Introduction to Energy

Energy

Mass and energy are the two important entities in the world. Mass refers to any matteror substance. Mass cannot be created or destroyed, but it can be converted into anotherform. It is called law of conservation of mass. Energy is a vital source for all processes.

Energy is defined as the ability of a system to do work. Any form of energy may be converted into another form. For example, all types ofpotential energy (raised mass, compressed or twisted spring, etc.) can be converted intokinetic energy. However, energy cannot be destroyed. Law of conservation of energystates that one form of energy can be converted into another forms but it cannot be destroyed.

Energy is expressed in J or kJ.

Power

Electric **power** is the rate at which energy is delivered. The SI unit of **power** is the watt, one joule per second. Electric **power** is usually produced by electric generators, but can also be supplied by sources such as electric batteries.

Need of energy in buildings and its assessment

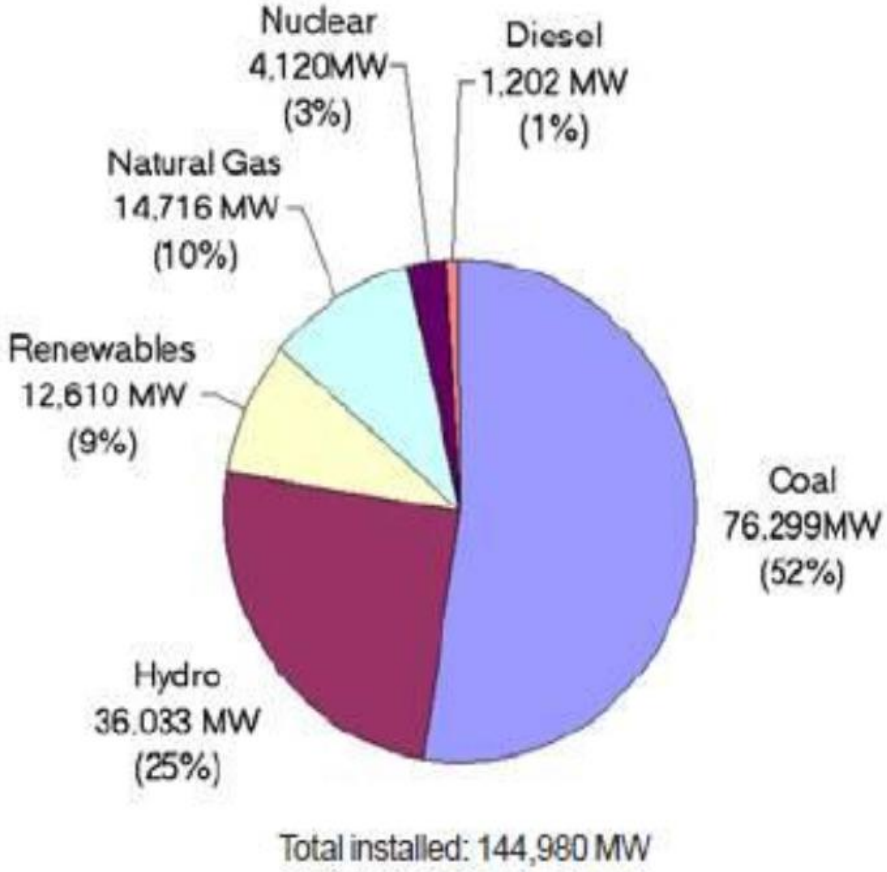
Energy is used in buildings for various purposes: heating and cooling, ventilation, lighting and the preparation of hot sanitary water among them. In residences and commercial buildings, installed equipment and appliances require energy, as do removable devices like mobile phone chargers and portable computers. However, identification of fixed and fluctuating demand for energy rarely appears in a building's consumption metric, as most measurement consider only the total amount consumed by the whole building. Subdivision of energy consumption can be particularly difficult in the cases of electricity, where air-conditioners, appliances, lights, pumps and heating installations all draw electricity and often from the same metering. Natural gas, too, can serve several end uses at once, including heating, cooking, and the provision of sanitary hot water. Given the difficulty in subdividing buildings' energy requirements and the use of different fuel types, most analysis examines energy use in building

as defined by end-use: space heating, cooling, cooking, etc. The split in use of energy will be due to uncertainties and it will vary with different types of building and also with the age and use of the buildings.

Building-related end-uses - heating, cooling, ventilation and the preparation of hot sanitary water - require approximately 75% of a residential building's energy demand. Building codes generally address these drivers of building-related consumption. Only more occasionally, codes cover other end-uses like lighting in service buildings. For service buildings, the share of energy use for other purposes will often be larger and for some types of service buildings it can be more than 50%.

Energy consumption pattern of various types of buildings

Power plant installed capacity in India



Sectorial Consumption of Energy

Table 2
Sectoral Composition of Commercial Energy Consumption in India in 2001 – 2002

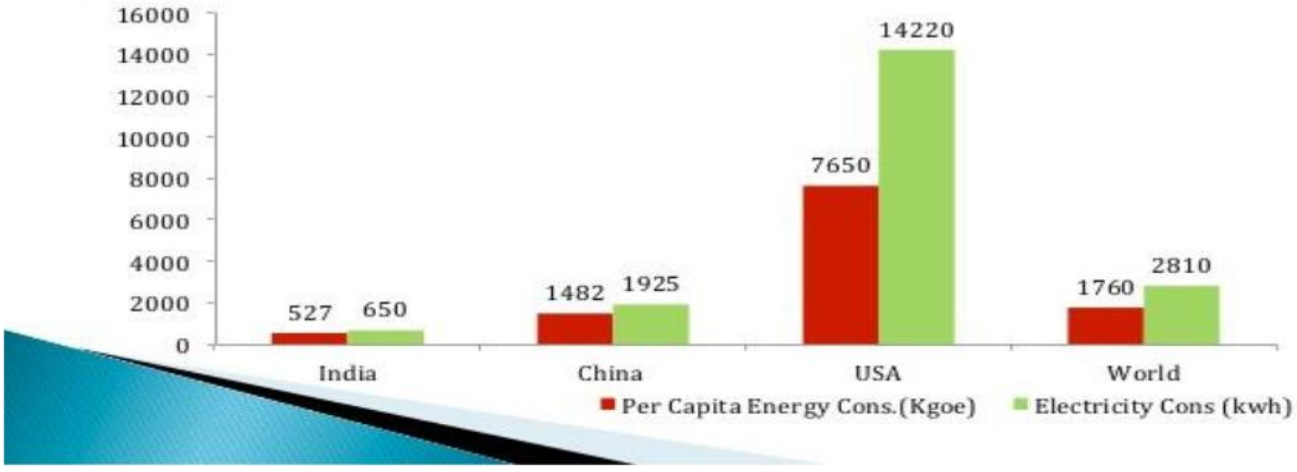
Sector	Commercial Energy consumed as MTOE	%	Sectoral Energy Consumption by fuel % Coal	Natural Gas	Petroleum Products	Electric Power	
Agriculture	14.93	5	0	1.3	9.5	89.2	100
Industry	146.35	49	73.1	2.4	13.6	10.9	100
Transport	65.71	22	0	0	98.5	1.5	100
Residential	29.87	10	0	1.1	71.3	27.6	100
Others	41.81	14	0	33.9	60.9	5.2	100
Total	**298.67**	**100**					

33% of electric power use in agriculture, 39% in industry and 20% residential .

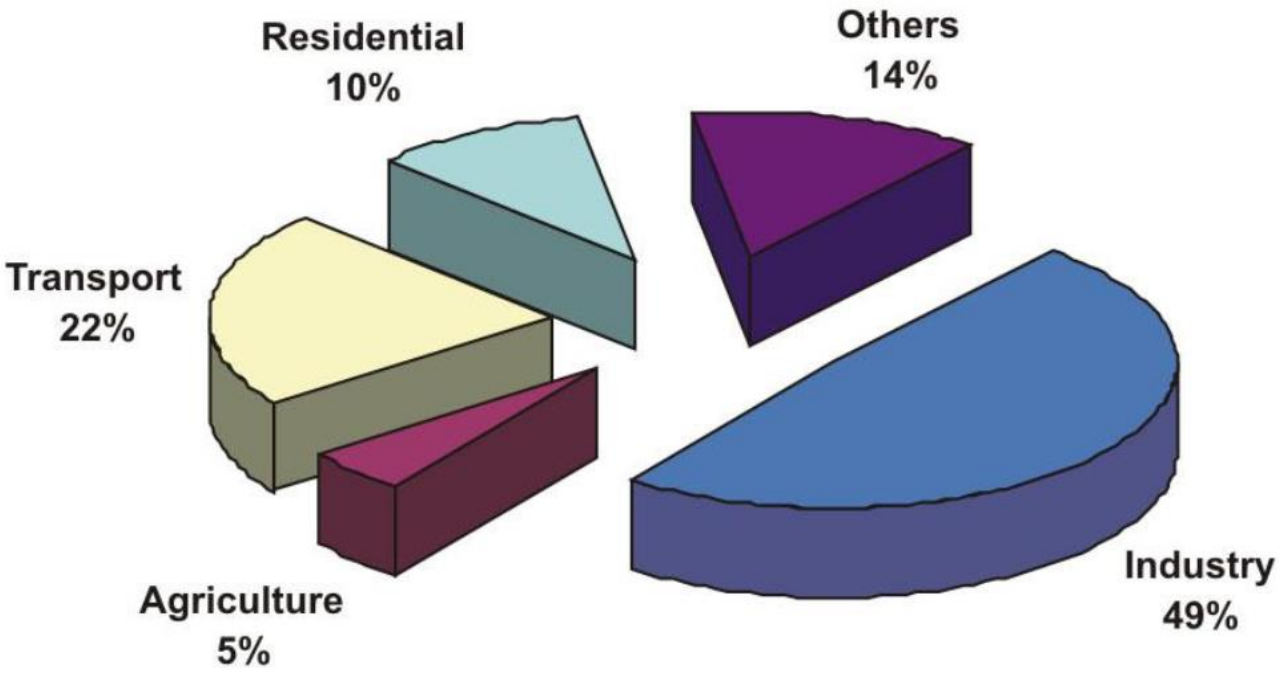
Source : The Energy and Resources Institute (TERI), Delhi [2]

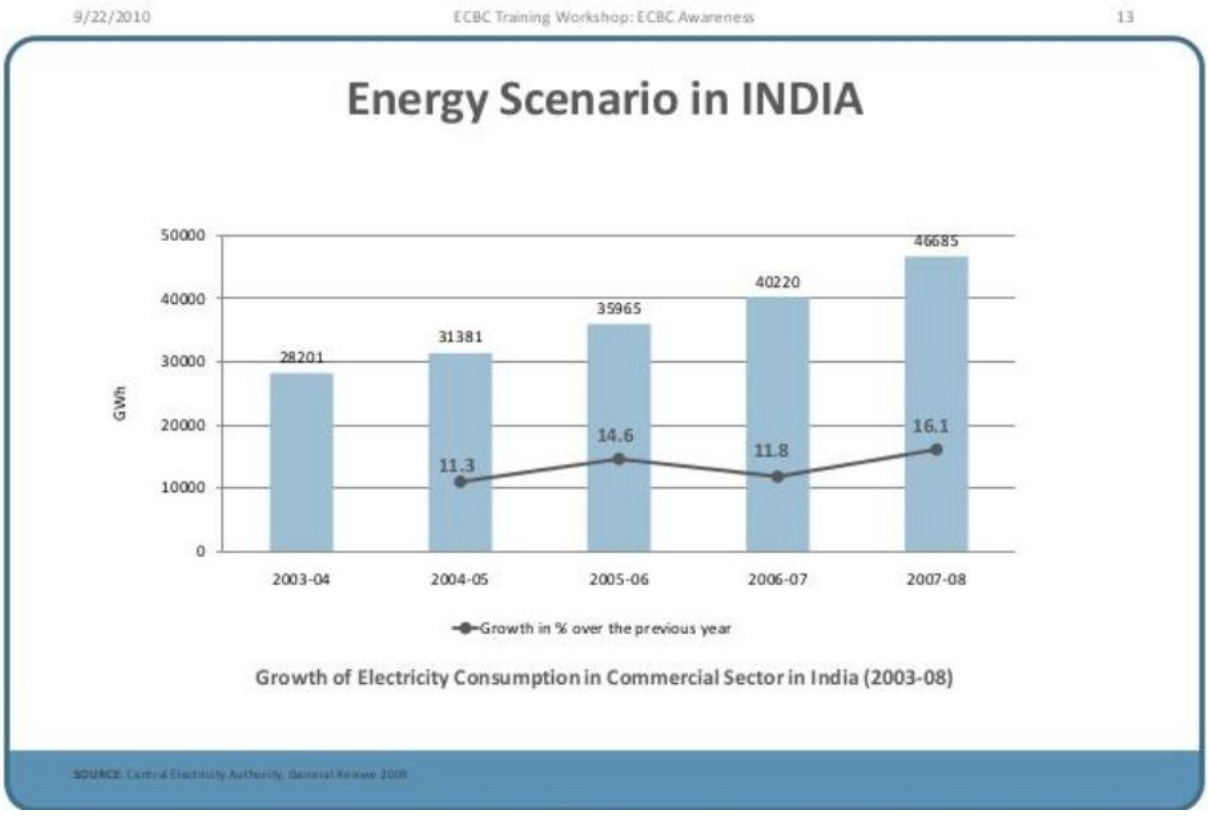
ENERGY USE IN INDIA

- Current share of global energy consumption – 3.5%
- Share to increase to about 10% by 2031
- Per capita energy consumption 1/3rd of world average.
- Consumption growth to meet the development targets
- Providing energy to rural areas
- Efficient use of energy to improve energy intensity



Sectoral Composition of Commercial Energy Consumption





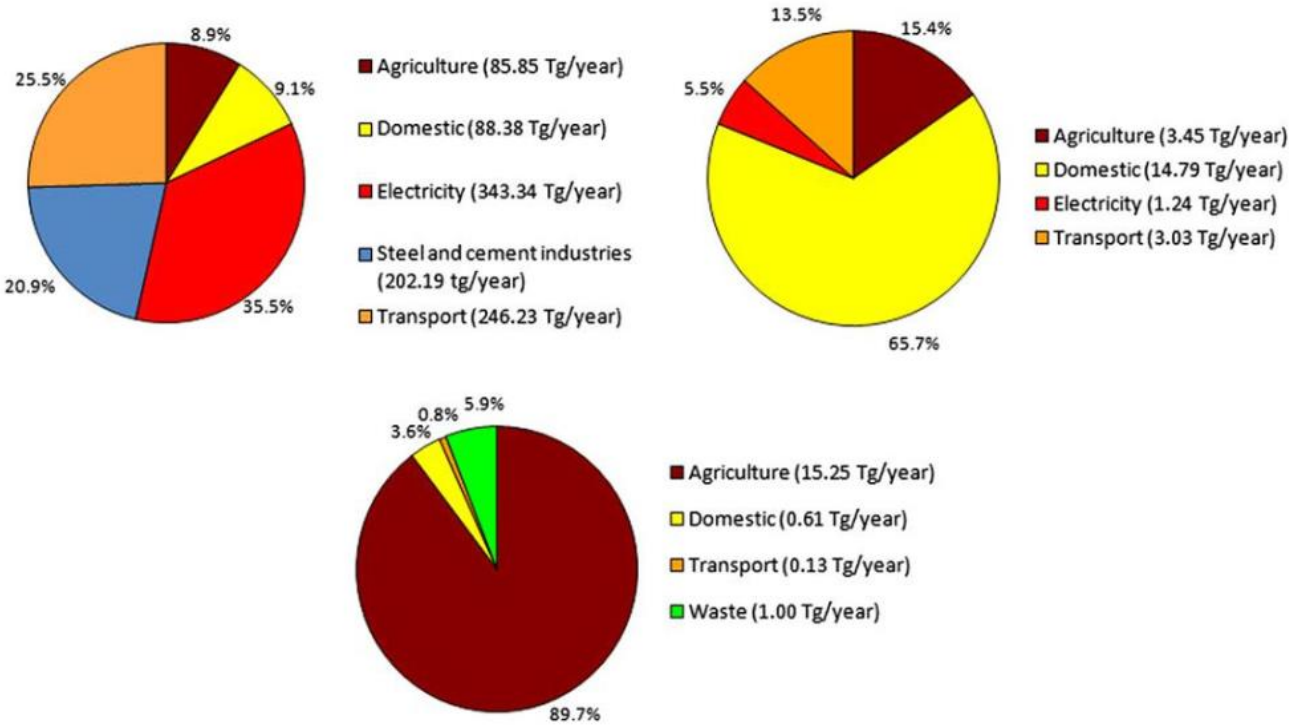


Fig. 8. Sector wise contribution in total Carbon emission (CO_2 = 987.1 Tg/year, CO = 24.7 Tg/year, CH_4 = 17.0 Tg/year) of India.

World final energy consumption by sector

Final energy consumption by sector (%)	1973	2004	Ratio
Industry	39	30	0.76
Transport	25	28	1.14
Other sectors	36	42	1.16

Source: IEA.

Weight of buildings energy consumption

Final energy consumption (%)	Commercial	Residential	Total
USA	18	22	40
UK	11	28	39
EU	11	26	37
Spain	8	15	23
World	7	16	24

Year 2004. Sources: EIA, Eurostat, and BRE.

Energy consumption by end uses in the residential sector

End uses in the residential sector (%)	Spain	UE	USA	UK
Space conditioning	42	68	53	62
Domestic hot water (DHW)	26	14	17	22
Lighting and appliances	32	18	30	16

Year 2003. Source: EIA, IDAE [8] and BRE.

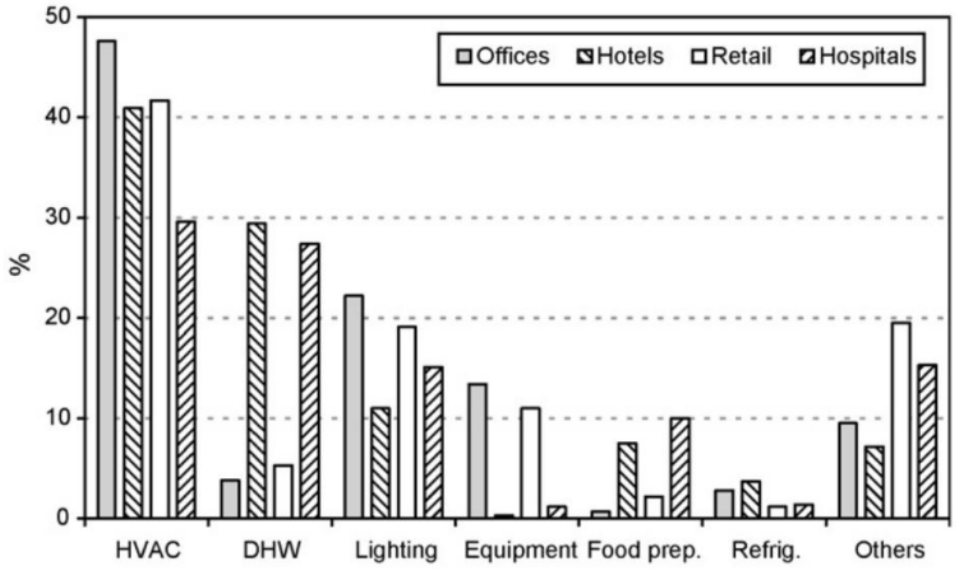


Fig. 5. Consumption by end use for different building types. Source: EIA.

Energy consumption pattern of various types of buildings

Energy use in the commercial sector by building type

Building type	USA (%)	Spain (%)	UK (%)
Retail	32	22	22
Offices	18	33	17
Hotels and restaurants	14	30	16
Schools	13	4	10
Hospitals	9	11	6
Leisure	6	–	6
Others	9	–	23

Year 2003. Sources: EIA, IDAE and BRE.

Factors influencing the energy use in building

Factors include:

1. Building Material
2. Size of the Building
3. A third key factor is the effect of the thermal mass of the external surface of the exterior wall in cutting energy consumption. It is explained in the following chapters by two examples.

Concepts of energy efficient building

Buildings, as they are designed and used today, contribute to seriousenvironmental problems because of excessive consumption of energy andother natural resources. The close connection between energy use in buildings and environmental damage arises because energy intensive solutions sought to construct a building & meet its demands for heating, cooling, ventilation & lighting cause severe depletion of invaluable environmental
resources.

However, buildings can be designed to meet occupant's need for thermaland visual comfort at reduced levels energy & resources consumption. Energy resource efficiency in new constructions can be effected by adopting anintegrated approach to building design. The primary steps in this approachwould be to:

Incorporate solar passive techniques in a building design to minimise load onconventional systems (heating, cooling, ventilation and lighting) Passivesystems provide thermal and visual comfort by using natural energysources and sinks e.g. solar radiation, outside air, sky, wet surfaces, vegetation, internal gains etc. Energy flows in these systems are by natural meanssuch as by radiation, conduction, convection with minimal or no use ofmechanical means. The solar passive systems thus, vary from one climateto the other e.g. in a cold climate an architects' aim would be design abuilding in such a way that solar gains are maximised, but in a hot climatehis primary aim would be to reduce solar gains, maximise natural ventilation and so on.

Design energy-efficient lighting and HVAC systems (heating, ventilation andair-conditioning) Once the passive solar architectural concepts are applied to a design, theload on conventional systems (HVAC and lighting) is reduced. Further, energy conservation is possible by judicious design ofthe artificial lighting and HVAC system using energy efficient equipments, controls and operation strategies.

Use renewable energy systems (solar photovoltaic systems/ solar water heatingsystems) to meet a part of building load The pressure on the earth's non-renewable resources can be alleviated by judicious use of earth's renewableresources i.e. solar energy. Use solar energy for meeting electrical needsfor a building can further reduce consumption of conventional forms ofenergy.

Use low energy materials and methods of construction and reduce transportationenergy An architect also should aim at efficient structural design, reduction of use of high energy building material (glass, steel etc.) and transportation energy and use of low energy buildings materials.

Thus in brief, an energy efficient building balances all aspects of energyuse in a building: lighting, space-conditioning and ventilation, by providingan optimised mix of passive solar design strategies, energy-efficient equipments and renewable sources of energy. Use of materials with lowembodied energy also form a major component in energy-efficient buildingdesign.

Energy efficient buildings in India

There are about 44 energy and resource efficient architectural projects in India". Each project highlights the energy efficiency measures, e.g. passive solar interventions, energy-efficient systems, buildingsmaterials with low embodied energy, adopted by several architects in their respective projects.

The projects have been classified climate-wise. The thermal performanceof a selected number of buildings have also been presented. The incrementalcosts for incorporation of energy efficiency measures to buildings have beenhighlighted wherever such data was available.

Architects can achieve energy efficiency in the buildings they design by studying the macro-and micro-climate of the site, applying bioclimaticarchitectural principles to combat the adverse conditions, and taking advantage of the desirable conditions. Some common design elements that directly or indirectly affect thermal comfort conditions and thereby the energyconsumption in a building are

(a) Landscaping,
(b) Ratio of built form to open spaces,
(c) Location of water bodies,
(d) Orientation,
(e) planform, and
(f) Building envelope and fenestration.

However, in extreme climatic conditions, one cannot achieve comfortableindoor conditions by these design considerations only. There are certaintested and established concepts which, if applied to a design in such climaticconditions, are able to largely satisfy the thermal comfort criteria. These areclassified as advanced passive solar techniques. The two broad categories ofadvanced concepts are,

1. Passive heating concepts (direct gain system,indirect gain system, sunspaces, etc.) and
2. Passive cooling concepts (evaporative cooling, ventilation, wind tower, earth-air tunnel, etc.).

The commonly considered design elements for achieving lower energyconsumption in a building are as follows.

Landscaping

Landscaping is an important element in altering the microclimate of a place.Proper landscaping reduces direct sun from striking and heating up of building surfaces. It prevents reflected light carrying heat into a building from theground or other surfaces. Landscaping creates different airflow patterns andcan be used to direct or divert the wind advantageously by causing a pressuredifference. Additionally, the shade created by trees and the effect of grass andshrubs reduce air temperatures adjoining the building and provideevaporative cooling. Properly designed roof gardens help to reduce heatloads in a building. A study shows that the ambient air

under a tree adjacentto the wall is about 2 °C to 2.5 °C lower than that for unshaded areas, whichreduces heat gain by conduction (www.greenbuilder.com).

Trees are the primary elements of an energy-conserving landscape. Climatic requirements govern the type of trees to be planted. Planting deciduous trees on the southern side of a building is beneficial in a compositeclimate. Deciduous plants such as mulberry or Champa cut off direct sunduring summer, and as these trees shed leaves in winter, they allow the sunto heat the buildings in winter.This landscaping strategy has been adopted to shade the southern side of the RETREAT building of TERI

List of Energy Efficient Buildings in India based on climatic zones.