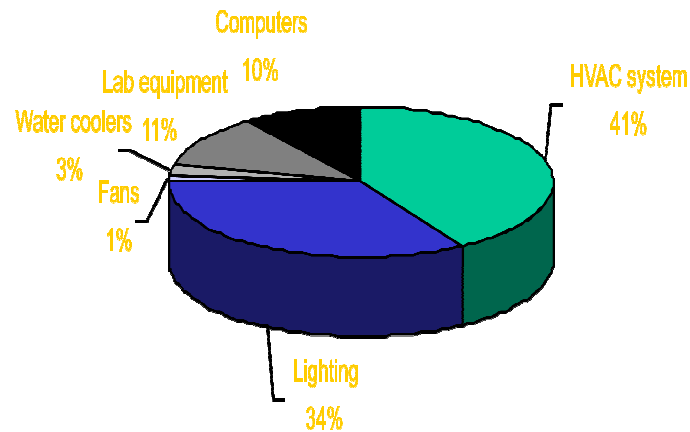


ENERGY IN BUILDINGS

Energy consumption in buildings:



Annual consumption of Construction industry at global scale:

- 40% raw stone, gravel and sand
- 25% wood
- 40% of the energy
- 16 % of water

Green and sustainable buildings:

- Comparatively less dependence on municipal water and electricity supply, hence more attractive options for users, hence a good mean of marketing.
- Improved microclimate and indoor environment and hence improved productivity.
- Trend setting model for the next generation construction industry.
- Encouragement by government: GRIHA is a Government of India's Rating system.
- Building run by efficient systems, sustainable resources and renewable energy.

DESIGN AND DEVELOPMENT OF SUSTAINABLE BUILDINGS:

- Sustainable Site Planning
- Orientation and shading

- Envelope optimization
- Heating, Ventilation and air Condition
- Water and waste water management
- Solid waste management
- Renewable energy utilization

Energy conservation building codes:

What are ECBCs?

- ECBC set minimum energy efficiency standards for design and construction
- ECBC encourage energy efficient design or retrofit of buildings so that
 - It does not constrain the building function, comfort, health, or the productivity of the occupants
 - Has appropriate regard for economic considerations (life cycle costs i.e. construction + energy costs are minimized)

Scope:

- Mandatory Scope Covers commercial buildings
- Applies to New Construction only
- Building components included
 - Building Envelope (Walls, Roofs, Windows)
 - Lighting (Indoor and Outdoor)
 - Heating Ventilation and Air Conditioning (HVAC) System
 - Solar Water Heating and Pumping
 - Electrical Systems (Power Factor, Transformers)

Compliance approaches:

- Component-based (prescriptive), which requires little energy expertise; provides minimum performance requirements; no flexibility
- System-based (trade-off), which allows some flexibility through the balance of some high efficiency components with other lower efficiency components

- Whole building design analysis (performance), which allows flexibility in meeting or exceeding energy efficiency requirements (as compared to a baseline building)

Building envelope design:

ECBC Compliant Design Strategy for a Building			
Heat/Moisture Losses	Walls	Roof	Window
Minimize Conduction Losses	Use insulation with low U-value	Use insulation with low U-value	Use material with low U-factor
Minimize Convection Losses & Moisture Penetration	Reduce air leakage & use vapor barrier	Reduce air leakage & use vapor barrier	Use prefabricated windows and seal the joints between windows and walls.
Minimize Radiation Losses	Use light colored coating with high reflectance	Use light colored coating with high reflectance	Use glazing with low Solar Heat Gain Coefficient (SHGC)

Low-Energy Building Design Guidelines:

Incorporating energy efficiency, renewable energy, and sustainable green design features into all federal buildings has become a top priority in recent years for facilities managers, designers, contracting officers, and others in government buildings procurement. These progressive design strategies have been formalized through Executive Order 13123 (known as *Greening the Government through Efficient Energy Management*), which was issued on June 3, 1999.

The low-energy design process begins when the occupants' needs are assessed and a project budget is established. The proposed building is carefully sited and its programmed spaces are carefully arranged to reduce energy use for heating, cooling, and lighting. Its heating and cooling loads are minimized by designing standard building elements— windows, walls, and roofs—so that they control, collect, and store the sun's energy to optimum advantage. These passive solar design strategies also require that particular attention be paid to building orientation and glazing. Taken together, they form the basis of integrated, whole-building design. Rounding out the whole-building picture is the efficient use of mechanical systems, equipment, and controls. Finally, by incorporating building- integrated photovoltaics into the facility, some conventional building envelope materials can be replaced by energy-producing technologies. For example, photovoltaics can be integrated into window, wall, or roof assemblies, and spandrel glass, skylights, and roof become both part of the building skin and a source of power generation.

For a particular project, the specific energy-saving techniques, strategies, and mechanisms to be deployed will vary greatly, depending on building and space type. Their selection and configuration will also be influenced by:

- Climate
- Internal heat gains from occupants and their activities, lights, and electrical equipment
- Building size and massing
- Illumination (lighting) requirements
- Hours of operation
- Costs for electricity and other energy sources.

Climate

Not just is it hot or cold, but how humid is it? Is it predominantly clear or cloudy, and during what times of the year? Clear winter climates are well matched with spaces that incorporate passive solar heating strategies. In contrast, spaces (and buildings) in clear summer climates generally require a high degree of sun control. Clear climates also make the best use of light shelves—horizontal surfaces that bounce daylight deeper into buildings. Even the site-specific and seasonal nature of the wind needs to be understood if natural ventilation strategies are to be incorporated into a building design.

Internal Heat Gains

The heat gains from building occupants, lights, and electrical equipment can be thought of as the interior climate and should not be generalized. Instead, during the early programming of the project, the heat gains anticipated from these sources should be quantified for the various spaces where they apply. In some cases, such as in storage buildings and other areas with relatively few occupants and limited electrical equipment, these heat gains will be minor. In other instances, the presence of intensive and enduring internal heat gains may be a determining factor in HVAC system design. Examples of intensive and enduring influences include activitybased gains, such as those produced by cafeterias and laundry facilities (where increased humidity is also a factor), and technological or industrial gains, such as the heat produced by mainframe computers or heavy machinery. These factors should be identified early on, and appropriate design strategies investigated (such as heat recovery or using a closed-loop heat pump system).

Building Size and Massing

In a low-energy building, both the indoor and outdoor climates exert a powerful influence on all aspects of building design. Sometimes, they complement one another, such as the case of a building with a lot of internal heat gains sited in a very cold climate. At other times, however, the two climates are antagonistic, such as when there are a lot of internal heat gains in a very hot climate. Understanding the implications of these factors is fundamental to determining appropriate low-energy design strategies for a particular building project.

Under hot/hot conditions, buildings with large footprints and a large amount of floor space far from the exterior of the building will require heat removal in the interior zones (generally by mechanical cooling) all or much of year.

The other basic planning approach is to position all spaces that can benefit from connection to the outdoors in proximity to exterior walls. To achieve this, buildings become much narrower, with a maximum width of about 70 feet. Such an approach to building massing must, by necessity, be introduced very early in the design process. Also, recognize that not all spaces need or want to be exposed to the exterior, including many areas of complex building types like hospitals and courthouses. These spaces often function better as interior placements within a wider and more compact building form.

Lighting Requirements

The lighting needs of a building's various spaces need to be identified, both quantitatively and qualitatively, as part of the environmental programming conducted early in the project. Many spaces, including lobbies and circulation areas, require general ambient lighting at relatively low foot-candle levels (10 foot-candles or less). Such spaces are ideal candidates for daylighting. In contrast, some spaces are used for demanding tasks that require high light levels (50 foot-candles or more) and a glare-free environment. Here the design team's attention may shift from daylighting to a very efficient electrical lighting system with integrated occupancy sensors and other controls.

Hours of Operation

Typically, on a per-square-foot basis, the most energy-intensive Federal building types are those in continuous use, such as hospitals and border stations. In these buildings, the balance of heating and heat removal (cooling) may be altered dramatically from that of an office building with typical work hours. For example, the around-the-clock generation of heat by lights, people, and equipment will greatly reduce the amount of heating energy used and may even warrant a change in the heating system. Intensive building use also increases the need for well-controlled, high-efficiency lighting systems. Hours of use can also enhance the cost effectiveness of low-energy design strategies, such as daylighting in a border station or weather station.

In contrast, buildings scheduled for operations during abbreviated hours (including seasonal occupancy facilities, like some visitor centers), should be designed with limited use clearly in mind.

Energy Costs

The cost for energy, particularly electrical energy, for most non-residential buildings is a critical factor in determining which design strategies will not only conserve energy, but will also be cost effective. In most locations in the United

States, electricity is three to four times more expensive than natural gas per Btu. This disparity can, at times, be capitalized upon by introducing design strategies that affect a trade-off in energy use. For example, increasing the glass area and the commensurate daylight entry can save expensive electrical use but, at the same time, occasion the purchase of additional (but relatively lowcost) heating energy. However, such an example should not be misconstrued as indicating that daylighting requires an excessive amount of glass, as that is just not the case. Daylighting primarily requires placing the glass carefully and selecting the appropriate glazing.

Utility deregulation imposes an uncertainty on future electrical and other energy prices. To the greatest extent possible, the life-cycle benefits of various design strategies should be investigated for the range of energy-cost scenarios deemed plausible.

Regulation of energy efficiency in new buildings:

Building envelope

The building envelope is a term for the parts of the building which surround the heated and cooled parts of the building. This includes external walls, floors or ground deck, roofs or constructions towards unheated ceilings, windows and doors. If a cellar is heated then the cellar walls and the cellar floor are part of the building envelope. If it is unheated, the building shell includes the floor between the ground floor and the cellar. The building envelope may also address heat loss through foundations or other thermal bridges. Requirements for energy efficiency in external parts of the building, the building envelope, are generally set based on resistance to heat transparency through a unit of the construction, R-values, or a value for the heat transparency through a unit by a specific temperature, a U-factor or a U-value. In cold climates, low U-values or high R-values prevent heat from escaping from buildings, and in hot climates they prevent heat from entering buildings. U-values or U-factors will typically be given in $\text{W/m}^2 \text{ per } ^\circ\text{C}$ or as $\text{Btu/ft}^2 \text{ per } ^\circ\text{F}$.

HVAC systems

HVAC systems maintain a building's comfortable indoor climate through Heating, Ventilation and Air Conditioning (Cooling). These systems profoundly influence energy consumption in buildings. Without heating, cooling and ventilation systems there would be no energy consumption in the building, since it would be totally dependent on outdoor conditions. There is an inverse correlation between the efficiency of the building and the need for HVAC systems: highly efficient building envelopes reduce the need for heating and cooling systems. Good and intelligent designed buildings can reduce or even avoid the need for heating and cooling and reduce the need for ventilation.

Efficiency improvements in HVAC systems can lead to substantial savings, but these savings will also depend on the efficiency of the building in general. If, for instance, energy efficiency is improved in a heating boiler or an air-conditioner, total savings will depend on the total need for heating or cooling in the building. Higher requirements for the building envelope might reduce the potential for savings in HVAC systems. Finally the HVAC systems need to be in a good balance with the buildings in general and they need to be of a proper size which fits with the actual heating, cooling and ventilation needs.

Renewable Energy

The use of local sources of renewable energy can be either passive or active. In passive systems the renewable energy is used to avoid the need for heating or cooling while the active systems will transform the energy from for instance the sun or the wind into electricity, heat or cooled energy carriers from which energy is used, as if it came from a non renewable HVAC system.

With a decreasing energy demand in buildings these sources become an important part of the energy performance of the buildings and the more advanced standards include these sources.

Requirements for energy efficiency in buildings and the calculation of energy performance can both address integrated renewable energy systems. These requirements can either be set for the renewable energy sources themselves – for example, in a demand for solar heating of sanitary water, as in the case for Spain - or as part of an overall energy performance (see below), where the demands are set for the maximum delivered energy.

Installed equipment

Installed systems other than HVAC systems can influence a building's energy performance in two different ways: through their own energy demand and through their production of waste heat which can

result in increased cooling loads or decreased heating loads. Given their connection with buildings, some appliances fall under the auspice of building energy efficiency requirements in building codes and appear in the calculation of energy efficiency performance of buildings.

Some equipment and electrical appliances have more loose connection to the building and can more or less simply be removed or exchanged without interfering actively with the building itself. Other IEA studies examine the efficiency of these appliances.

Zoning of buildings

Zoning of a building means that the building is divided up into separate areas, each with the potential for uniquely-calculated requirements for energy efficiency and indoor climate. There might be transfers of energy from one zone to another, if there are differences in the indoor temperatures. Zoning can be needed for passive solar conditions, for building ultra low energy consumption and for complex buildings that have multiple functions, to ensure that suitable indoor climatic conditions are obtained in different parts of the building.

Integrated design

Integrated design is a term used for a process where all the elements described above are used to reduce the energy consumption in a building.³⁴ In this process actions are taken to reduce the energy consumption as well through insulation or efficiency as through the design of the buildings and the HVAC systems. Passive use of renewable energy and other natural sources is an integrated part of the design and development process and there is an interactive process between the design of building and systems.

Integrated design requires more emphasis on energy efficiency and systems in the early planning phase than traditional design and it is difficult to regulate through building codes and energy efficiency standards, but the most advanced standards or energy performance calculation includes options for integrated design. Some examples where the integrated design process is used are described later.

Top 20 No- or Low-Cost Green Building Strategies:

Energy

1. ORIENT BUILDING TO MAXIMIZE NATURAL DAYLIGHTING

Description: : Natural daylighting is usually available to the east, south, and west facades.

2. PLACE WINDOWS TO PROVIDE GOOD NATURAL VENTILATION

Description: Natural ventilation systems take advantage of prevailing winds and thermal convection to ventilate living spaces.

3. SELECT A LIGHT-COLORED “COOL ROOF”

Description: Dark roofing materials absorb heat, making the house warmer in summer months, whereas light colored roofing reflects heat away from the building.

4. PROVIDE OVERHANGS ON SOUTH-FACING WINDOWS

Description: Overhangs or screens on south-facing windows are one component of a natural cooling system.

5. INSTALL WHOLE-HOUSE FANS OR CEILING FANS

Description: Whole-house and ceiling fans improve interior comfort by circulating cold and warm air. They can be adjusted to either draw warm air upward during summer months or push it downward during the winter.

6. ELIMINATE AIR CONDITIONING

Description: After the refrigerator, air conditioning is the second biggest consumer of electricity in an average household.

7. PROVIDE COMBINED-HYDRONIC HEATING

Description: Combined hydronic heating uses hot water stored in the water heater to operate radiators typically installed in baseboards.

8. INSTALL FLUORESCENT LIGHTS WITH ELECTRONIC BALLASTS

Description: Interior fluorescent bulbs and fixtures produce light quantity and quality that is comparable to incandescents, while expending less energy. Electronic ballasts also improve efficiency and reduce flickering.

9. INSTALL HIGH R-VALUE INSULATION

Description: Insulation provides a continuous thermal barrier to minimize heat flow through the walls, ceiling and floor. The higher the R-value, the greater is the material's ability to insulate.

10. SELECT ENERGY STAR APPLIANCES

Description: Refrigerators and freezers are among the largest users of electricity in most homes. They can account for up to 25% of household energy use.

Energy Star appliances use 10-15% less energy and water than standard models.

Water

11. DESIGN WATER-EFFICIENT LANDSCAPES

Description: Low-water landscape designs (such as xeriscape) reduce water use by emphasizing native and/or drought tolerant plants, eliminating turf areas, and minimizing maintenance. Efficient irrigation systems, such as drip and micro irrigation, place the correct amount of water directly at the base of each plant, thus reducing water use and waste from overwatering.

12. INSTALL WATER-EFFICIENT TOILETS AND FIXTURES

Description: New toilets use 1.6 gallons per flush compared with old toilets that require 5-7 gallons per flush. Flow reducers fit into the aerator at the tip of the faucet and reduce the rate of water flow through the faucet. Low-flow showerheads replace standard showerheads.

13. USE PERMEABLE PAVING MATERIALS

Description: Permeable paving allows stormwater to percolate into the soil.

Materials

14. USE 30% - 50% FLYASH IN CONCRETE

Description: Flyash is a byproduct of coal burning power plants and can be an inexpensive substitute for 15% -40% of the Portland cement used in concrete.

15. USE ENGINEERED WOOD FOR HEADERS, JOISTS, AND SHEATHING

Description: Solid sawn lumber in sizes of 2X10 or greater typically comes from old growth forests. Engineered lumber products, however, come from small diameter and fast growing plantation trees. 2X10 and larger dimensional lumber is typically used for floor and ceiling joists and some seismic applications. Large size lumber can be replaced with engineered lumber (microlam, paralam, gluelam) in most applications unless required by seismic codes. Solid sawn 4X6s are often used for headers when smaller dimension lumber would suffice, such as double 2X6s, unless solid 4X6s are required by seismic codes. Wood I-Joists are an alternative to 2X6s or 2X8s used for floor and roof joists.

16. USE RECYCLED-CONTENT INSULATION, DRYWALL, AND CARPET

Description: Recycled-content insulation, drywall, and carpet are made from recycled paper, recycled plastic and glass bottles, recycled wool or recycled cotton.

They don't differ in appearance or performance and the prices are comparable to conventional products.

Indoor air quality

17. USE LOW- OR NO-VOC PAINT

Description: No-VOC paint does not emit odors related to volatile organic compounds (VOCs). Organic chemicals are widely used as ingredients in household products like paint, adhesives, cleaning supplies, etc. No-VOC paint is used exactly like conventional paint. No-VOC paints are most suitable for indoor use.

18. USE FORMALDEHYDE-FREE OR FULLY SEALED MATERIALS FOR CABINETS AND COUNTERS

Description: Particleboard typically contains formaldehyde, which can offgas for 10-15 years. EPA ranks formaldehyde as a probable human carcinogen. Exposure can cause eye, nose and throat irritation, skin rashes, headaches, nosebleeds and nausea.

19. VENT RANGEHOOD TO THE OUTSIDE

Description: Steam, gases, smoke and other combustion by-products (such as unburned hydrocarbons) can result from cooking. Stovetop range hoods expel these by-products to the outside.

20. INSTALL CARBON MONOXIDE DETECTOR

Description: Carbon monoxide detectors monitor the level of this gas in individual dwelling units.