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Energy conservation scenario for Buildings in India: A review

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Abstract

In today's modern world, energy requirements are rising enormously. That's why it is one's moral responsibility to conserve as much energy as possible. The economic growth and technological advancement of every nation depends on energy conservation. Energy conservation is a viable tool to promote economic efficiency. Among all the types of electricity consuming sectors, Buildings account for more than 30% of electricity consumption in India being second only to industries. This paper provides a review of an energy conservation scenario in building sector of India. This study mainly focuses on the energy consumption pattern in building sector, energy policy and role of Energy Conservation Building Code in India.
It is evident from the analysis that environmentally sensitive designs, which is recommended by Energy Conservation Building Code, can lead to savings of around 20- 50% in buildings. Apart from this, various energy efficiency measures for building have been identified in this paper. The result suggest that total 20-70% energy can be conserved by successful implementation of recommendations for improving energy efficiency in heating, ventilation & air conditioning system, lighting, water heating, refrigeration and electronics.

Keywords-Energy conservation, Energy efficiency, Energy audit of buildings, Energy Conservation Building Code, Energy savings

"I. INTRODUCTION"

An important role of energy took place through the Human history, starting from the prehistoric age. Before 1970, the supply and consumption of energy were not relatively clear to most people. Within less than a decade, however, "energy" word has arisen as one of the most provocative words of the times [1].

The increase of energy demand largely observed during the last two decades and it will continue rising incrementally by the same rate. Energy consumption might become twice between 2015 and 2020 referring to low production of energy and high growth of energy [1].

In recent era, energy conservation has received wide range of attention, with prediction of the energy consumption of a building becoming one of the most important individual and societal energy conservation issues. However, predicting building energy consumption is complicated as energy consumption data present nonlinear patterns caused by such factors as climate, settled population, and seasonal changes. Therefore, it is a challenging task to get accurate and rapid prediction of building energy consumption [19].

Energy consumption in developing countries has been rising enormously due to recent economic growth than development. According to Building Energy Standards (BES), this energy consumption has led to serious environmental difficulties such as increasing energy demand, global warming, air pollution and acid rain. In developing countries, the number of new buildings is growing rapidly and the energy prices and market often do not encourage the use of efficient technologies. In view of these facts, there is a pragmatic shift to the use of building energy standard and code to reduce building energy consumption in developed countries. Building energy regulations can be used to address the energy use of an entire building or building systems such as heating or air conditioning. Energy regulation is one of the most frequently used instruments for energy efficiency improvements in buildings and can play a vital role in enhancing energy efficiency in buildings [2].

In a major encouragement to institutionalize energy efficiency in the India, the Government of India enacted the Energy Conservation Act in year 2001 [11]. Under the Energy Conservation Act 2001, the Government of Indian established Bureau of Energy Efficiency (BEE) in March 2002, a statutory authority under the Ministry of Power (MoP) to legislate and enforce energy efficiency policies through various regulatory and promotional measures. BEE developed an energy efficiency Action Plan which focused on various thrust areas which include Energy Efficiency in Commercial Buildings, Energy Conservation Building Code (ECBC), Energy Managers and Energy Auditors Certification Program, and others [11].

Indian commercial building sector (which includes commercial and public buildings) has started to receive the attention of policy makers for the last 10 years. The building construction industry at present contributes about 10% of GDP, and is expanding rapidly at over 9% per year spurred largely by the strong growth in the services sector. Electricity consumption in the commercial sector in India at present accounts for about 8% of the total electricity supplied by the Utilities and has been growing annually at about 11-12%, much faster than the average 5-6% electricity growth in the economy [11]. This can mainly be attributed to the increasing energy intensity of the existing buildings, apart from new buildings which are coming up at a faster rate all over the country.

Building owners in India are facing significant difficulties with the rapidly rising energy cost and decreasing availability and reliability of energy supply. Rising operating budgets are directly attributable to increasing energy costs for lighting, air conditioning and building services [11]. But unlike many other operational costs, energy costs are under control. Building energy assessments can assist building owners to learn more about their facilities' energy use and take steps to effectively manage the energy use for long-term savings [11].

Nomenclature

BEE	Bureau of Energy Efficiency
DEA	Department of Economic Affairs
EC	energy conservation
ECBC	Energy Conservation Building Code
EE	energy efficiency
EPI	Energy Performance Index
FYP	Five-Year Plans
GDP	Gross domestic product
GEF	Global Environment Facility
GHG	greenhouse gas
GWh	giga watt-hour
HVAC	heating ventilation and air conditioning
ICICI	Industrial Credit and Investment Corporation of India
Kgoe	kg of oil equivalent
kWh	kilo watt-hour
Mtoe	metric ton of oil equivalent
NAPCC	National Action Plan on Climate Change
NBC	National Building Code
SBEM	Simplified building energy model
UNFCCC	UN Framework Convention on Climate Change
USD	US dollar

The first step towards reducing energy consumption is becoming familiar with current energy use and learning how to make existing processes more energy efficient. By undertaking an energy assessment, a building owner can identify energy intensive systems and greatest potential for energy savings [11]. All the levels of building energy assessment give the owner with a baseline of their facility's energy usage that can be compared to other facilities to set performance targets and determine future course of action. Energy assessment also provides the tools to the building owners as they need to provide accurate information for reporting energy consumption to internal and external entities.

Energy auditors or energy service companies (ESCO) can provide guidance to building owners by assessing the existing energy use and providing lists of both low-cost and no-cost measures and capital intensive energy efficiency measure that building owners can pursue to meet their energy efficiency goals [11].

Although a large number of building energy audits has been conducted in India, but conversion of energy audits into actual projects is very low[11]. The energy audit reports, which could have been used as a reliable source of primary data, have not been used for creating useful benchmarks of energy use in the commercial and public buildings. Experience from around the world and in India has presented that there are several energy saving opportunities that can be identified in focused energy audits and which does not require a huge capital investment and depends more on the technical knowledge, expertise, and experience of engineers and service providers [11].

This review is done to study about energy conservation scenario for buildings in India. This paper covers effect of energy consumption on GDP as well as on GHG emission, the role as well as features of BEE and current energy policy in India. In addition, this paper also includes energy consumption and energy efficiency trend especially for buildings. Various energy conservation measures for buildings have been discussed in this paper and based on this; appropriate recommendations for each measure are suggested.

"II. ENERGY EFFICIENCY IN INDIA AND THE INSTITUTIONAL SETUP"

India has the world's second largest population and continues to grow at 1.34% per year during the years 2007 and 2008 [3]. India is among the 10 fastest growing economies in the world with an average growth rate in the GDP of 5.8 percent during the first decade of economic reforms (1992-2001). The continued annual GDP growth was affected by the global financial crisis over the past two years decelerating from 9.3% in 2007 to 6.1% in 2009. Commercial primary energy consumption in India has grown by about 700% in the last four decades [4]. The current per capita commercial primary energy consumption in India, is about 350 kgoe/year which is well below that of developed countries [5]. Driven by the rising population, expanding economy and a quest for improved quality of life, energy usage in India is expected to rise to around 450 kgoe/ year in 2010. In future, these growth rates are expected to continue, fuelling the energy demand further. The International Monetary Fund has predicted India's growth to accelerate to 6.5% in 2010 from 5.3% in 2009. The Eleventh Five-Year Plan (2007-2012) predicts an energy demand of 547 Mtoe in 2011-12 and between 1,350-1,700 Mtoe by the year 2030. While the country's per capita energy consumption will remain much lower than that of industrialized countries, India's total energy consumption is expected to continue increasing significantly.

Increased energy consumption will lead to more greenhouse gas (GHG) emissions with serious impacts on the global environment; in particular, since the predominant usage of coal in the country's energy sector is expected to continue until 2020. Coal provided about 52% (199 Mtoe) of the energy demand in 2006-07. The capita energy consumption and emissions have remained relatively low at 1.2 tonnes of carbon dioxide per person [6] in 2005 due to the large population. India is currently the world's seventh largest consumer of energy and the sixth largest source of greenhouse gas (GHG) emissions and second in terms of annual GHG emissions growth. According to an International Energy

Outlook in 2009, India accounts for 7% of the world's coal-related carbon dioxide emissions from 2006 to 2030 and carbon dioxide emissions from coal combustion are projected to total 1.3 billion metric tonne in 2030, accounting for more than 7% of the world total.

The expected increase in energy demand, along with the predominance of coal in the energy mix, highlights the significance of promoting energy efficiency. The recent Five-Year Plans (FYP) has emphasized the need for efficient use of energy resources to achieve sustainable development. By the end of the XIst FYP, a potential was assessed to save 23,700 MW of power generation capacity in the country. Some of the major efforts promoting energy efficiency in the past are summarized below:

- Setting up or supporting institutions for the promotion of energy efficiency services. These include industry associations such as Confederation of Indian Industry (CII), the Indian Green Building Council (IGBC), Financial Institutions (FI), such as the Indian Renewable Energy Development Agency (IREDA), Industrial Development Bank of India Limited (IDBI Bank) and ICICI Bank, as well as the National Productivity Council (NPC) and research institutes, such as The Energy and Resources Institute (TERI).
- Regulatory reforms were initiated in 90's for rational pricing of energy. These have brought average retail energy prices to levels that are at par or above the cost of supply. Coal and petroleum prices have been largely deregulated and average electricity prices paid by the end- users now approximate long-run marginal costs and based on multi-year tariffs (MYT).
- The Energy Management Centre (EMC) was established for planning and developing energy efficiency programmes. With the enactment of Energy Conservation Act (passed in 2001), the roles and responsibilities have been assigned to a new agency, the Bureau of Energy Efficiency (BEE).

A. Energy Policy in India and role of Bureau of Energy Efficiency

Considering the vast potential for energy savings, the Indian government in 2001 enacted the Energy Conservation Act (EC Act). The Act provides for the legal framework, institutional arrangement and a regulatory mechanism at the Central and State level to embark upon energy efficiency drive in the country. The EC Act mandates Government to designate consumers who consume power beyond a benchmarked limit. Designated consumers [7] are required to appoint Energy Managers [8], to adhere to energy efficient consumption norms, required to submit consumption information and to conduct mandatory audit (if required). Designated consumers include railways, the power sector, energy-intensive industries (e.g., fertilizer, cement, paper, steel and certain chemical industries) and large buildings.
The EC Act (EC Act 2001) [8] deals with several mandatory and promotional measures:

- Standards and labeling for equipment and appliances – To reduce the energy consumption in domestic sector and to transform the market with energy efficient appliances.
- Development of Energy Conservation Building Codes – To conserve energy in building sector. The Energy Conservation Building Code prescribes the specifications for various building components to construct energy efficient new buildings.
- Energy audits for existing buildings – To achieve improved energy performance in existing buildings.
- Professional certification and accreditation of energy auditors and energy managers - To produce trained professionals to conduct energy audits manage energy in industries, buildings, municipalities and agriculture operations.
- Elaboration of manuals and dissemination of information and best practices - To produce best practice manuals and guidelines for different industries.
- Support energy efficiency policy research – To continue support on formation of effective policies for energy efficiency in different sectors.
- Capacity building and energy conservation awareness in education – To raise awareness at school and university level about energy efficiency.
- Designated consumers – To identify energy intensive industries and name them as designated consumers and promote energy efficiency in each of them.
- Establish energy efficiency (EE) delivery systems through public-private partnerships – To develop innovative energy efficiency delivery systems through public private partnerships

The Bureau of Energy Efficiency (BEE) was established in March 2002 under the Ministry of Power (MoP) to implement the EC Act 2001. BEE is the statutory body for development of energy efficiency policy and strategies based on self-regulation and market principles and for the facilitation and coordination of energy efficiency at the central level while "state designated agencies" (SDAs) do the same at the state level in 30 states. The EC Act 2001 further mandates BEE to work with designated consumers and other agencies to enforce the provisions of the act. However, there are no provisions in the budget of the central government at present to enforce checks and compliance to the Act [8].
The major functions of BEE [8] include:

- Develop and recommend to the Central Government the norms for processes and energy consumption standards.
- Develop and recommend to the Central Government minimum energy consumption standards and labeling design for equipment and appliances.
- Develop and recommend to the Central Government specific Energy Conservation Building Codes (ECBC).
- Recommend the Central Government for notifying any user or class or users of energy as a designated consumer.
- Take necessary measures to create awareness and

disseminate information for efficient use of energy and its conservation.

B. Energy efficiency trend in building

Buildings account for more than 30% of electricity consumption in India being second only to industries. It has been estimated that the total built -space in the country would increase five-fold from 2005 to 2030, and by then more than 60% of the commercial built space would be air- conditioned [9]. With so much to be built in the country in the following decades every new inefficient building constructed would represent a loss of precious energy for the coming decades. It is also estimated that the urban population of the country would rise to about 590 million by the end of 2030 [10]. This migrating population from villages to towns and cities would require additional buildings and energy and thus it is important to keep a check on the way these buildings would be built and behave. Building codes and standards for various aspects such as building structure, safety, water requirements, etc. establishes minimum criteria, following which a building would become safe and habitable. Building energy codes deal with the energy consumption aspect of the buildings. On one hand they save precious energy and on the other give monetary benefits compared to conventional buildings over a period of time. Codes are important for new buildings because it is easier, cheaper and gives long term operational benefit while implementing energy conservation measures in the case of new construction than through retrofitting. Thus, India has this opportunity to capture savings in buildings which are not yet built. It is also estimated that nationwide enforcement of ECBC would yield annual savings of around 1.7 billion kWh [11]. Currently the code targets only commercial buildings because of their high energy intensity. Commercial buildings as stated in Energy Conservation Building Code (ECBC) are “all buildings except for multi-family buildings of three stories or fewer above grade and single-family units”. These include a wide range of buildings like private offices, government offices, hotels, hospitals, retail spaces, educational institutes, universities, high rise residential apartments and others. Commercial buildings together consumed a total of 58,971 GWh of electricity during the year 2009–2010 in the country. This is about 9% of the total electricity consumed during that period [12]. Energy consumed by these buildings could be mainly attributed to lighting, running office equipments and for HVAC systems. It varies with building type, activities and climatic region in which the building is located.

Prior to the ECBC, the only country level code, which attempts to guide construction of energy efficient buildings is the National Building Code (NBC) of India. The first version of National Building Code was published in the year 1970 [13] by Indian Standards Institution (now Bureau of Indian Standards) to provide unified guidelines for construction practices in the country. It was prepared as a guiding code for municipalities and development authorities across the country for preparing local byelaws. Based on the comments and suggestions from the various stakeholders like architects, engineers, planners, building material manufacturers, contractors, etc. a revised version of the code was published in 1983. A few important changes in this revised code included, norms for plantation and greenbelts, fire safety for high rise buildings, earthquake safety for buildings, acoustical considerations in buildings, energy conservation measures for air-conditioned buildings, etc.

NBC contains some provisions related to energy efficiency such as studying climatic factors of the site, use of day lighting to reduce power consumption through artificial lighting, use of fluorescent lamps in place of incandescent ones, planting trees to reduce effects of solar radiation, etc. but it does not specifies other parameters required for energy efficiency such as building envelope specifications, HVAC, lighting and equipments efficiency [18].

Various studies have been carried out around the globe to understand the impact of building energy codes on a large number of buildings. One of them carried out in Hong Kong where a set of more than 80 existing commercial buildings were studied and their energy savings potential were calculated, assuming the building energy code becomes mandatory [14]. In an another attempt to study the potential of energy savings in buildings at city level researchers have developed a modeling concept using a statistical approach in which they have categorized commercial buildings on the basis of their usage, size, planning and heat source system. They have assumed different energy conservation measures for building envelope, lighting and HVAC under different scenarios and projected energy saving potential till 2050 in a city [15]. Another similar study focused on the energy conservation regulation in China estimates a potential of 29% energy savings in buildings with the help of SBEM energy simulation software [16].

Literature suggests that there has been significant possibility for energy efficiency in commercial buildings in India. For new commercial buildings [9], BEE has developed the Energy Conservation Building Code (ECBC). The purpose of ECBC is to provide inputs to the energy-efficient design and construction of buildings. The total commercial building floor area in India is estimated to be about 430 million m^2 in the year 2010 [17]. Most commercial buildings in India have an Energy Performance Index (EPI) of 200-400 kilowatt-hour (kWh) per m^2 per year, while similar buildings in North America and Europe have EPI lower than 150 kWh per m^2 per year. BEE has data on energy savings through the implementation of energy efficiency measures in new and existing buildings. BEE has facilitated implementation of such initiatives in several government buildings.

Energy-conscious building design has been shown to reduce EPI to 180 kWh per m^2 per year (national benchmark) and is considered as ECBC compliant. ECBC compliant means those buildings which meet the code and are considered as EE buildings. These case studies show that employing environmentally sensitive designs can lead to savings of the order of 20- 50%. Initial investment cost will increase by 10-15%, with payback period varying from 3 to 7 years. Further, star ratings are given to the commercial buildings as per their performance which ranges from180 kWh per m^2 (one star) until about 100 kWh per m^2 per year (five star).

C. India and Climate Change

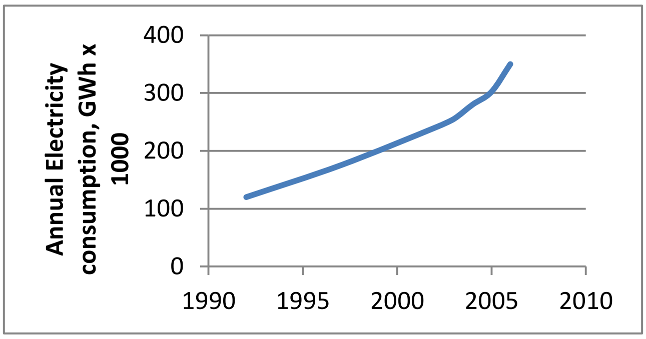
India is undertaking several initiatives to address the threat of climate change on issues ranging across forestry, glaciology, energy efficiency and climate change technology. India is an active participant in international negotiations on climate change under the UN Framework Convention on Climate Change (UNFCCC). The Ministry of Environment and Forests is UNFCCC focal point as well as the operational focal point of the Global Environment Facility (GEF), while the Department of Economic Affairs (DEA) of the Ministry of Finance is the GEF political focal point.

The 8 missions under India’s National Action Plan on Climate Change (NAPCC) are, National Solar Mission, National Mission for Enhanced Energy Efficiency, National Mission on Sustainable Habitat, National Water Mission, National Mission for Sustaining the Himalayan Ecosystems, National Mission for a Green India, National Mission for Sustainable Agriculture, and National Mission on Strategic Knowledge for Climate Change. The NAPCC’s relevance relating to this project includes:

- Achieving national growth objectives through a qualitative change in direction that enhances ecological sustainability, leading to mitigation of greenhouse gas emissions;
- Devising efficient and cost-effective strategies for end-use demand-side management.
- Engineering new and innovative forms of market, regulatory and voluntary mechanisms to promote sustainable development.

“III. ENERGY CONSUMPTION IN BUILDINGS”

Over the years, electricity use has increased drastically in the commercial sector (see Figure 1). In commercial buildings, the annual energy consumption per square meter of the floor area is in excess of 200 kWh with air-conditioning and lighting serving as the two most energy consuming end-use applications within a building. This has led the government including them as a “designated consumer” under the Energy Conservation Act (2001). “Designated consumers” as identified by BEE are energy intensive industries or similar establishments recognized under the EC Act (2001).



“Figure.1. Annual energy consumption in commercial sector”

The building sector is the second largest employment provider next to agriculture. Its size is expected to reach USD 60 billion per year by 2010 and commercial real estate market specifically would reach USD 12 billion per year. The building sector contributes to about 5% of the country’s GDP, which is expected in the next 4-5 years to rise to 6%. In 2004-05, over 40 million m^2 of commercial and residential construction was added. Recent trends show a sustained growth of 8-10% over the coming years, thus highlighting the pace at which energy demand in the building sector is expected to rise and the building sector is growing at 8-10% annually.
Consequently, the building industry is also one of the biggest emitter of GHGs in India. Of the building sector, commercial building space accounts for 33%. There are vast opportunities to reduce electricity consumption and increase energy efficiency within commercial buildings.

“IV. ENERGY EFFICIENCY MEASURES FOR BUILDINGS”

It is estimated that new buildings can reduce energy consumption on an average between 20-50% by incorporating appropriate design interventions in the building envelope, heating, ventilation and air-conditioning (HVAC, 20-60%), lighting (20-50%), water heating (20-70%), refrigeration (20-70%) and electronics and other (e.g., office equipment and intelligent controls, 10-20%). Through energy efficiency measures for buildings, the energy consumption in a building can be reduced while maintaining or improving the level of comfort in the building [17].

They can typically be categorized into:

(a) Reducing heating demand;
- Limiting the area exposed to outdoors to a minimum (more complex design, more exposed surface area)
- Improving air tightness (e.g., caulking holes and cracks) and the insulation of the building
- Reducing ventilation losses
- Selecting efficient heating systems with effective controls

(b) Reducing cooling demand (need for air conditioning);
- Controlling solar gains by avoiding excessive glazing, use of shading and blinds, glazing with the lowest solar heat gains factor;

- Selecting office equipment with reduced heat output;
- Making use of thermal mass materials and night ventilation to reduce peak temperatures
- Reducing lighting loads and installing effective lighting controls

(c) Reducing the energy requirements for ventilation;

- A building design that maximizes natural ventilation (air passing from one side to the other side of the building)
- Effective window design
- Using energy efficient mechanical ventilation systems

(d) Reducing energy use for lighting;

- Appropriate window design and glass to make maximum use of daylight while avoiding excessive solar gain
- Energy efficient lighting systems (e.g. using task lighting to avoid excessive background luminance levels; selecting lamps with a high efficacy; providing effective controls that prevent lights being left on unnecessarily

(e) Reducing energy used for heating water;

- Proper insulation of pipes
- Installing time controls and setting hot water thermostats to the appropriate temperature
- Switching of electric heating elements when hot water is available

(f) Reducing electricity consumption of office equipment and appliances;

- Use energy-efficient appliances (computers, monitors, printers, faxes, copiers, etc.), taking advantage of labelling schemes
- Employ 'switching off – power down' modes in equipment

(g) Good housekeeping measures

- Implement an energy conservation plan, involving staff, setting targets, conducting walk-around

"V. CONCLUSION"

At the end, this paper concludes that there is vast potential of savings possible through the implementation of ECBC in the country. An urgent need to implement ECBC is required in order to get more the savings. It also highlights the fact that different buildings have different energy saving potential depending on the construction specifications, usage, systems and installed equipments, conditioned area and other factors. Apart from this, India has the opportunity to capture savings in buildings which are not yet built. It is also estimated that nationwide enforcement of ECBC would yield annual savings of around 1.7 billion kWh.

The result also suggests that the energy savings potential in buildings ranges from 20-50% therefore huge savings are possible by implementing more advanced features of the ECBC. It can be highlighted that 20-60% energy in HVAC, 20-50% energy in lighting system, 20-70% energy in water heating system and 10-20% energy in electronics and other office equipments of building, can be saved by successful incorporation of appropriate design interventions in the building.

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