

# Energy Conservation Opportunities and its Techniques in Net Zero Energy Buildings

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**Abstract.** The electrical energy is very necessary to address all household needs and commercial needs. This energy is used all over the world for almost all purposes. It is diminished day by day as fossil fuels are used for energy production. As natural resources are limited and getting exhausted, there is every need to conserve energy. It even involves in rising up pollution and increasing the global temperature by emitting greenhouse gases. It shows severe impact of climate. This paper explains the term energy conservation, methods to conserve energy, use of energy efficient devices and also how energy efficient devices are chosen for various purposes. This paper even focuses on net zero energy buildings and explains a methodology for arranging lights and blind control for windows in net zero buildings to conserve energy.

## 1 Introduction

India's electricity installed capacity is 408 GW in 2021-22, out of which fossil fuel sources contribute 58% (236 GW) and renewable sources contribute 42% (172 GW). The total power generated was about 1492 BU during 2021-22 out of which renewable energy constitutes 13% (194 BU). There is a deficit of about 0.4% (5.8 BU) in the power availability [1]. Similarly, there is a deficit of 1.2% in meeting the peak demand during 2021-22, and 80% of electricity demand is still being met from fossil fuels and biomass [2].

The consumption in residential sector constituted 26% of the total consumption during 2021-22. India's electricity consumption was 1,208 kWh/capita in FY2019 [3-4]. The residential sector is an end-use sector consisting of dwelling units. Common uses of domestic energy consumption include space heating, water heating, air conditioning, lighting, refrigeration, cooking, washing and running a variety of other appliances. The residential sector excludes institutional living quarters [5].

In view of India's commitment at the COP26 at Glasgow, UK to reduce the carbon intensity of our economy by 45% by 2030 over the 2005 level [6-7], and to reduce the total projected carbon emissions by 1 billion tonnes from 2022 to 2030, and achieving the target of net zero emissions by 2070, there is an imperative need for energy conservation [8-9] and efficiency improvement in the domestic sector also along with other sectors.

The energy conservation is necessary as the consumption of appliances are increasing day by day

and it's to reduce the demand for energy [10-11], it is necessary to understand the conservation of energy. One way of energy conservation is by understanding the energy star rating of various energy consuming appliances and using them in daily basis. Another way of energy conservation is by reducing the use of appliances [12-13]. For this, we need to know the amount of energy consumed by each appliance. In this paper, firstly, we understand the word called energy conservation, ways to reduce energy conservation and then the survey of energy consumption in an educational institution and also the concept of net zero energy building [14-15].

The statistics about energy conservation techniques adopted are presented in Section II with an introduction from section I. Section III presents the energy conservation techniques through electric appliances. Section IV gives energy conservation techniques adopted for net zero buildings. Finally, the section V presents the conclusions.

## 2 Statistics about Energy Conservation Techniques Adopted

Energy is never generated. It is just converted from one form of energy to another. For example, if solar energy is considered as the energy, the heat energy from the sun is converted to electrical energy. If thermal energy is considered, the heat energy from the fossil fuels is converted to electricity, hydel, the potential energy from water bodies is converted to electricity.

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In this way, energy is never produced. The available energy either from fossil fuels or the natural forms of energy is converted to electricity for the purpose of utilization of consumers. As already discussed, the world energy consumption is increasing rapidly as such it is unable to meet the demand of consumers. Fig. 1 shows the world energy consumption for the year 2022. It can be understood from the figure that the maximum energy is produced from thermal energy. Only a small amount of energy is produced from renewable energy sources.

Even though large energy is produced in the world, the world energy production is not able to meet the present electricity demand and the electricity demand is still deficit. This scenario urges to produce more energy. The general stakeholders are general public, students, youth, NGOs, resident welfare associations, energy professionals, public representatives and government functionaries. Fig 2 shows the Asian countries Energy consumption in the year 2022 which gives the similar results.

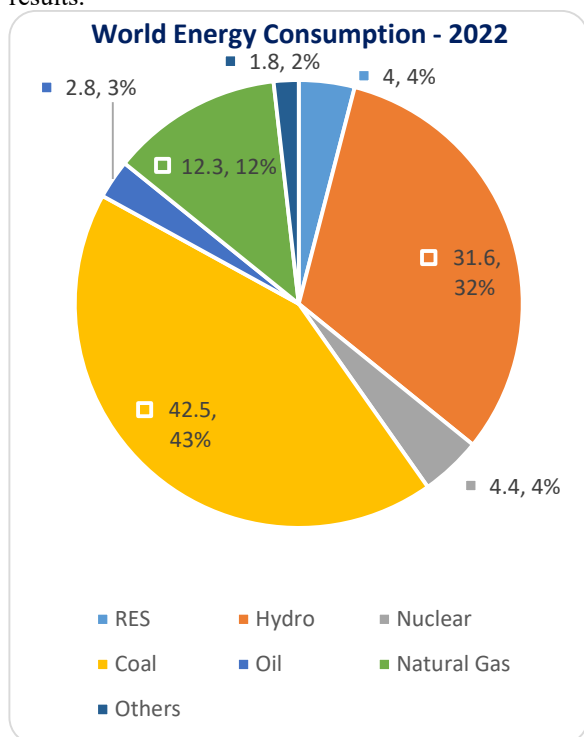


Fig. 1. World Energy Consumption for the year 2022

Instead of producing more energy, energy conservation gives a better solution. Energy conservation is the nothing but the decreasing in the use of wasteful energy and use the energy effectively. It can be done an effective usage by using it if and when necessary, like lightening can be avoided using daylight which reduces pollution as well. Reducing pollution in turn helps in reducing global warming which is the major issue in 21st century. Turn off electrical and electronic appliances when not in use can help a better way to conserve energy.

Energy conservation helps in sustainable development of individual and nation as well. The goal of energy conservation is to reduce poverty, increase health and well-being, give in quality education, show gender equality, provide clean water and sanitation,

provide affordable and clean energy, enhance economic growth, stable climate condition, maintain peace, justice and strong institutions. Fig 3 gives the analysis of average energy utilized by each sector.

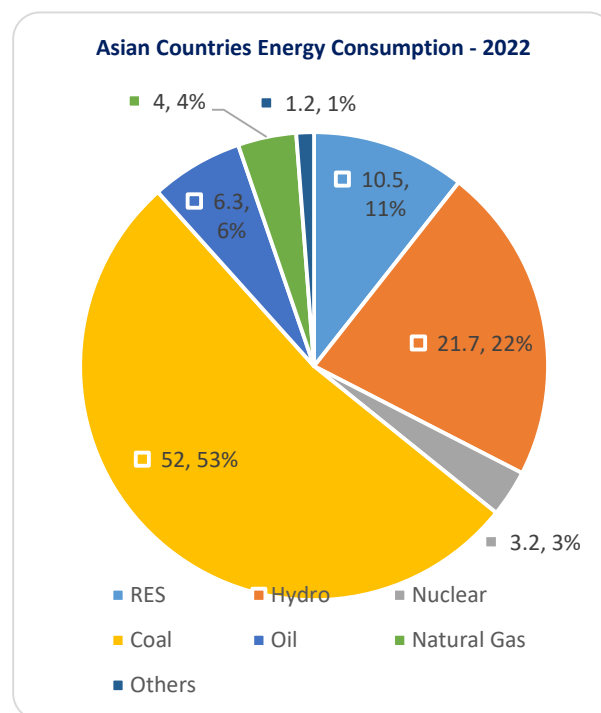


Fig. 2 Asian Countries Energy Consumption in the year 2022.

Fig. 4 explains the relation of energy conservation and climate change. It explains that the increased in electrical energy consumption due to increase in population, increases the emission of CO2 gases emission which the earth temperature and increases the global temperature.

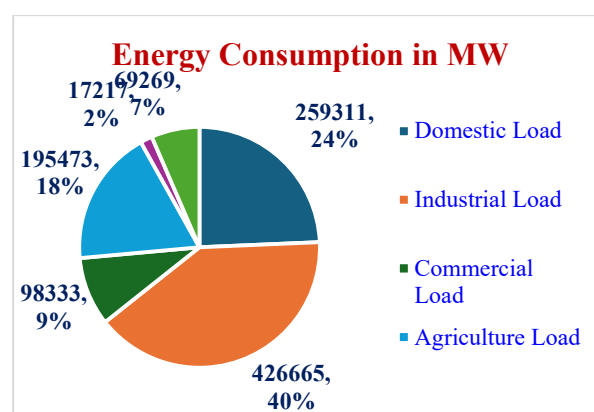


Fig. 3 Average Energy consumption by each sector in a nation.

One kWh conserved means is nothing but 1.2 kWh need not be produced, thus preventing burning of 0.6 Kg of coal & 1.2 kg of CO2 is prevented. Thus energy conservation is important and necessary.

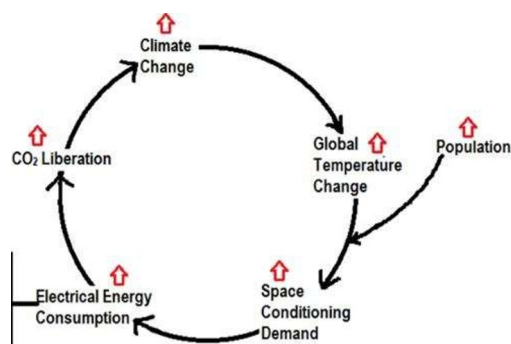


Fig. 4 Relation of energy conservation and climate change.

### 3 Energy Conservation Techniques Through Electric Appliances

Usage of smarter devices can help in conserving energy as smart meter can track the amount of energy consumed by the consumer. Once consumer has the track on energy utilized, daily one can measure the energy and avoid the usage if done heavy. Smart automated devices usage in domestic areas, reduce the necessary of energy. These devices are generally lightening devices. They operate when human beings are near it, if not, they generally turn off automatically.

An alternate way to conserve energy is by using energy efficient appliances. Let us discuss how to choose energy efficient equipment.

#### 3.1 Lighting

An LED bulb uses 75% less energy on average compared to a standard fluorescent bulb. Choose a bulb (warm white) with color temperature of  $\leq 2700\text{K}$ , preferably 2400K to avoid blue light. Choosing a bulb with high Color Rendering Index (CRI)  $> 90$ . Even for 2700K light color, a higher CRI LED bulb has less blue and more red energy. A M/P ratio  $\leq 0.4$  which informs the relative amount of blue light in light's spectrum is efficient for lightening at domestic needs. T5 LED tubes are used for home, T8 LED tubes are economical for commercial areas and parking lots.

#### 3.2 Fans

Fans with Brushless DC motors feature high efficiency and excellent controllability with remote. This BLDC motor has power saving advantages relative to other motor types. This motor is more efficient as it reduces wear and tear with its no brushes mechanism, where brushes help in commutation. In brushless DC motor, commutation is achieved by electronics-based driving algorithm. Even Brushless DC motors with solar powered motor helps in providing clean and green energy to population.

#### 3.3 Building Space

Another method to conserve energy is by planning the building spaces to enable natural lightening and ventilation. This forces the consumer in avoiding

switching on lights during daylight. Switch off the lights and fans when not in use.

#### 3.4 Bulbs

Replacing incandescent bulbs with 36/40 W FTLs/CFL lamps with LED tubes. This way helps in saving 90% and 50% energy compared to incandescent lamps and FTLs/CFLs respectively.

#### 3.5 Regulators

Usage of electronic regulators in place of resistive type regulators for fans.

#### 3.6 Lifts

Lifts are very energy consuming appliances. Lifts from branded company save on energy maintenance. Avoid usage of lift for 1st and 2nd floors. Selecting a lift with AC VVVF motor drive with Automatic Rescue Device (ARD) saves energy efficiently.

Selection of lift depends in various features like building population, passenger arrival patterns, building usage like office, residential and hospital etc., number of floors, car park usage, location of special floors like meeting floors and restaurants.

#### 3.7 Refrigerator

A fridge is chosen such that its refrigerant is eco-friendly as far as possible. Selecting a suitable size refrigerator with BEE 5 star for inverter compressor, auto temperature control. Placing the fridge 50mm (2 inch) away from the wall to allow heat dissipation helps in quick cooling cycles. For energy efficient of refrigerator, check the setting of thermostat frequently as per the season. Ensuring regular maintenance of refrigerator helps in saving the energy used for freezing the items in refrigerator.

#### 3.8 Mixer Grinder

In mixer grinder, electrical energy is converted to mechanical, heat, noise and light energy. The mixer power consumption is directly proportional to size of jar, material to be ground and speed. Using a solar powered BLDC motor drive for a mixer grinder is best suited for energy conservation.

#### 3.9 Air Conditioner

An air conditioner is used to cool the room temperature. Choosing AC with eco-friendly refrigerant helps in conserving energy. Selecting AC with copper coil ensures proper insulation of tubes for AC. An inverter size is selected based in room size and usage. Setting temperature air conditioner at 24-25°C conserves energy as load on the inverter is less. Proper maintenance and cleaning the air filters of air conditioners regularly cleans the dust accumulated, helps in providing cool air in the room. Selecting an AC

with BEE 5/4/3-star rating based on extent of usage. Selecting an AC with ISEER standard is important which ranges from 3.30 – 5.00 for split air conditioner and 2.70 – 3.50 for window air conditioners.

### 3.10 Water Heater:

Usage of solar water heater helps in conserving energy. A water heater/geyser is to be selecting based on family size. Selecting a geyser with 4/5 rating is important. Selecting a heater with thermal cut-out or technically termed thermostat is necessary. Keeping the temperature setting at 45-50°C is necessary.

### 3.11 Solar Water Heater:

A Solar water heater provides hot water for bathing, washing, cleaning etc., It is generally installed at terrace or where sunlight is available. It generally heats water when daylight is available and stores in insulated storage tank for use when required. As sunshine is free, they can be used in any season and at any climate. There are two types of solar heating systems: Active, which have circulating pumps and controls and passive, which don't have them.

Evacuated tube collectors (ETC) type solar heaters work better than Flat plate Collectors (FPC) as they are cost-effective, easier to install, have low maintenance and can extract heat energy from humid areas. FPC is more efficient if full sunshine is available. Once a residential solar water heater is available, it lasts for approximately 20 years.

Solar thermal heating technique is simple technique and more space efficient than Solar PV system. They can be 70% more efficient in collecting heat from sun rays in compared to Solar PV. Solar thermal systems convert 60-70% solar energy into heat, while high end PVs top out at 24% efficiency.

### 3.12 Microwave Oven:

Microwave Oven is most used in purposes for heating or baking. To serve multi – purposes, generally an oven with a conventional cooking option is suited. The one with well-designed sensors, auto cook function, good visibility and ease of use performance techniques helps than just inverter functionality. Setting the timer for cooking duration conserves energy.

### 3.13 Diesel Generator:

Diesel generator serves as the alternate source of electricity when power is unavailable for shorter duration. To conserve energy while using diesel generator regular maintenance is necessary with experienced technician, will help in identifying components needing repair or replacement. Minimizing generator use for shorter duration and using generator based on solar power or natural gas helps in conserving energy.

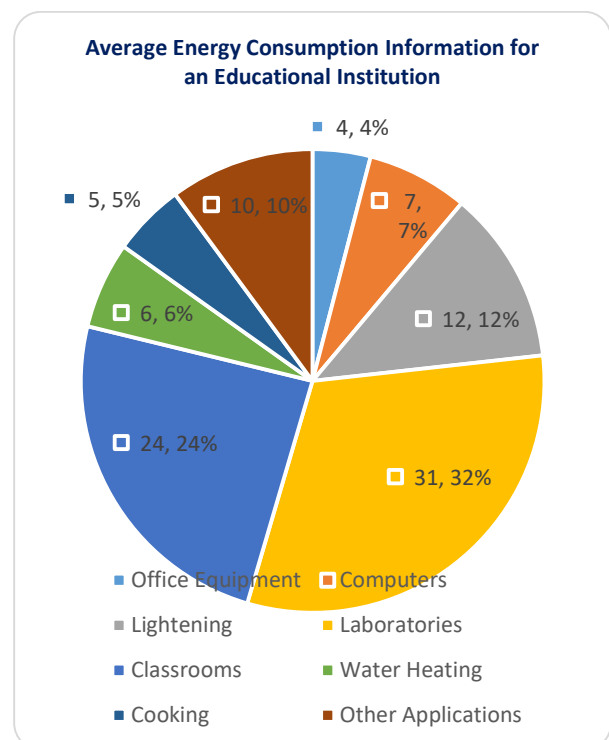
Carbon polymer ash produced from diesel generator accumulates in injector, piston, engine etc., leading to

black smoke after running for a few months. Carbon deposit on generator engine leads to more fuel usage. Hence, clean diesel generator and remove traces of carbon deposits minimum twice a year. Avoiding loading stress as it lowers fuel efficiency. If it operates at <50% load, it takes longer to attain maximum operating temperature leading to more fuel consumption.

## 4 Energy Conservation Techniques Adopted for Net Zero Buildings

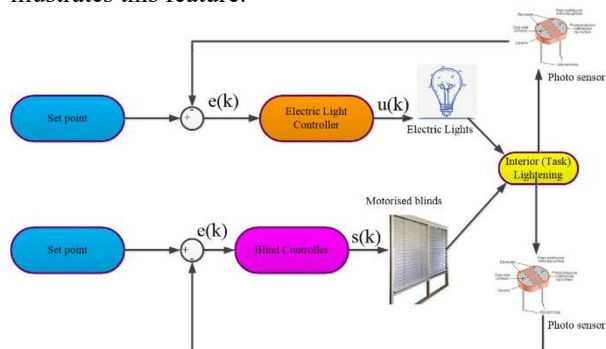
Zero energy buildings achieve one key green building goal of reducing energy use and greenhouse gas emissions. To achieve increase the efficiency of resource use like energy, water and materials and reduce building negative impact on environment during buildings life cycle, green buildings play a key role. Green buildings are those which result in energy saving of 40-50% and water savings of 20-30% compared to conventional buildings in India as certified by Indian Green Building Council (IGBC). Green buildings benefits are at personal level, country level, global level, environmental level, environmental and social levels.

Fig. 5 indicates the average percentage of energy consumption of an educational institution. It explains that the lightening loads, laboratories, computers and classrooms uses large portion of energy. To use energy for all purposes, amount of energy required to attend such purposes is high. Depending of grid to meet these demands, makes a heavy demand for grid. Instead, green building is a solution. Green buildings use solar energy for lightening controls. It uses solar water heating technique for washing cleaning and bathing purposes.



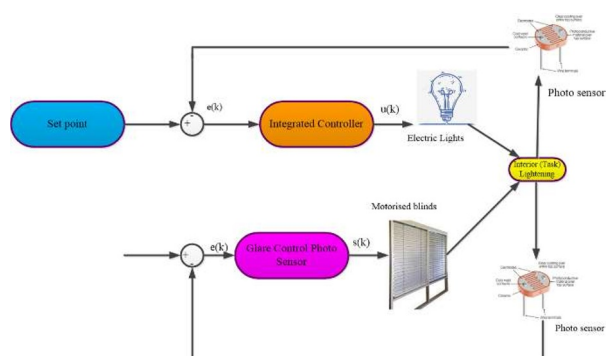
**Fig. 5** Average Percentage of Energy Consumption for an Educational Institution.

Another major technique used in green buildings is that, two major systems of any building namely, lights and blinds of windows are controlled independently using separate sensors to each control loop to achieve desired light and ventilation in work space. Fig. 6 illustrates this feature.



**Fig. 6** Independent control of closed loop lightening system and closed loop blind system.

The alternative method to achieve light and blind angle for window is to use an integrated fashion using the output of a single photo sensor on the work surface and deploying the control algorithm to minimize the energy consumption and maximizing the use of daylight. Fig. 7 illustrates this phenomenon.



**Fig. 7** Integrated lightening and daylight control system.

Using these conservation techniques, energy conservation is possible in domestic as well in commercial buildings efficiently. Net zero energy buildings can also be achieved if a small interest is taken when design and construction is elevated.

## 5 Conclusion

Energy conservation is playing a key role now a days as the natural resources are diminishing day by day and they are limited. Saving of energy is necessary. Saving one unit of energy/day means saving 30 units per month or about Rs. 180 per month. If one KWh P F energy is conserved means 1.2KWh need not be produced at power station, saving 0.6 kg of coal. Thus, emission of about 1.2 kg CO<sub>2</sub> is prevented. This energy conserved is utilized for irrigation, illuminating thousands of villages. Green buildings help in saving energy as well. Zero Net Energy Structures are being created in an effort to slow down the rise in energy use, which is endangering our way of life worldwide. A variety of technologies and system solutions must be developed in

order to achieve this on a commercially feasible scale. These cover anything from building envelope technology to sensors and controls for appliances, HVAC, lighting, and solar PV, among other renewable energy sources. Future developments, such DC grids in buildings, might be useful in this situation. This will present a significant opportunity for the creation of critical components to handle this significant challenge, such as power converters, lamp drivers, motor controllers, smart sensors, and network controllers.

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