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Building Energy Conservation and Green Architecture “Zero Net Energy Building”

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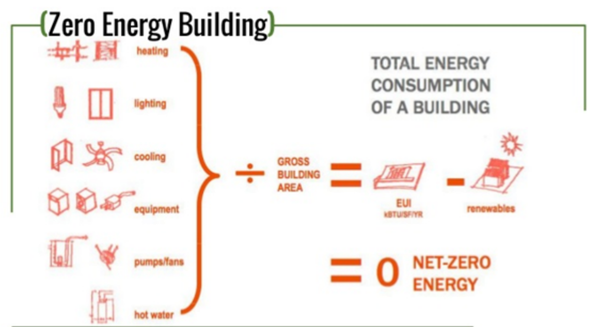
Abstract—*A building known as a zero net energy (ZNE) building, net zero energy building (NZEB), or net zero building, is a structure with zero net energy consumption which means that the total amount of energy consumed by the building on an annual basis is approximately equal to the amount of renewable energy created within the premises. This category of building tends have no greenhouse effect in the atmosphere. The wording “Net” emphasizes the energy exchange between the building and the energy infrastructure. By the building-grid interaction, the Net ZEBs become an active part of the renewable energy infrastructure. Zero net energy (ZNE) has massive potential to transform the way buildings use energy. This ultra-efficiency goal is one that owners can define, design teams can reach for and occupants desire. An increasing number of buildings are meeting this standard, raising confidence that a ZNE goal is realistic given current building technologies and design approaches.*

This paper deals with net zero energy building, its design and construction, comparison with green building and their pros and cons.

1. INTRODUCTION

Buildings that produce a surplus of energy over the year may be called “energy-plus-buildings” and buildings that consume slightly more energy than they produce are called “near-zero energy buildings” or “ultra-low energy houses. A building called zero energy is one that consumes almost zero energy from the grid, because it can produce its own required energy. Generally the sum amount of the energy utilized by these building on a on a yearly basis is all about the same amount of the renewable energy generated on the location. Being zero-net energy though does not mean that a building is no longer responsible for carbon emission, due to unavailability of the renewable energy resources at certain times of the year, usage of power form the grid makes a zero-energy building emit greenhouse gases. When a building can eventually generates as much energy as it needs, it will be grid independent successfully, and it will no longer be responsible for the global warming.



(slideshare.net)

These buildings consequently contribute less overall greenhouse gas to the atmosphere than similar non ZNE building. They do at times consume non-renewable energy and produce greenhouse gases but at other times reduce energy consumption and greenhouse gas production elsewhere by the same amount. Traditional buildings consume 40% of the total fossil fuel energy in the US and European Union and are significant contributors of greenhouse gasses. The zero net energy consumption principle is viewed as a means to reduce carbon emissions and reduce dependence on fossil fuels and although zero-energy building remain uncommon even in developed countries, they are gaining importance and popularity. The zero-energy goal is becoming more practical as the costs of alternative energy technologies decrease and the cost of traditional fossil fuels increase. The development of modern zero-energy buildings became possible not only through the progress made in new energy and construction technologies and techniques, but it has also been significantly improved by academic research, which collects precise energy performance data on traditional and experimental buildings and provides performance parameters for advanced computer models to predict the efficacy of engineering designs. Zero-energy buildings can be part of a smart grid. The zero net concept is applicable to a wide range of resources due to many options for producing and conserving resources in buildings (e.g. energy, water, waste). Energy is the first resource is to be targeted because it is highly managed, expected to continually become more efficient, and the ability to integrity and transparency.

2. CODES AND POLICIES OF ZERO-NET ENERGY

Policies and programs can dramatically change the landscape for Zero Net Energy (ZNE) buildings. There is burgeoning market interest in ZNE, and policies and programs can foster and grow that interest through leadership, direct support, and the reduction of risks and uncertainties. Cities and states are leading the way, accompanied by communities or district-scale efforts.

ZNE is still a relatively new movement; only a small percentage of current building construction has a goal of ZNE. However efforts are increasing, with a doubling in the number of commercial ZNE buildings over the last two years. ZNE homes and buildings have been designed and constructed by a growing number of design teams and builders and are spread throughout a number of climate zones and political jurisdiction, including 36 states in the U.S. and a number of Canadian provinces.

ZNE buildings have now passed the "proof of concept" stage, with both more ZNE buildings being constructed as well as larger and more complex buildings. The question now is how to garner the significant carbon benefits of rapidly increasing the number of ZNE homes and buildings through policies and programs that target ZNE.

States and local government are leading the way. Several schools and public buildings have been identified in early policies for ZNE. Other policies and/or programs are being developed to bring ZNE to scale. Utilities and program administrators have also operated successful ZNE pilots in at least two states, with pilots just getting underway in several other jurisdictions. Even building codes are at the early stages of considering the changes that could be better support ZNE in the future, with leading efforts including a focus on stretch codes and establishing energy targets for codes.

The policy and programs depicts many of the best options for advancing ZNE buildings and districts. Almost all of these ZNE policies follow from broader climate or energy policies enacted state legislatures, governors, mayors and city councils.

3. CERTIFICATIONS

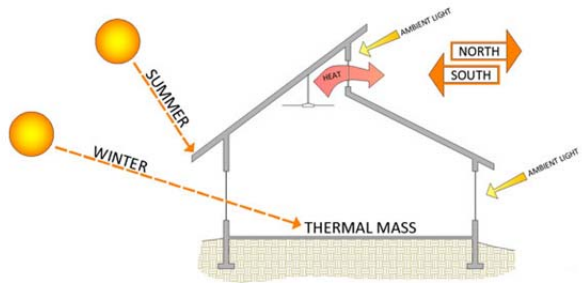
Many green building certification programs do not require a building to have net zero energy use, only to reduce energy use a few percentage points below the minimum required by law. Green globes involves check lists that are measurement tools, not design tools. Inexperienced designers or architects may cherry-pick points to meet a target certification level, even though these points may not be the best design choices for a specific building or climate. In November 2011, the International Living Future Institute developed the Net Zero Energy Building Certification. Designed as part of the Living Building Challenge, Net Energy Building Certification is simple, cost-effective and critical for integrity and transparency.

4. DESIGN AND CONSTRUCTION

Standard House Condition for ZNE (pininterest.com)

The most cost-effective steps towards a reduction in a building's energy consumption usually occur during the design process. To achieve the efficient energy use, Zero Energy Design departs significantly from conventional constructional practice. Successful zero energy building designers typically combine time tested passive solar, or artificial conditioning, principles that work with the on-site assets. Sunlight and solar heat, prevailing breezes, and the cool of the earth below a building, can provide daylighting and stable indoor temperatures with minimum mechanical means, ZEBs are normally optimized to use passive solar heat gain and shading, combined with thermal mass to stabilize diurnal temperature variations throughout the day, and in most climates are super insulated. All the technologies needed to create zero energy building are available of the shelf today.

Sophisticated 3D building energy simulations tools are available to model how a building will perform with a range of design variables such as building orientation (relative to daily and seasonal position of the sun), window and door type and placement, overhang depth, insulation type and values of the building elements, air tightness (weatherization), the efficiency of heating, heating and cooling, lighting and other equipment, as well as local climate. These simulations help the designers predict how the building will perform before it is built, and enable them to model the economic and financial implications on building cost benefit analysis, or even more appropriate- life cycle assessment.



Zero energy buildings are built with significant energy-saving features. The heating and cooling loads are lowered by using high-efficiency equipment, added insulation, high-efficiency window, natural ventilation, and other techniques. These features vary depending on climate zones in which the construction occurs. Water heating loads can be lowered by using water conservation fixtures, heating recovery units on waste water, and by using solar water heating, high-efficiency water heating equipment. In addition, daylighting with skylights or solar-tubes can provide 100% of daytime illumination within the home. Night-time illumination is typically done with fluorescent and LED lighting that use 1/3 less power than incandescent lights, without adding unwanted heat. And miscellaneous electric loads can be lessened by choosing efficient appliances and minimum phantom loads or standby power. Other techniques to reach to reach the net zero (dependent on climate) are earth sheltering buildings principles, superinsulation walls using straw-bale construction, Vitruvian built pre-fabricated building panels and roof elements plus exterior landscaping for seasonal shading.

Zero energy buildings are often designed to make dual use of energy including white goods; for example, using refrigerator exhaust to heat domestic water, ventilation air and shower drain heat exchangers, office machines and computer servers, and body heat to heat the building. These buildings make use of heat energy that conventional buildings may exhaust outside. They may use heat recovery ventilation, hot water heat recycling, combined heat and power, and absorption chiller units.

5. ZERO ENERGY BUILDING VERSUS GREEN BUILDING

The goal of green building and sustainable architecture is to use resources more efficiently and reduce a building's negative impact on the environment. Zero Energy Buildings achieve one key green building goal of completely or very significantly reducing energy use and greenhouse gas for the life of the building. Zero energy buildings may or may not be considered "green" in all areas, such as reducing waste, using recycled building material, etc. However zero energy or net zero buildings do tend to have a much lower ecological impact over the life of the building as compared with other "green" buildings that required imported and/or fossil fuel to be habitable and meet the needs of occupants.

Because of the design challenges and sensitivity to a site that are required to efficiently meet the energy needs of a building and occupants with renewable energy (solar, water, wind, geothermal etc.) designers must apply holistic principles, and take advantage of the free naturally occurring assets available, such as passive solar orientation, natural ventilation, daylighting, thermal mass, and night time cooling.

6. ADVANTAGES

- Isolation for building owners from future energy price increase.
- Increased comfort due to more-uniform interior temperatures(this can be demonstrated with comparative isotherm maps)
- Reduced requirement for energy austerity.
- Reduced total cost of ownership due to improved energy efficiency.
- Reduced total net monthly cost of living.
- Reduced risks of loss from grid blackouts.
- Improved reliability- photovoltaic systems have 25 year warranties and seldom fail during weather problems- the 1982 photovoltaic systems on the Walt Disney World EPCOT Energy Pavilion are still working fine today, after going through three recent hurricanes.
- Extra cost is minimized for new construction compared to an afterthought retrofit.
- Higher resale value as potential owners demand more ZEBs than available supply.
- The value of a ZEB building relative to similar conventional building should increase every time energy costs increase.
- Future legislative restrictions, and carbon emission taxes/penalties may force expensive retrofits to inefficient buildings.

7. DISADVANTAGES

- Initial costs can be higher- effort required to understand, apply, and qualify for ZEB subsidies, if they exist.
- Very few designers or builders have the necessary skills or experience to build ZEBs.
- Possible declines in future utility company renewable energy costs may lessen the value of the capital invested energy efficiency.
- New photovoltaic solar cells equipment technology price has been falling at roughly 17% per year – it will lessen the value of capital invested in a solar electric generating system- Current subsidies will be phased out as photovoltaic mass production lowers future price.
- Challenge to recover higher initial costs on resale of the building, but new energy rating systems are being introduced gradually.

- While the individual house may use an average of the net zero energy over a year, it may demand energy at the time when peak demand for the grid occurs. In such a case, the capacity if the grid must still provide electricity to all loads. Therefore, a ZEB may not reduce the required power plant capacity.
- Without an optimised thermal envelope the embodied energy, heating and cooling energy and resource usage is higher than needed.
- ZEB by definition do not mandatory minimum heating and cooling performance level thus allowing oversized renewable energy systems to fill the energy gap.
- Solar energy capture using the house envelope only works in the location unobstructed from the sun. The solar energy capture cannot be optimized in north (for northern hemisphere, or south for southern hemisphere) facing shade, or wooded surroundings.

8. FIVE COMPONENTS OF ZERO ENERGY BUILDING

Unfortunately, there is not a recipe for constructing a net zero energy building, but these guidelines provide a fundamental basis of how net zero energy is achieved through smart design and innovative technologies.

Alternative energy source

Alternative energy source can come from a variety of sources: solar, wind, geothermal, and biomass. These renewable sources can be harnessed in a variety of ways to provide power, heating and cooling to a building and lower supplemental consumption by traditional grid utilities. The most influential factor in achieving net zero energy in a building is choosing what type and how much alternative energy will be used. Simply put, the alternative energy source should be chosen based on the natural resources offered by the particular region of the world building site is located. A marine or coastal building site might consider wind while a tropical site might consider solar, and inland moderate site may want to explore the local geothermal resources. There are by no means strict guidelines for choosing a source but offer a logical basis of how to choose which source a feasibility analysis should be performed on.

In addition to an alternative source of energy, other sustainable construction design, technologies and components must be used in order to further lower a building's demand to traditional grid utilities.

Passive solar design

On aspect of building design that has been around for hundreds of years but is very under-considered is how the building will behave according to the sun. Solar gain is responsible for the heat gain that can drive the costs of cooling a building through the roof. On the other hand, sun offers valuable natural light, and solar gain in the winter can help to heat the building's ability to naturally collect, store and distribute energy as needed according to a building site's particular climate.

Paying close attention to the building's orientation on the site, and the window and door placement is essential to passive solar design. In addition, it is important to use components of a high performance building envelope, further reducing energy loads to create a net zero building.

High performance building envelope

Today, many building materials and technologies are designed to contribute to a building's ability to lower heating and cooling loads. The concept of super-insulation is to make a building as air-tight as possible. This can be done by adding multiple high-performance insulations to a traditional structure, or by using penalized or site casted wall systems that eliminate thermal bridging while offering sound structural performance. These non-traditional wall structural systems are structural insulated panels (SIPs) and insulated concrete forms (ICFs). Unfortunately, these panels cannot alone be responsible for creating a super-insulated envelope as windows and doors will likely be present on every side of the building. The highest whole wall R-value is achieved by using SIPs and ICFs in combination with super-insulated doors and windows.

Lighting and daylighting

In commercial buildings, only one energy load is more demanding than heating and cooling individually. That is the energy consumption by lightning. In recent years, lighting products and systems have improved significantly to contribute to lower demands. Of course, using no artificial lighting at all is the most beneficial to lowering consumption. A typical net zero energy building will effectively allow daylight to penetrate deep into highly occupied spaces, and employ a high-tech sensored lighting system that adjusts artificial lighting output based on the amount of daylight present. In addition, occupancy sensors can be used for areas that do no constantly need to be lit. of course, the artificial light source itself can draw less power when CFL and LED bulbs are used.

Low Consumption Technology / Appliances

Oher than lighting, additional electrical consumption comes from appliances and office equipment. Fortunately, many manufacturers across many industries have sustainable initiatives that focus on lowering the power consumed by their products. Many rating systems such as the U.S. Government's Energy Star program make it simple for consumers to choose the right products that will help to achieve a net zero energy goals.

9. THE FIRST ZERO ENERGY BUILDING IN INDIA: THE INDIRA PARYAVARAN BHAVAN, NEW DELHI

The Indira Paryavaran Bhavan

- Its India’s first zero net energy building that has been constructed with adoption of solar passive design and energy-efficient building materials.
- Functional since a year, a tour of the Indira Paryavaran Bhavan, a building under the Central Government, was organised by The Energy and Resource Institute (TERI) and the Association for Development and Research of Sustainable Habitats on some occasional days. It aimed at reinforcing the need for more such buildings across the country.
- Speaking about the energy efficiency of the building, TERI (Sustainable Habitat Division) director Mili Majumdar said: “The Indira Paryavaran Bhavan is one of the first building in India to have deployed energy efficiency and renewable energy technologies at a large scale. It is one of the exemplary projects to be rated under Green Rating for Integral Habitat Assessment (GRIHA) and has set standards that be emulated by upcoming buildings in the region.”

  The building boasts an earthquake-resistant structure with the total plinth area of 31,488 sq. m. It covers only 30 % of the total area, while more than 50% area outside the building is a soft area with plantation and grass. The building has a robotic parking system in the basement that can accommodate 330 cars. Thin-client networking system has been provided instead of conventional desktop computers to minimise energy consumption.

“Building have an enormous impact on environment, human health and economy. The energy used to heat and power our buildings leads to the consumption of large amount of energy, mainly from burning of fossil fuels, oil, natural gases and coal, which generates significant amount of carbon monoxide and carbo dioxide, the most widespread greenhouse gases. The successful adaptation of green building strategies can maximise both the economic and environmental performance of buildings” added Mr. Majumdar.

The building has received GRIHA 5-star (provisional) rating for the following features:

1. The design allows for 75% of natural daylight to be utilised to reduce energy consumption.
2. The entire building has an access friendly design for differently abled persons.
3. With an installed capacity of 930 kW peak power, the building has the largest rooftop solar system among multi-storied buildings in India.
4. The building is fully compliant with the requirements of the Energy Conservation Building Code of India (ECBC). Total energy savings of about 40% have been achieved through the adoption of energy efficient chilled beam system of air conditioning. As per this, air conditioning is done by convection currents rather than airflow through air handling units, and chilled water is circulated right up to the diffuser points unlike the conventional systems.
5. Green materials like fly-ash bricks, regional building materials, materials with high recyclable content, high reflectance terrace tiles and rock wool insulation of outer walls have been used.
6. Use of renewable bamboo jute composite material for doorframes and shutters.
7. UPVC windows with hermetically sealed double glass. Calcium Silicate ceiling tiles with high recyclable material content and grass paver blocks on pavement and roads.
8. Reduction in water consumption has been achieved by use of low-discharge water fixtures, recycling of waste water through sewage treatment plant, use of plants with low water demand in landscaping, use of geothermal cooling for HVAC system, rainwater harvesting and use of curing compounds during construction.

10. CONLUSION

Zero Energy Building Technology requires more of government incentives or building code regulations, the development of recognized construction and design standards and significant increase in cost of conventional energy. This can be proved to be significantly more progressive and sustainable from other low energy building designs. Use of standards will develop and a society with better building techniques and energy cost modelling, hence zero energy homes will be very affordable to build while also having the least greenhouse effect on atmosphere.

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