02 ENERGY AND BUILDINGS

Centre for Science and Environment
41, Tughlakabad Institutional Area, New Delhi 110 062, INDIA
Ph: +91-11-29956110 - 5124 - 6394- 6399 Fax: +91-11-29955879
E-mail: cse@cseindia.org Website: www.cseindia.org

The challenge

Buildings do not consume, people do. According to the International Energy Outlook 2013, the energy use tracker of the US Energy Information System, the building sector accounts for more than one-fifth of total worldwide energy use, and India mirrors the trend.

The Energy Statistics 2013 of India's National Statistical Organisation (NSO) shows electricity accounted for more than 57 per cent of the total energy consumption during 2011-12 in India, and building sector is already consuming close to 40 per cent of the electricity. This is expected to increase to 76 per cent by 2040. A large quantity of incremental electricity demand will come from the residential sector in India.

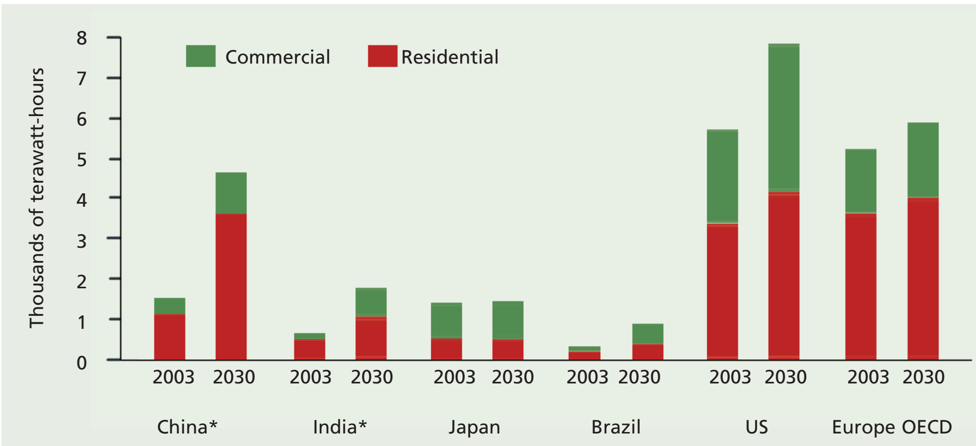
One of the projections of the International Energy Outlook 2013 also shows that India's residential energy consumption trend resembles that of China at 3.7 per cent per year, and India's commercial sector energy consumption growth is projected to increase at an average rate of 5.4 per cent per year, which is also the world's highest (*see Graph: Projection of energy for buildings by region 2003-30*). Compared to the industrialised world, India's energy consumption in households is much lower and frugal. Currently, only one-sixth of Indians using electricity consume over 100 kilowatt hour (kWh) per month. But the average US household consumes over 900 kWh per month (see Graph: Annual per capita electricity consumption). This, however, will change dramatically in India with the transformation in lifestyles, incomes and growing electrification. The future growth, especially in commercial and retail sectors, will see greater absorption of mechanised heating and cooling that will push up overall energy consumption and costs significantly.

India is yet to build nearly two-third of its 2030 building stock, according to a report by McKinsey & Company. In contrast, the industrialised world has reached a point of saturation. In the US, for instance, 70 per cent of the future stock has already been built. While India is yet to add more new building stock, only 67 per cent of its households have access to electricity and a miniscule percentage of buildings have 24x7 electricity supply. Over half of the electricity consumed in India in 2004-05 served only the top 20 per cent of the population.

These contrasting scenarios have implications for energy management strategies in buildings. The industrialised world is focusing more on improving the efficiency of energy systems in buildings, whereas for India designing the building structure to prevent lock-in of energy and carbon as well as improving operational efficiency are needed for effective impact.

A report by McKinsey Global Institute says, "In the developed world with its aging infrastructure, the biggest opportunity lies in retrofitting existing buildings,

Graph: Projection of energy for buildings by region, 2003-30



8Energy used from marketed sources

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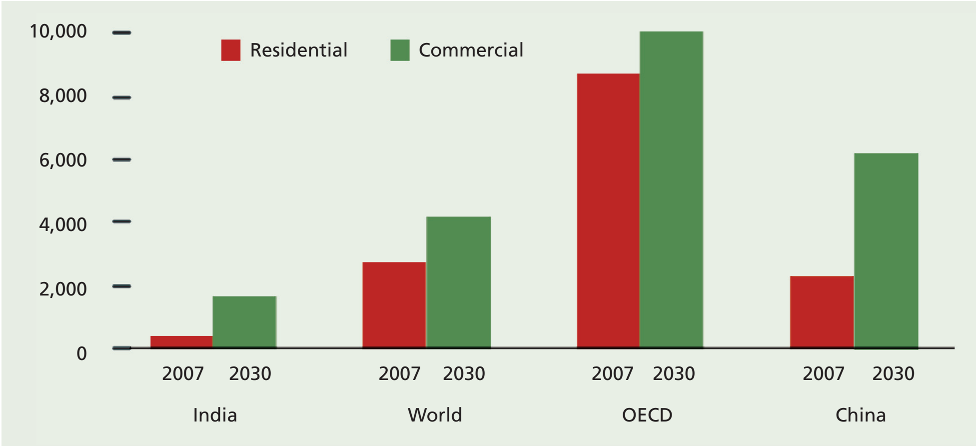
Graph: Annual per capita electricity consumption



Source: Adapted from: IEA, 2009

especially with better insulation. In developing economies, improving the energy efficiency of new buildings represents a bigger opportunity. Energy-efficient new buildings could require only 20 to 30 per cent of the average consumption of energy of existing buildings in developed countries today".

Energy use and climate change

Globally, building construction and occupation have come under spotlight for its very strong linkages with energy use and climate impacts. The World Energy Outlook 2009, the global energy usage tracker of the Paris-based International Energy Agency says that the half of world's population in cities is already consuming two-third of world's energy. By 2030, cities will be consuming 73 per cent of world energy, accounting for 70 per cent of CO2 emissions. It projects big increase in global CO2 from the increase in floor space in buildings of various types, especially in non-OECD countries (Organisation of Economic Cooperation of Developed Countries) due to lifestyle changes. Within the climate and energy debate the urban consumption pattern in building units in cities thus becomes the focal point of mitigation.

In India building construction and usage consume one third of the primary electricity. The National Habitat Standard Mission states that building energy consumption has increased from a low of 14 per cent in 1970 to 33 per cent in 2004-05.

Climatic conditions have a strong bearing on the usage of energy in buildings. BEE has come up with typical values for different climatic zones of the country and for different building usage (*see Table: Typical energy consumption in buildings*). The typical values show that offices, retail and hotels are high end users of energy.

Residential energy use: substantial

BEE has not estimated the residential sector energy demand and usage that well, as these buildings are still not within their regulatory focus. Residential homes are expected to have a broad bandwidth of energy and resource use given the range of low-cost housing to high-income housing. Residential building energy demand is influenced largely by the extent of the use of household electrical appliances. The lifestyle driven change will come mainly from the increased use of electrical appliances. The ownership of modern electrical appliances in India is quite low as compared to that in other developed countries (see *Graph: Appliance ownership in India compared with the OECD*). But this is poised to grow rapidly.

There is a distinct difference in the way appliances are used in commercial and residential buildings. BEE's assessment shows that lighting and air conditioning use 80 per cent of the energy in commercial buildings whereas fans and refrigerators guzzle maximum energy in residential buildings (*see Graph: End use of electricity in commercial and residential buildings*). Usage of appliances is also more varied in residential units that are mostly lifestyle related.

Lifestyle is rapidly changing the electric appliance market. A study by the Pune-based think tank Prayas Energy shows that given the income levels in India the major initial spurt will be in the basic appliances like fans and televisions as more households will move up the income ladder. Though much smaller in volume compared to fans and TVs, the air conditioning market is galloping at a much faster rate — about 25 per cent a year. According to Prayas Energy, by 2030 more than 70 per cent of appliances will have been added just after (*see Graph: Ownership of appliances in India*

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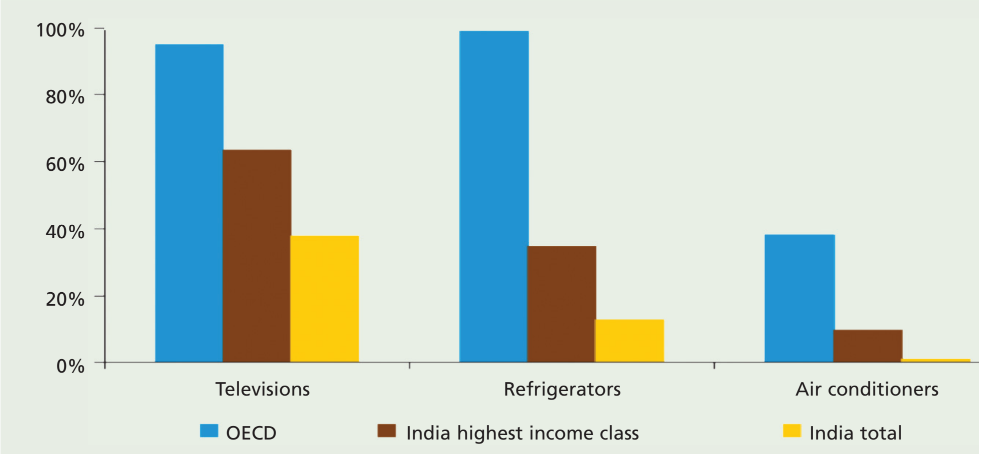
Table: Typical energy consumption in buildings – climatic zone-wise and building-use-wise

Building category	Climate zone wise typical energy consumption kWh/ft²/yr (in bracket in kWh/m²/yr)			
	Temperate	Warm & humid	Composite	Hot & dry
Office	18.55 (199)	15.36 (165)	8.68 (93.39)	8.14 (87)
Shopping Mall	28.43 (306)	15.31 (164)	27.96 (301)	11.87 (128)
IT Park	10.08 (108)	3.62 (39)	45.14 (485)	NA
Hotel	NA (324)	30.13	NA	37.2 (400)
Hospital	NA	NA	NA	11.7 (126)
Residence	15-30			

Note: a. IT Park in temperate and W&H zone were not fully functional; b. Shopping Mall is W&H zone was not full AC
N.A. No Building of category was available in the buildings surveyed
Source: Bureau of Energy Efficiency

Graph: Appliance ownership in India compared with the OECD



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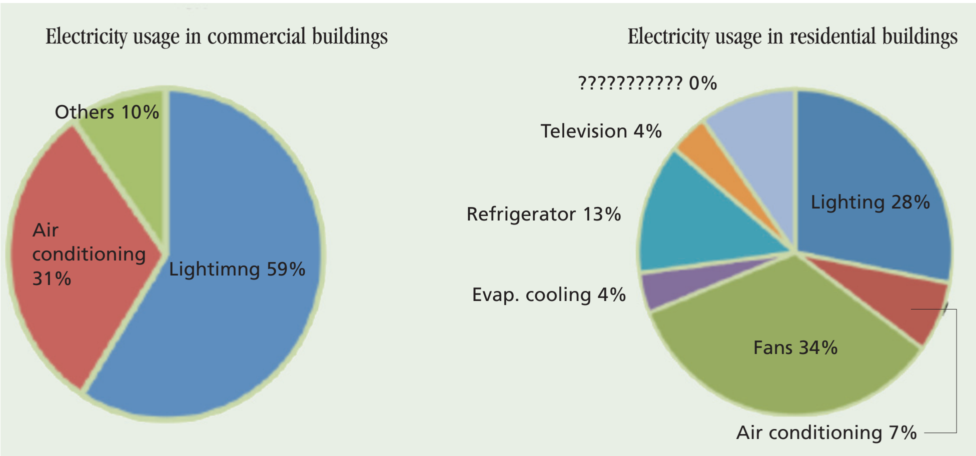
Graph: End use of electricity in commercial and residential buildings



Source: Bureau of Energy Efficiency

growing rapidly).

Commercial buildings spikes energy use: According to a 2011 study by the Alliance for an Energy Efficient Economy (AEEE), and association of the energy industry, the increase in commercial buildings stock is pushing electricity consumption of the sector which is growing rapidly at 11-12 per cent annually.

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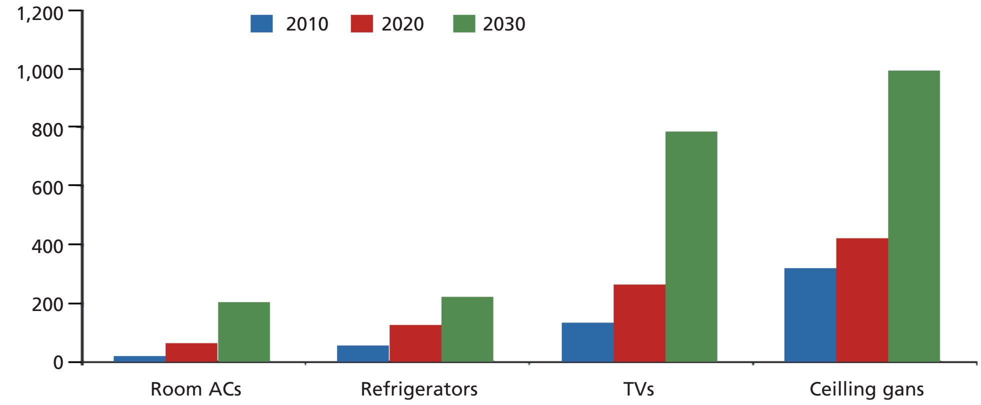
Graph: Ownership of appliances in India growing rapidly



Note: By 2030, more than 70% of the stock of appliances will have been added just after

Between 1990 and 2005 commercial building energy consumption has increased by 60 per cent. It further states that the approved 580 special economic zone that is expected to cover 1.1 billion sq meters, by 2030. This will drive demand for energy intensive air conditioned space as about 60 per cent of the commercial space in India will be air conditioned and while four out of every 10 urban homes will have at least one air conditioned system, as per the Mckinsey 2009 estimates.

Buildings can save energy: Significant energy savings is possible from changes in building construction, climate sensitive design, use of locally appropriate material, and operations. The energy audits of buildings carried out by the BEE shows that existing buildings have 30 to 50 percent energy savings potential. For example, BEE found that in a typical office building energy consumption per unit of area can be reduced from 186 to 86 kWh/m2/Year with interventions.

Studies have also begun to appear on the potential green house gas savings from energy efficiency improvement in the building sector in India. With improved and optimized insulation, highest efficiency electric appliances energy consumption for heating, ventilation and air conditioning, energy consumption can be reduced by 55 per cent — this can cut 150 million tonne of CO_2 by 2030.

What is influencing our energy consumption?

Idea of comfort will influence change: What will drive this sector in the future is the rapidly changing aspiration for good living. This will be guided by the change in the notion of comfort itself.

The National Building Code of India (NBC) 2005 describes human thermal comfort, as the condition of surrounding thermal environment under which a person can maintain a body heat balance at normal body temperature without perceptible sweating. It depends on factors like age, metabolic rate and clothing, which in turn are affected by air temperature, relative humidity, radiation from solid surroundings and rate of air movement. NBC states that the thermal comfort of a person in India lies between TSI temperature values of 25°C and 30°C with optimum condition at 27.5°C.

Popular perception of comfort: Something interesting happened in India with the IT sector boom beginning from mid 90's especially with the advent of IT complexes, BPOs, hotels etc. which led to the introduction of the new building typology. There was surge in air conditioning along with tall buildings with glass facades which were reminiscent of buildings in New York, Chicago etc. These buildings introduced air conditioning in the country in a big way.

Over the years there has been exceptional increase in demand for similar air conditioned buildings as perception of comfort is changing rapidly. Past decade has seen growth in the numbers of theatres, malls, buses, residential apartments, schools etc. that have opted for air conditioning to meet people's rising expectations of comfort that can now be artificially controlled.

Now young people and families crowd malls and multiplexes in the summer to escape the heat and revel in crisp air-conditioned comfort. Higher disposable incomes and changing lifestyle are major drivers of the

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demand for ACs in India.

Comfort defines buildings: Studies show that living and working in buildings with strictly controlled temperature conditions raises thermal comfort expectations. People become accustomed to air-conditioning and resent its unavailability.

The building industry responded to this new comfort expectation with vigor. Further, India's growing appetite for comfort also led to ingress and growth of market for electronics and refrigeration companies, which were reaching stagnation in the west.

A study by Mckinsey Global Institute (MGI) states the middle class in India will swell from 50 million at present to about 583 million by 2025. That will be 41 per cent of the population. Small wonder then the AC market in India is growing at over 25 per cent annually.

Air conditioning is one of the most energy intensive technologies which are used in buildings. With increase in the uptake of this energy guzzler, overall energy footprint of Indian building stock has gone for a toss. As a result India is witnessing significant spike in energy demand and further widening the demand supply gap. Challenge in India is thus threefold and action is needed not just in building design but in appliances and lifestyle too.

Though the market share of room ACs is still the smallest compared to other appliances, it has already recorded more than 25 per cent annual increase in sales recently. At the same time electricity intensity and energy cost of fully air conditioned buildings is all set to further increase. This is likely to increase electricity consumption from 140 Terra-Watt Hours (TWh) in 2005 to 1,300 TWh by 2030 in India.

The recent construction and energy end use trend in India is alarming. The energy consumption in new commercial Indian buildings has drastically increased especially for heating and cooling. The total specific energy consumption or Energy performance index (EPI) for conditioned buildings range from 280 - 500 kWh/m^2 states Hamburg Institute of International Economics in its 2004 study.iv Energy performance index (EPI) is calculated by dividing the annual electricity consumption of the building (excluding electricity generated by harnessing renewable means) by the built up area. This is used as an indicator to benchmark energy use in buildings.

Policy to address comfort issues: Authorities

Changing lifestyles and ACs

Some architects believe that Indians need to use ACs only during the peak summer months. A well ventilated room with a fan at maximum speed can provide adequate comfort the rest of the year. The demands of modern living have substituted traditional commonsensical measures, such as wearing light clothing, eating light and taking afternoon siestas, with more energy-intensive cooling mechanisms.

"Medical science has established that being exposed to a wide temperature range allows the body to be more resilient in the face of variation. Instead, most people today prefer to have an artificially controlled environment through mechanical cooling," says architect Gaurav Shorey. "What's even worse is that people wear three-piece business suits or stretch jeans and then run ACs at 19°C to keep themselves cool. What is it that stops them from wearing a cotton shirt or a kurta which can keep the body cool naturally," asks Shorey.

"Well conditioned spaces encourage people to work longer and more productively," says Bhargav. However, a 2004 Cornell University study highlights that uneven airflow in cooled buildings often leaves some people shivering and others sweating in corners, thus affecting their performance at the workplace.

A growing number of Indian and international studies highlight the perils of excessive air-conditioning on human health. "Overindulgence in air-conditioning has made people captive users and they hardly venture outdoors," says S K Chhabra, head of cardio-respiratory physiology, Vallabhbhai Patel Chest Institute in Delhi. Chhabra cautions that a sedentary air-conditioned lifestyle could cause obesity, cardiovascular diseases and psychological infirmities. A preliminary study done by a team of doctors from various medical colleges in India found the frequency of respiratory symptoms like coughing, wheezing and breathlessness was higher among AC users.

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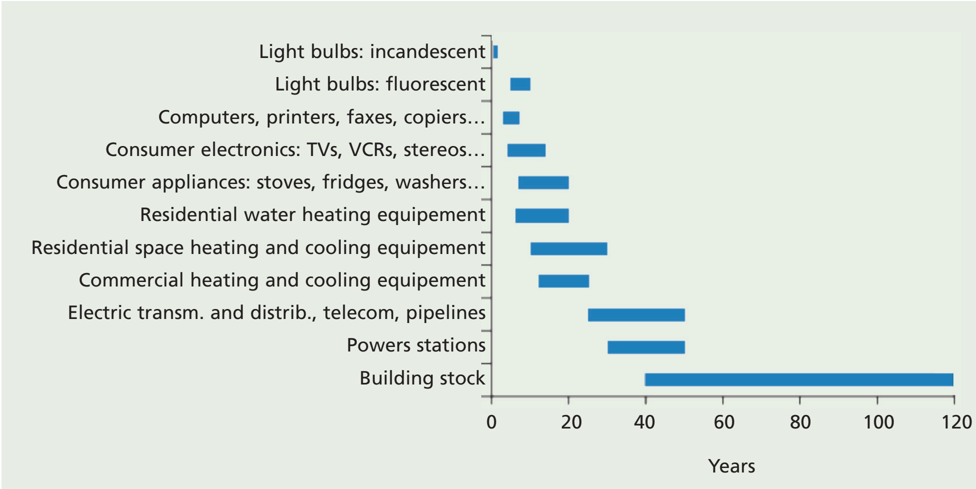
Graph: Economic life span of energy consuming equipment and infrastructure



Source: Energy Technology Perspectives: Scenarios & Strategies to 2050, 2010, International Energy Agency

have been proactive in defining and regulating comfort standards for people and buildings. NBC sets lighting standards to control visual comfort levels inside buildings and similar standards exists for various other parameters to ensure healthy living conditions inside for building occupants. There are multiple health and cleanliness standards in place too. But when it comes to thermal comfort, NBC has dual stand. While it recommends TSI temperature range for unconditioned buildings, for air-conditioned spaces proposes an indoor temperature range of 23-26°C for summers and 21-23°C for winters. This is critical because of high energy cost related to this difference. Internationally, South Korea and cities of Japan have placed regulation which forbids commercial units to reduce their temperature settings below 26'C and 28'C respectively, to reduce the load on city's energy demand while insuring their citizen's comfort. (*See Box: Bushirt Rule*).

The Bureau of Energy Efficiency's Energy Conservation Building Code (ECBC), which aims to regulate energy consumption of commercial buildings that are expected to have ACs, does not define temperature and humidity standards. However without thermal comfort standards customised for Indian climatic conditions, air-conditioned office buildings in India operate at 22.5 (± 1°C). Consequently, mechanical systems have to use massive energy to cool temperatures down from 42-45°C to 21-22°C.

With growing aspiration and demand for resource intensive lifestyle, regulations will have to be stepped up to reduce energy intensity of built up areas as well as manage demand and aspiration with market based instruments and efficiency measures. Therefore, at the early stages of growth, India will have to take steps to find innovative and creative architectural ways to optimize use of climatic advantages of different zones, minimize use of artificial cooling and heating of built environment and reduce demand for energy intensive technology.

Glass

One of the major reasons behind the increased cooling load in new buildings in the subcontinent is the growing use of 'glazing' — external wall made of glass — in buildings. Glass traps heat from the sun and warms up the interiors of the building (*see Box: How green is glass?*). Glazing tends to reduce lighting demand by using daylight. However, along with light, the rate of heat exchange of the building with the outside environment also goes up (*see Table: Glazing and conditioning — the co-relation*). Thus, glazing should be optimised on the basis of minimum specific energy demand for both air conditioning and lighting inside a building. In other words, glass usage in a building should be balanced in a way to improve day lighting without compromising the building's thermal performance.

The country's glass industry is expected to be worth Rs 340 billion by 2015, according to a study by the industry body Assocham. Growth in glass consumption is estimated at 10-12 per cent in the construction sector. Per capita glass usage in India is a lowly 1.2 kg compared with eight-nine kg in developed countries and 30-35 kg in the US, highlighting the market potential in India.v

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Bushirt Rule

Waning winter is the time when people call up their dry cleaners to get heavy business suits and jackets cleaned before packing them for the next season.

But air conditioning is probably changing the way we dress. Conference rooms, auditoriums, workspaces and malls are running their air conditioners at as low as 18-19°C to keep it cold for their employees and visitors. The question then is: Is cold is really comfortable?

At such low temperatures, only a person wearing a climate-inappropriate three three-piece business suit or a stretch lycra jeans would feel fine while someone who is clad in a summer-friendly bush-shirt would be quivering in the cold. Also, for every degree decrease in thermostat setting, there is an increased energy consumption of five per cent.

It is surprising that India with all its energy concerns never gave serious consideration to appropriate clothing as an energy conservation measure. Our neighbour, Pakistan, has proved to be the smarter one. Like in most parts of India, temperatures in some parts of Pakistan reach around 40°C in peak summers.

The Pakistani PM's office prescribed a dress code for summers. The dress code recommends light-coloured, loose-fitting clothes to combat summer heat. Government employees will also be allowed to wear shoes without laces or sandals without socks at work. Further, the government has also gone ahead with stricter steps–like banning air-conditioners in its offices–to cope with power shortage. The Japanese have also mandated season appropriate dressing for building occupants. So three piece suits are out for them in peak summers, and peak summer for them is just around 30°C!

Whither policy?

Energy regulations for buildings are a fairly new policy phenomenon in India that has evolved in stages. The Energy Conservation Act 2001 ('the EC act') notified by the union Ministry of power (MoP) in 2002 had first set the terms when it sought energy efficiency measures throughout the country and the Central and State governments to have a legal framework to implement energy efficiency measures.

Nascent steps in cities

While central government policies are taking steps state governments have also initiated small steps on energy savings measures in a few cities. These are still *adhoc* and nebulous. Collectively they include policy statement and intent on promotion of cool roof approaches, working on process to adopt energy code for buildings, energy saving measures for targeted buildings, and application of solar heating devices.

Delhi has initiated cool roof programme, promoting implementation of ECBC in government buildings, revising master plan to include some energy saving measures, under Enhanced Energy Efficiency Mission plans to retrofit 100 existing buildings with area above 10,000 sft, Delhi secretariat and about 15 more government buildings to be identified will be converted into a green building; solar water heater system is mandatory in industries, hotels, hospitals, nursing homes, and residential buildings with 500 sq meter area and subsidy for purchase of solar water heater is available. There is also a proposal for a solar city in the NDMC area.

Haryana has mandated implementation of ECBC in government buildings and is in the process of modifying municipal building bye laws accordingly. It has amended schedule of rates to include energy efficient materials, introducing CFLs, water heating system, street light luminary system and prepared energy efficient building module for replication. It has also initiated monetary incentives for architects and buildings that adopt energy efficiency measures and announced financial support to bear energy audit costs for various commercial buildings.

Odisha has been the first State to have amended the ECBC to match the local requirements in consultation with BEE. Odisha State energy conservation fund rule has been notified and the fund has been created. Draft energy policy is being reviewed for finalization. Likewise several other states including Rajasthan, Tamil Nadu, Maharashtra, among others are framing their policies though implementation is tardy.

Building Code for energy saving: next generation challenge

An important policy instrument that is expected to set the sustainability terms for energy savings in new construction in India is the Energy Conservation

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How green is glass?

Industry is selling glass on the grounds that it contributes to aesthetics, energy efficiency, safety, security and comfort. Saint-Gobain Group, the world leader in glass manufacturing, has a website called 'glassisgreen.com'. The company's India unit is the founding member of the Indian Green Building Council that awards green ratings to buildings. The website of another glass maker AIS Glass also highlights the green caliber of glass.

Being transparent, glass gives a sense of open space. By letting in natural light, while keeping dust and insects away, it reduces the need for artificial light. But there is a cost to it. Glass traps heat. This is the principle on which greenhouses work. Buildings with high proportion of glass, thus, get overheated, pushing up the energy use for keeping them cool. This is unsuitable for tropical climates.

To cut down on the heat and glare transmission, the glass industry has devised several technologies. A typical version is double glazing with air gap in between for insulation. However, a study by the Indian Institute of Technology (IIT)-Delhi in Delhi, Jodhpur and Chennai found that energy use increases with the increase in glazed area, irrespective of glass type, climate or orientation of the building.vi

Glass consumes high amounts of energy right from its manufacturing processes to its transportation and installation. The embodied energy of glass is between 15.9 and 26.2 megaJoules per kg (MJ/kg); it is 1.06 MJ/kg for bricks.vii The embodied energy of glass increases considerably when used as double or triple glazing or when inert gases like argon replace the air gap to further improve insulation capacity.

Glass also poses safety concerns. In 2011, Mumbai's chief fire officer Uday Tatkare told a leading newspaper that buildings with glass facades are major fire hazards and pose hindrances in firefighting. Glass sheets often do not have a fire-retardant coating and shatter once the threshold temperature exceeds. There are no standards to regulate the quality of glass used in buildings. To make matters worse, the BEE offers considerable leeway for the use of glass in commercial buildings — its energy conservation code (ECBC) allows a maximum WWR of 60 per cent.

Building Code (ECBC).This is part of the central regulations that sets norms and guidelines to influence the construction and designing of new buildings. Though framing of this code is part of the first generation action in India, ensuring its effectiveness and implementation are part of the next generation challenge.

The code initially targeted buildings having a load of more than 500kW or contract demand of 600kVA. However, an amendment in the ECA 2001 broadened this categorisation to include buildings having 100kW load or 120kVA contract demand. This amendment was done to address the concern that the previous requirements considered only very large buildings and left out large chunk of commercial buildings from the ambit of regulations. Code covers new buildings as well as old buildings which are getting renovated and/or extended.

The ECBC provides minimum requirements for energy efficient design and construction of buildings. The code specifies the threshold levels for various energy-related aspects of buildings in five broad categories of walls, windows, roofs and skylights (termed as the building envelope); use of day light and design of efficient electrical lighting; mechanical ventilation, air conditioning and space heating as applicable; service hot water heating (mandates usage of solar water heating) and losses in electricity transmission and distribution. ECBC serves as a cross-check for building designs and specifications to reduce the energy consumption in various building functions by design and choice of material and equipment.

According to BEE adoption of this code can reduce energy demand by at least 25 per cent in new buildings compared to recent buildings. At present, the code is voluntary and it's implementation falls under the jurisdiction of the state government with guidance from the BEE. The code needs to be suitably modified and changed according to the climatic and regional conditions of respective states and notified. Once made mandatory the code will bear the distinction of being the only legislation concerning energy efficiency in buildings which must be complied with in the state. As of now, all other codes including the National Building Code (NBC) are recommendatory guidelines.