Introduction to Energy: Need of energy in buildings and its assessment

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%.

In order to succeed in developing a more sustainable society, buildings will need to be continuously improved. Appreciating the importance of energy use in these buildings requires a look at the national energy statistics. These use two categories of energy:

- **Primary energy** − this is essentially energy in its 'raw' form. Examples include crude oil before it is refined and the fuels used to generate electricity: coal, natural gas and nuclear heat.
- **Delivered (or final) energy** − this is the energy that the consumer actually receives (and pays for): refined petrol and diesel, mains electricity, piped natural gas.

The statistics also split energy use into different sectors: the domestic sector − people's homes; the services sector – shops, offices, schools, etc.; transport and, finally, industry.

Energy use is, of course, only the means to provide various energy services. The real task is to provide these at a lower energy and environmental cost. The energy services in buildings include:

- the provision of comfortable homes and working environments
- hot water for washing
- cooking food
- safe chilled food storage
- adequate lighting for homes and offices
- the ability to use electronic equipment for communication and entertainment (and producing and studying material such as this course).

Of the energy use in buildings about two-thirds was used in the domestic sector and about a further 20% in the services sector.

Energy is one of the most important catalysts in wealth generation, economic growth, and social development in all countries. Buildings have a significant share in total energy consumed globally; therefore, they have a profound impact upon the environment. Energy is used in every stage of building life cycle (these stages are choice of locality, architectural design, structural systems and material selection, building construction, usage and maintenance, demolition, reuse-regain-recycle, and waste disposal). According to World Watch Institute data, buildings are responsible for the annual consumption of 40% of the world's energy. Energy consumption of buildings can be reduced significantly in every stage of a building life cycle. This study investigated the energy-efficient methods in building life cycle. In this context, we give information about the life cycle of building and explain energy-efficient guiding principles in life cycle stages. Buildings consume energy at different levels in every stage of life cycle.

Approximately half of all non-renewable resources (water, energy, and raw materials) mankind consumes are used in construction. Contemporary human civilization depends on buildings and what they contain for its continued existence, and yet our planet cannot support the current level of resource consumption associated with them. Construction also has a major impact on the environment in its consumption of energy. For example, building materials occupy a great share of this consumption. The large bulk of materials used consume a great deal of energy for transport. There is a growing concern about energy consumption in buildings and its possible adverse impacts on the environment. These are issues that the building professions in the whole world have to address. Energy consumption is rapidly increasing due to the increase in population and urbanization. Residential energy requirements vary from region to region, depending on climate, dwelling type, and level of development. There is a growing concern about energy consumption in buildings and its possible adverse impacts on the environment. These are issues that the building professions in the whole world have to address.

Buildings consume energy at different levels and different aims in every stage of the life cycle. In an operating phase, a building with at least a 50-year lifespan, energy used for production of materials, transportation, and construction, "at least five times" as is required in the amount of energy use and operating phases. A large part of the energy (35–60%) is used for heating, air-conditioning, ventilation, and artificial lighting at this stage. Energy-efficient approaches that have the potential to significant energy economy, most of the buildings if you live a long time considered more than 50 years. Methods for ensuring energy efficiency in buildings

It is not possible to bring recommendations of solution that can procure energy efficiency for all buildings. As the function, system, position, and importance of a building changes from building to building, the ways of solution providing energy efficiency will also change. Therefore, a conscious approach needs to be developed in order to reach the right solution at the stage of architectural design through enabling necessary data. In the end, the product to be obtained must be aimed to have the quality of being more efficient, in other words, spending less resource within a longer period of time to perform the same action. There are very different applications targeting the decrease of energy consumption of buildings. Considering energy consumption in each phase of structuring is achieved with the analysis of building life cycle.

In this respect, we need to know the life cycle of building. Building life cycle is divided into three main phases such as the

- pre-building phase,

- building phase, and

- post-building phase.

These phases have some processes. Prebuilding phase includes the appropriate site selection, site planning, building form, building plan, and appropriate space organization, building envelope design choosing energy-efficient building materials, energy-efficient landscape design, obtaining raw materials for building material, manufacturing, and transporting them. The building phase includes the construction and usage processes of the building. The post-building phase is the phase following the completion of building usage. In this phase, we have the demolition, recycling, and wipe-out of the building.

The methods applied so as to fulfil the energy efficiency of buildings depending upon life cycle phases.

The prebuilding phase includes the choice of the space where construction is to be built, the design of the building, the choice of building materials, obtaining raw materials for building material, manufacturing, and transporting them. In these processes, the strategies have been explained with significant energy saving in building life cycle such as the appropriate site selection, site planning, building form, building plan and appropriate space organization, the design of building envelope, the choice of building material, landscape design, and benefitting from renewable energy resources in sequence. These strategies are explained below.

Appropriate site selection

The locations of the hemisphere, slope, and aspect are important design parameters. Location of the building determines the microclimate conditions which has very important role in building energy efficiency, as it is important for learning, climatic values such as sun radiation, air temperature, air circulation, and humidity, which effect energy costs.

The site of building and distance between other buildings are one of the most important design parameters, which affect sun radiation amount and air circulation velocity around the buildings. For this reason, the site of the building in the area should be determined to benefit and defend from the renewable energy resources like sun and wind.

In order to provide adequate protection from the prevailing wind and sun, the orientation of buildings on the land needs to be appropriate to the climatic conditions of the region. In cold regions, lower overnight temperatures cause colder, denser air to accumulate in hollows and valleys. Therefore, in cold regions it is advisable to position buildings on hillsides rather than in valleys.

Site planning

In the design of buildings, distance between buildings is an important designing parameter that affects utilization of solar energy, wind direction, and speed concerning artificial environment. In the design process, building should be handled as a whole with its environment. The distances between buildings highly affect the energy performance in the usage phase of building. The fact that a building remains within the shading space of other buildings influences the utilization of solar rays and will raise the consumption of energy. In order to utilize solar radiation, building spaces must not be less than the tallest shade height of other buildings. Besides, the position and distance of other buildings affect the speed and direction of wind on building, and this impacts the energy performance of building.

Orientation of building affects the ratio of the solar radiation gain of building sides, consequently the total solar radiation gain of building. In addition, the side of buildings affects wind amount, consequently, affecting natural ventilation possibility and heat loss amount by convection and air lack. For this reason, according to the necessities of that region, buildings must be oriented for avoid of or benefit from the sun and wind according to the conditions.

As the positioning of buildings as attached to each other would decrease the building envelope/volume rate, declines heat loss and gains through building envelope. In addition, positioning them in the direction of south, southeast, and southwest as an external curve crescent make them utilize solar rays more.

Building form

The shape of building which is a considerable factor affecting heat loss and gain can be defined through geometrical variables making up building such as the proportion of building length to building depth of the building in the plan, building height, type of roof, its gradient, front gradient, and bossages. Heat loss-gain of building may rise and decline depending upon the proportion of the surfaces constituting environment to volume.

Energy performance of building is affected by such factors as its form, volume surface rate and frontal motions. There is a direct relationship between the geometrical shape and energy performance of building. The shape of building is important in areas that have different climate conditions. In cold climate regions, compact forms should be used which minimize the heat loss part. In hot-dry climate regions, compact forms and courtyards should be used which minimize heat gain and helps to provide shaded and cool living spaces. In hot-humid climate region, long and thin forms whose long side oriented to the direction of prevailing wind makes possible maximum cross-ventilation. In mild climates, compact forms, which are flexible more than the forms used in cold climate regions, should be used. Building plan and appropriate space organization

Building plan and shapes should be effective in energy conservation. Therefore, buildings should be formed to ensure minimum heat gain in warm seasons and maximum in cold. Due to simple plan types such as square or rectangle having a reduced surface area, their heat-loss and -gain are also reduced. Smaller buildings, where internal space has been used efficiently, use less energy as they can be heated, cooled, and illuminated more efficiently than larger buildings

According to the results of the research called "Construction and Energy" performed by German Ministry of Research and Technology, the place of space in the organization of plan is more efficient than the orientation of space with respect to energy consumption. The energy requirement of buildings can be reduced by the internal layout of the design. By making the best use of the sun's radiation, the need for heating energy can be reduced. These communal areas require more heating, whereas spaces with a lower heating requirement such as the pantry, bathroom, and toilet can be used as buffer areas, reducing heat transfer to the exterior by placing these in areas of heat-loss. Spaces such as sun rooms, if located on south façades of buildings, also contribute to heating of the building and energy conservation, by storing solar radiation. In the building design, stratification can perform zoning depending on buffer zone, sanitary spaces, noise level, lighting level, and heating need. Therefore, areas with many users and which are used throughout the day should face southerly direction. Thermal zoning and the settlement of indoors can be designed in a way to raise mutual air motion Deep plans and the use of too many dividing elements may restrict air motion in environments.

Building envelope

Building envelope is the components such as wall, ceiling, ground, window, and door which separate building (conditioned space) from outdoor and let heat energy transfer into inside or outside. As an indoor and outdoor reagent, it has a vital impact on energy consumption. While the cost of constructing a building, envelope makes up 15–40 of the total constructional cost, its contribution to life cycle costs especially to energy cost is around 60%. The skin of building performs the role of a filter between indoor and outdoor conditions, to control the intake of air, heat, cold, and light. Building envelope should minimize the heat loss in the winter and the heat gain in the summer.

The physical and structural specifications of building components, such as walls, windows, flooring, and doors, which make up the outer shell of the building, have a significant impact on the energy consumption of the building. The thermal performance, thickness, and color of the materials used in these components play a significant role in regulating the heat loss and gain of the building. The energy-saving features of the building components analyzed are described below. Outer walls: Thermal and massive characteristics of outer walls are related to building material constituting them and the characteristics of building element layers and how they are sorted. The walls that will minimize heat loss and gain are well-isolated massive walls with high heat-storing capacity. The formation of outer surfaces that can get most solar radiation or be protected from radiation in terms of heat gain should be handled depending upon the characteristic of climatic zones. To keep sunlight as much as possible in winter, wall-to-window ratio is desired not to exceed 15% with the use of dark and high-density materials in the parts exposed to the sun.

Roofs.

In commercial and institutional buildings, roofs are generally flat, and the insulation can be resting on the suspending ceiling. In gabled roof construction where the attic is not used, the insulation is generally in the ceiling. The shape, material, gradient, orientation, outer surface colour, and insulating qualities of the roof determine the thermal performance of the buildings. Therefore, roofs need to be designed in such a way to suit the climatic conditions. Thermal insulation qualities of roofs, their gradient and facade should be chosen properly to climatic character, their outer surface colour and stratification order should, however, be chosen taking heat gain and loss into account. In temperate dry and temperate humid climatic zone and cold climatic zones, the well-isolated gradient roofs should be preferred. In hot and dry climate zones, flat roofs should be preferred to reduce the impact of solar radiation; in hot and humid climates that allow air flow, raised or sloping roof should be arranged.

Windows.

Windows affect energy efficiency in buildings via heat loss or gain, natural ventilation, and illumination. The most appropriate direction is south in terms of heat gain, after the east and west side. Large windows reduce the need for artificial lighting while improving daylight. Windows should be designed in the magnitude that is sufficient to provide natural lighting. For example, window magnitude should be at least 15% of the room’s floor area. While taking a decision on the transparency rates in building envelope, in which climatic zone the building is placed should be ascertained in advance. Since protection from solar radiation and wind is the basic purpose in hot and arid climatic zones, small and few windows should be used. In hot and humid climatic zones, by taking necessary precautions, large openings should be used in order to raise indoor air circulations. In cold climatic zones, to minimize the heat losses stemming from windows, again small and few windows should be used. Yet, so as to utilize the beneficial effect of solar radiations, the window openings in the southern front should be kept more than the ones in other fronts. In temperate climatic zones, however, it should be given to openings that would enable sufficient air circulation.

The use of windows also serves a number of essential purposes such as ventilation, natural lighting, and opening to scenery; it does not bring much load on constructional cost. In the climatic zones having cold winters, positioning window openings in the north should not be preferred due to the fact that heat gain from the sun is too little to be considered and air penetrations increase because winter winds usually blow from the north and thus heat losses grow. It is possible to obtain a certain amount of sun gain from the openings placed in the east and west, even if it is less in winter than the southern front. However, since the summer sun comes horizontally in the morning and afternoon hours, it is very difficult to protect these openings and we may face the problem of overheating. The windows looking toward south, however, may utilize solar rays coming horizontally in winter almost the whole day; in summer, they may be easily protected from the rays coming more vertically.

Because of all of these components, southern windows are the systems which can be very commonly used in utilizing sun passively. Yet, compared with wall, due to their weak isolation qualities they are much more open to heat-loss and gain; therefore, it is needed to take precautions for winter and summer. In this case, the application of double-glazing gains a high importance. Night isolation applications, however, are necessary to dismiss the heat losses that may occur after sunset. These isolation elements may be shutter, roller blind, or jalousie fixed either from inside or outside. Or, losses should be reduced through at least bringing curtains strictly down. In summer days, windows may be easily protected by the help of eaves, sunshade, or curtain.

In the front, high performance glass that has the most suitable thermal and light transmittance coefficient for the desired qualities depending on climate, sun direction, and the usage purpose of building should be used. Energy can be efficiently used thanks to isolated joineries, low-E covered glasses, argon or krypton-filled double-glazing and air proof detailing and montage.

Doors.

The position of outer doors should be chosen considering wind effects, heat gain, and losses. In cold climatic zones, windbreak is suggested in order to be protected from the wind effect increasing heat losses. In hot-arid and temperate climatic zones, as wind does not have a restorative impact on comfort, surfaces closed to wind should be preferred.

Floors.

Floorings grounded on soil should be arranged in a way to enable the desired performance in terms of heat and moisture. In cold and temperate climatic zones, well-isolated floorings should be preferred. In warm-humid climatic zones, however, heightened floorings can be preferred since air streams become important. In the volumes getting sunlight, floor laying can be used as a thermal heat store. In floor laying, dark colour materials having a high heat-storing capacity should be preferred. Not laying carpets on floor and leaving it open increase its capacity of heat absorption.

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