scheme of grid-connected renewable electricity system for ZEB

5. RENEWABLE ENERGY SOURCES THAT CAN BE USED IN "ZERO ENERGY BUILDING" FOR FULFILLING THEIR ENERGY DEMANDS

- Solar energy
- Wind energy
- Geothermal energy
- Hydropower
- Biomass and bio fuel

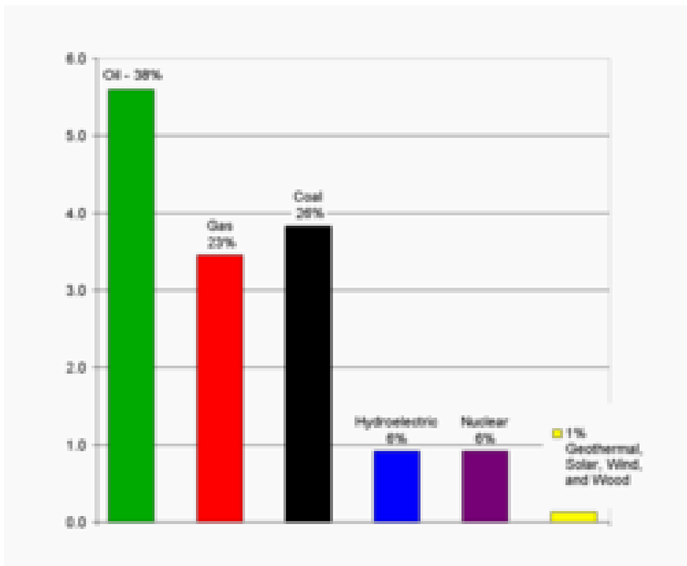

Fig. 4. Worldwide energy supply in TW

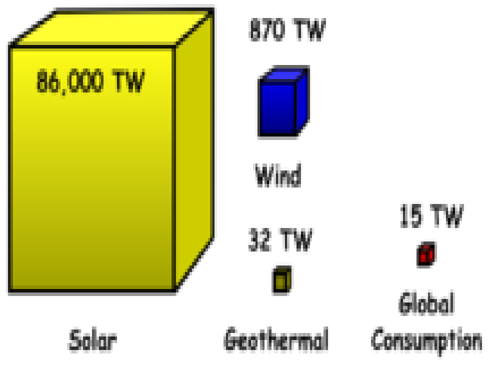

Fig. 5. Available renewable energy The volume of the cubes represent the amount of available geothermal, wind and solar energy in TW, although only a small portion is recoverable. The small red cube shows the proportional global energy consumption

6. CONCLUSION

With increasing degradation of the environment because of increased energy consumption, environment conscious building design has become urgent. The benefits of green design to society in general, and building owners and users in particular, are manifold. The construction of such buildings results in reduced destruction of natural habitats and bio-diversity, reduced air and water pollution, less water consumption, limited waste generation and increased user productivity. The cost differential between passive and conventional systems is hard to determine, as passive elements are an integral part of the building architecture. However, it is believed that passive design could prove to be a cost effective solution and should not cost more than 15 to 20 percent of the total building cost. What is needed now is to educate society about energy conserving concepts and motivate architects and builders to design and construct such buildings. The sector is a promising one and is expected to develop further at a faster rate with the active cooperation of architects, engineers, builders and policy makers. The whole design process can be summarized into three steps. Firstly, an analysis of local climate data is of primary importance in order to make use of the local climate condition for promoting zero energy homes. Secondly, the application of passive design methods and advanced facade designs to minimize the load requirement from heating and cooling through building energy simulations. Finally, through the use of TRNSYS to investigate various energy efficient mechanical systems and renewable energy systems including photovoltaic, wind turbines and solar hot water system to enable system design optimizations.

7. REFERENCES

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