IMPACT: International Journal of Research in Humanities, Arts and Literature (IMPACT: IJRHAL)
ISSN (P): 2347-4564; ISSN (E): 2321-8878
Vol. 6, Issue 6, Jun 2018, 375-384
© Impact Journals

A REVIEW OF ENERGY CONSUMPTION IN RESIDENTIAL SECTOR IN INDIA; POSSIBILITIES FOR ENERGY CONSERVATION

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Received: 12 Jun 2018 **Accepted:** 18 Jun 2018 **Published:** 22 Jun 2018

ABSTRACT

Building industry is one of the largest consumers of energy and thus has a high potential of saving the consumption as well. Currently, the residential and commercial sectors account for 30% (22% residential and 8% commercial) of total electricity use and consumption in these sectors is rising at 8% annually (Dr Satish Kumar, USAID ECO - III Project, 2011). As energy consumption from residential buildings is predicted to raise by more than eight times by 2050 under the business as usual scenario, it is of vital importance for India to develop energy-efficiency strategies focused on the residential sector to limit the current trend of unsustainable escalating energy demand (Residential buildings in India, projections and saving potential, 2014). The Bureau of Energy Efficiency (BEE) has carried out energy audits in buildings which show that existing buildings have 30 to 50 percent energy savings potential. This paper tries to understand the energy consumption in residential sector and the ways to optimize it through the identification of suitable electrical equipment and appliances. This paper studies the energy consumption pattern in residential sector in India and tries to explore the possibilities of energy optimization.

KEYWORDS: *Energy Consumption, Electrical Equipment, Efficiency, Climate, Air Conditioning*

INTRODUCTION

India is now transforming in to a one of the important Nation being the third largest economy in the World. The consumption of energy in buildings depends on factors like ambient temperature, weather condition, daylight hours, building design; inherent efficiency of equipment used and installed efficiency of equipment used. Thus, dependence on energy driven systems can be reduced through climate sensitive design where the building envelope responds favorably to the local climatic factors, by proper operation & maintenance of electrical equipments and appliances and by appropriate material selection in construction process. And also with improved and optimized insulation, selecting the energy efficient electric equipment for heating, ventilation and air conditioning, energy consumption can be reduced by 55 per cent which can cut 150 million tons of CO2 by 2030. Recent policy changes are going to improve the countries growth enormously in coming years. Being a developing country, power consumption has been increasing at greater pace in India. As per the NMEEE document, 2009, from annual consumption of 19200 KWh in 2005 only from Residential & commercial buildings, it is predicted to reach 89,823 KWh in 2030. Energy consumption growth rate in commercial buildings is 8% and that of Residential sector is 5% and floor area increase itself is expected to grow from 659 million Sq. Mts in 2010 to 1900 million Sq.Mts in 2030.The main drivers for this development are the population growth, increased economic development and the ever increasing urban population. But India is still in the nascent stage in energy

conservation point of view in any of the sectors. Energy efficiency of a building is achieved by reducing the energy demand and the same time creating optimal comfort conditions in the spaces of the building. India has been responsible for almost 10% of the increase in global energy demand since 2000. Its energy demand in this period has almost doubled, pushing the country's share in global demand up to 5.7% in 2013 from 4.4% at the beginning of the century. (India energy outlook, IEA, 2015)

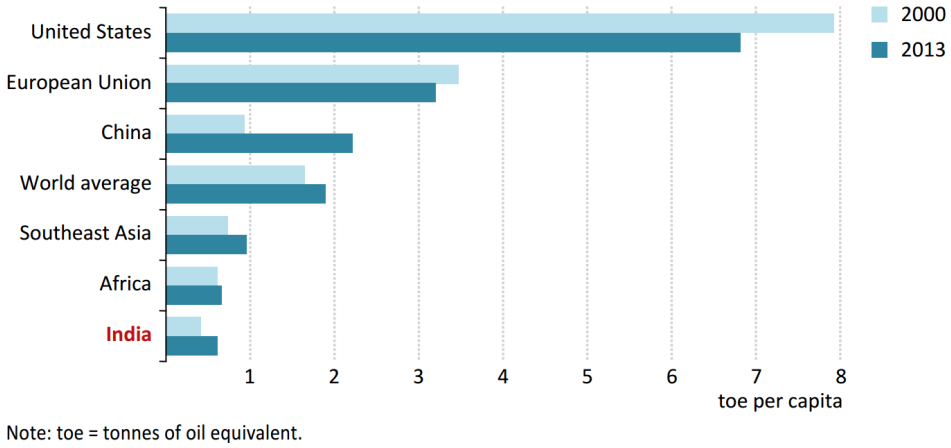

Figure 1: Per Capita Energy Consumption in India and Selected Regions

(Source: India Energy outlook, EIA, 2015)

Because of the variations in demography, climate and cultural differences, it is difficult to generalize the energy consumption patterns in India. Electricity is an important component in the economic development of the country and its demand has been increased from 376TWh in 2000 to 897TWh in 2013 (India Energy outlook, EIA, 2015). If you see the supply side, India has got the capacity of 290 gigawatts5 (GW) of which maximum is generated by coal (60%) based thermal power plants followed by hydropower (15%).

RESIDENTIAL ELECTRICITY CONSUMPTION PATTERNS IN INDIA

A bottom-up approach was used to estimate appliance energy usage and made the simplified assumption that residential energy usage is solely dependent on household income (The World Bank, 2008). The Climate Works Foundation study on "Reducing GHG Emissions in the Building Sector in India" (Climate Works Foundation, 2010) indicates that the residential sector accounts for 21% of total electricity consumption. The energy consumption distribution in the residential sector is shown in Figure 5 where ceiling fans and lighting constitute the majority of energy use at 62% (Climate Works Foundation, 2010). Within this, the Indian residential sector has been seeing the maximum growth which may be attributed to the higher GDP, population increase, urbanization and improving economy and higher income levels (Chaturvedi, Eom, Clarke, & Shukla, 2011). The consumption of energy in the building sector can be seen in Figure 3.

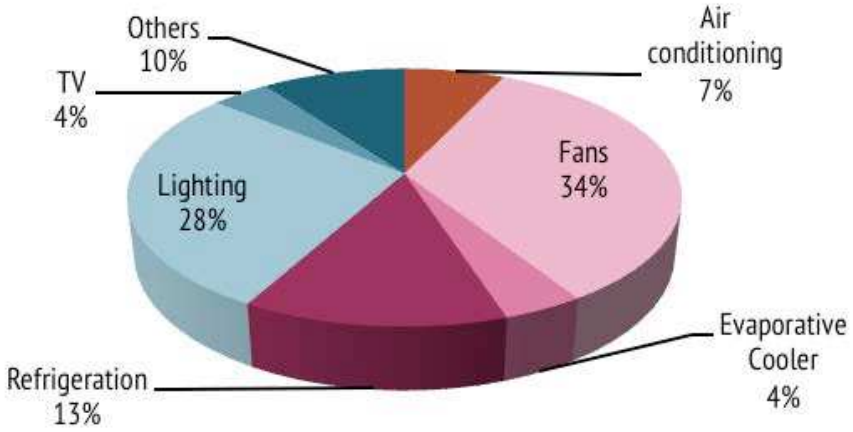

Figure 2: Energy Consumption in Residential Sector (Source: Planning Commission, 2011)

From Figure 2 above, we can conclude that lighting and space cooling are the biggest consumers of electricity in India in buildings in India.

Same time the growth of building sector in India is phenomenal as shown in figure 3. The Climate Works Foundation study (Climate Works Foundation, 2010) also predicted that the major growth in the construction industry will be seen in the residential and commercial sectors and will be as much as four to five times when compared to its condition in 2005 (Planning Commission, 2011). If our buildings achieve better energy efficiency, it will resultantly reduce the energy consumption of these sectors.

Figure 3: Growth of Building Sector, Source (Source: Planning Commission, 2011)

As per the surveys, the average annual energy consumption in India is 3755 kWh. The growth of per capita energy consumption in india in the past ten years is given in the below Figure 4. As per the ministry of power, Govt. of India, per capita energy consumption in residential sector in India is constantly in rise and especially in the last 10 years there is an increase of 30% witnessed.

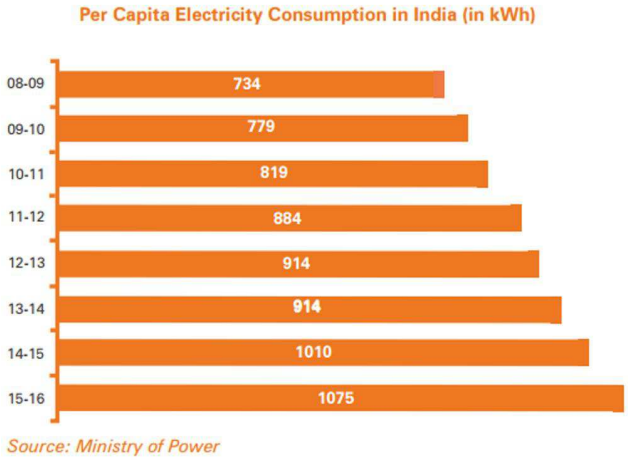

Figure 4: Per Capita Energy Consumption in India (Source: Ministry of power)

Same time if you see the energy consumption in urban and rural areas, the difference is huge. Energy demand in India is going to rise further in coming years with the day to day improving economy and the ever increasing population of this country, it is expected that India will become the most populous country in the world by 2025. The Figure below shows the projected energy demand in India. Quantitative analysis of major home appliances indicates high penetration rate in urban households and they have shown positive as well as relatively stronger correlation with electricity consumption (Jaya Singh et al, 2018).

Indian power generation is mostly dependent on fossil fuels, and renewable energy resources generate only 6.62%. Coal is the key source of CO 2 and primarily responsible for global warming. These numbers reflect how Indian domestic energy is compounding the problem of carbon footprint. The urban population increased from 217 million to 377 million during 1991–2011 a 73% increase, whereas the demand for energy more than doubled from 1990 to 2009. Urbanization is happening at a great pace in India, while energy consumption and emissions are increasing at a much faster pace (Sainu Franco et al, 2016)

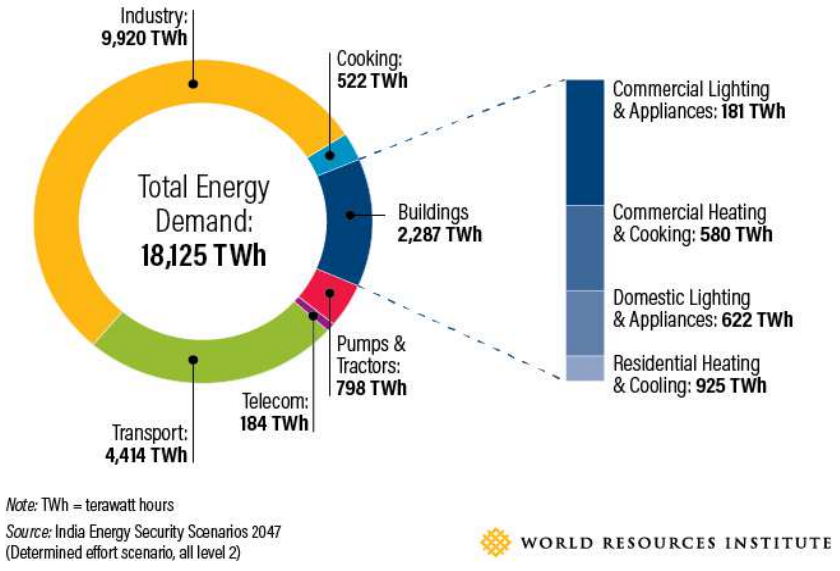

Figure 5: India's Projected Energy Demand by 2047 (World Resource Institute)

As per the study conducted by Jaya Singh and others the family size and the appliances they are using in various climatic zones in India are tabulated below.

Table 1

			Percentage Ownership of Appliances		
Climate Region	**Family size**	**Floor Area in Sq.mts**	**AC**	**Refrigerator**	**Water Heater**
Hot and Dry	4.61	114.47	36.4	91.5(96)	6
Warm and Humid	4.17	68.75	63.5	91.4(94)	24
Mumbai	4.2	62.43	62	93(92)	12
Thane	4.27	66.7	68.5	99.3(100)	7
Composite	5.1	126.53	50.3	98.4(110)	7
Indore	4.3	152.55	55	98.8(108)	24
Kanpur	5.8	116.31	46.5	99(115)	6

Figure 6 Statistical overview of household attributes in major cities in India (Source: Jaya Singh et al, 2015))

During this study authors have collected information about the kind of electrical appliance used by the households and classified them as per the area of the house, type of the climatic region to ascertain the energy consumption patterns in various climatic regions of the country. This study shown that there is not much of strong correlation between the demography and the household energy use and the households in hot and humid regions are consuming more energy than households in hot dry regions. It further showed the stronger penetration of electrical appliances in Indian households irrespective of the climatic regions.

As per the study conducted and the data collected and analysed by Centre for Advanced Research in Building Science & Energy (CARBSE) at the (CEPT) University, the EPI values for different numbers of bedrooms with different numbers of AC units are shown in the table below. This study demonstrated that a 1BHK unit will have a higher EPI, due to intensification in the use of appliances. Also, residential units with a higher number of AC units have a higher EPI. The increased use of air conditioners has steadily increased the energy consumption of households. However, once the number of air conditioners reaches more than three, energy consumption stabilises or reduces, indicating that usage patterns vary significantly for homes with more than three air conditioning systems.

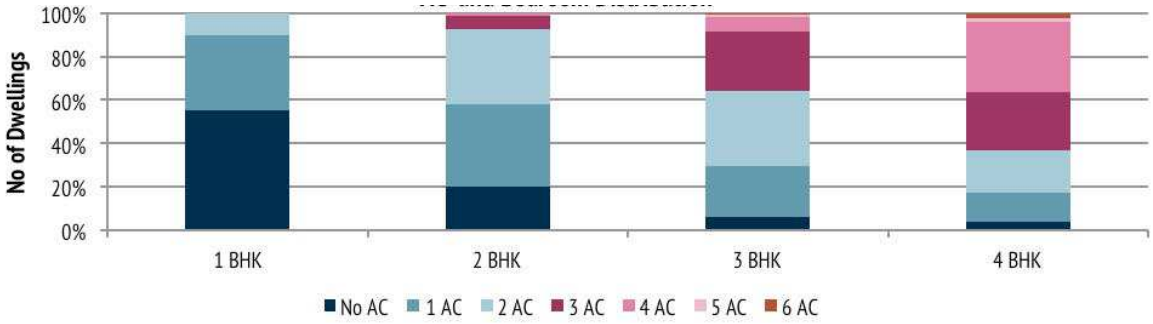

Figure 7: AC and Bedroom Distribution

GOVERNMENT EFFORTS TOWARDS ENERGY EFFICIENT BUILDINGS

The increasing demand for buildings and rising energy consumption have alerted the government for taking up energy efficient measures in buildings. The Integrated Energy Policy 2006 (Planning Commission) and the National Housing and Habitat Policy 2007 (Ministry of housing and urban poverty alleviation, 2007), are important policy

documents enacted by the government for the optimization of energy consumption in buildings. It is expected that these measures will encourage energy efficiency in residential building sector in India. Encouraging the use of building automation systems in buildings will help in reducing the energy consumption. Appliances with energy rating given by BEE (Bureau of Energy Efficiency) may reduce the energy consumption considerably. The comparison of electrical appliances with and without energy rating is given in the table below.

Table 2: Average Wattage of the Cheapest and Most Efficient Model

Appliance	Cheapest model	Energy efficient model	Savings
	W	W	In %
Incandescent bulb to CFL	55	15	73%
Direct Cool Refrigerator	350 kWh	179 kWh	49%
Flat Screen TV	73	51	30%
Fan	70	50	29%
Tube light T12 to T8*	49	36	27%
Window AC	1892	1406	26%
Air cooler	162	125	23%

Apart from choosing the energy efficient equipment it is also important to place the equipment in an appropriate place in buildings. For example, shading the outdoor unit of the air conditioner from the sun and is essential & will make it perform up to 10 percent more efficiently. When evening temperatures cool down, a window fan can be used instead of air conditioning placing the fan in a living room window blows hot indoor air outside. Closing all other windows except the bedroom window will creates a slight suction that brings cooler outdoor air indoors through the bedroom window.

ENERGY CONSERVATION MEASURES IN BUILDINGS

Implementation of ECBC

Energy conservation Building Code (ECBC) was developed by BEE Bureau of Energy Efficiency under MoEF, Govt of India. Any building having a connected load of 100 kW or greater or a contract demand of 120 kVA or greater are come under this act. ECBC sets minimum standards for design and construction through buildings components and systems. This acts empowers the Governments to facilitate and enforce efficient use of energy and its conservation, notifies energy intensive industries, establishments and commercial buildings as designated consumers and prescribe energy consumption norms and standards for the Buildings. It specific requirements for the insulation of building envelop by considering surface reflectance, heat transfer and solar heat gain etc. This code prescribes comfort requirements and efficiency levels for HVAC, other electrical systems, various material specifications and lighting fixtures.

Selection of appropriate electrical appliances

BEE gives the energy star rating for various electrical appliances and lighting fixtures used in buildings. According to various surveys conducted, electrical appliances consume substantial portion of energy in a building especially appliances such as refrigerators, water heaters, Iron boxes and microwave etc. It is also important to decide the placement of the appliance carefully. For example placing a refrigerator near a heat source like microwave or exposed to sun light attracts more electricity than normal. It is also suggested to replace the major appliances for 10-15 years of usage. In cooling dominated climates, energy-efficient appliances that do not excessively heat the indoor environment can also

save additional energy by not increasing the air-conditioning usage.

Lighting Fixtures

Compact Fluorescent Lighting use about 75 percent less energy and last 10 times longer than standard incandescent bulbs. Compact fluorescents can be three to four times more efficient than incandescent because they use more of their energy to produce light. Standard incandescent bulbs waste 90 percent of their energy producing heat instead of light.

Table 3: Comparison of Lighting Fixtures

Compact Fluorescent*		Standard Incandescent*	
Watts	Lumens (Amount of Light)	Watts	Lumens
15/16	900	60	860
20	1200	75	1170
22	1900	100	1500
30	2400	150	2780

Replacing just one 100-watt standard incandescent light bulb with a 22-watt compact fluorescent saves enough energy over the life of the bulb, reduces CO2 emissions by the amount emitted from a car driven 1,100 miles & prevents the burning of 400 pounds of coal. A typical CFL can pay for itself in energy savings in less than 9 months.

LED Lighting LED bulbs are rapidly expanding in household use. Energy rated LEDs use only about 20%-25% of the energy and last up to 25 times longer than traditional incandescent bulbs. They come in a variety of colors, and some are dimmable or offer convenient features such as daylight and motion sensors. Controls such as timers and photocells save electricity by turning lights off when not in use. Dimmers save electricity when used to lower light levels.

Building Automation Systems

The trend of going green in aspects of life has been emerged significantly across the globe including India. This offers good opportunities for the building automation systems for HVAC, lighting. Building automation strategies which are adopted for are the lighting management systems with the occupancy based sensors, dimmers, integrated building management systems with the appropriate integration of the HVAC, diesel generator sets, lighting safety and security systems, elevator management systems. The energy efficiency objective should be integrated right at the design stage, which will enable the developer to design the building by incorporating maximum natural light, enhanced HVAC design etc., This will aid in reducing the energy consumption

Renewable Energy Sources

There are many options for using renewable energy at home including solar panels and small wind turbines. Solar panels are the most popular form of renewable energy today. They may be used to generate heat, electricity, and indoor and outdoor lighting. A small wind turbine for pumping water or for other applications may also be used.

In addition to using renewable energy in your home, buying of electricity generated from renewable energy resources like Sun, wind, water and geothermal.

CONCLUSIONS

Energy consumption in India especially in residential sector keep increasing in coming years due to ever increasing built area and associated energy requirements, as long as resources and economic considerations allows it. Surveys show that nine end-uses or appliances contribute almost all the electricity consumption in Indian households. Furthermore, just four appliances / end-uses– lighting (incandescent bulbs and tube lights), ceiling fans, TVs, and refrigerators are responsible for 80% of the electricity consumption in residences. In addition, shifting to the most energy efficient appliances available now for all future sales results in annual savings of about 57 TWh in 2013 which is about 30% of the additional annual consumption that would otherwise have happened under a BAU scenario in the year 2013. It should also be noted that our results indicate that if all new sales are of energy efficient appliances, then the consumption will be similar or equal to five years before 2008 consumption even though many more new appliances will have been added. These potential savings in energy would avoid more than 250,000 MW in generating capacity additions, equivalent to one ultra-mega power plant every year for five years. This result is assumed based on the presumption that all appliances used from now on will be of energy efficient ones. Public initiative along with government intervention by promoting energy efficiency, new technologies for energy production and reducing energy demand will be important for sustainability in energy sector in India.

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