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Seminar on

"NET ZERO 2070 AND BUILT ENVIRONMENT"

June 10-11, 2023
New Delhi

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FOREWORD

The trend of development taking place along population growth of our most populous country in the world reflects that its energy demand is set to grow by more than that of any other country in the coming decades. Design, Construction, Operation and maintenance activities of the Built Environment for catering the growing need of the population involves large amount of energy and takes a heavy toll of the natural resources thereby generating huge amount of waste and ultimately responsible for GHG emission and climate change.

The climate change problem has been felt globally. To cope with the situation, we need to evolve alternate/renewable energy sources and to meet the commitment of our country made by the Prime Minister during the 26th Conference of Parties (COP-26) in Glasgow, and to meet 50% of its electricity requirements from renewable energy sources by 2030 and to reach net zero emissions by 2070.

There is urgent need to effectively and efficiently harness the most popular renewable energy sources (Solar energy, Wind energy, Hydro energy, Tidal energy, Geo-thermal energy and Biomass energy) to achieve the target of net zero.

Installation of solar power plants requires nearly 2 hectares land per MW capacity. Although Solar sharing , canal top solar PV, solar panel layers, solar trees, vertical solar panels, solar panelled roads, floating solar panels etc. are some of the options available to save land but how much load can be shared with these options is yet to be ascertained. It is not possible to have 100% onsite generation and lot of land will be required for off-site generation necessitating cutting of existing trees which will negate the purpose / mission of NZE.

Huge investment in Research and innovation is required for developing new materials, & technologies besides improvement in efficiency of the existing technologies in energy generation from renewable resources to make all new buildings NZE and convert all existing buildings to NZE.

We also need well-designed policies so as to set up a balance between affordability, security and sustainability so that ultimately our energy transition benefit the citizens and they enjoy the benefit of net zero built environment assets by way of reducing greenhouse gas (mainly CO_2) emissions.

All the related aspects related to creation of Net Zero Built environment by 2070, are proposed to be identified, deliberated upon and analysed with a view to propagate awareness in the Construction industry. It is hoped that useful recommendations shall emerge out of the deliberations on various sub-themes which will be of great value to all the stake holders in the construction industry.

(V.S.Verma)
President IBC

PREFACE

Emissions of CO_2 and other greenhouse gases are primary driver of Climate Change. The buildings during their construction and maintenance emit such gases hence are also responsible to the Climate Change. On the other side, ever increasing population coupled with exponential pace of urbanisation and economic development has manifested itself in the growing demand of buildings and other infrastructure facilities. Thus, buildings are also responsible for damaging ecology, temperature rise, ozone depletion and global warming as they consume about half of the global energy, use majority of resources and generate 45% carbon emissions. Considering buildings' contribution in carbon emissions, UN has also realized their critical role in controlling global warming and promoting sustainability through its sustainable goals.

Considering the requirements of the sustainable development, buildings need to be planned, constructed and operated focusing on energy conservation and sustainability; minimizing and recycling waste and promoting non-conventional energy resources so as to achieve net zero emissions by 2070 as committed by India in November 2021 at the Conference of Parties (COP) to the United Nations Framework Convention on Climate Change (UNFCCC). Therefore, there is a need of paradigm shift in terms of the energy generation and consumption as a strong narrative for decarbonising the planet for controlling the rise in global temperature.

For achieving the target of Net Zero emission by 2070, India has set goals for itself that included generation of non-fossil energy and renewable energy, and reduction of the carbon intensity of its economy by more than 45% by 2030.

Buildings are traditionally designed for being safe and sound performing occupational requirements as 80% of human life is spent within four walls of the buildings. However, energy efficiency and sustainability has to be made part of basic concept and to design all new buildings now by providing adequate concern for energy, depleting natural resources, environment and ecology. Net zero and net plus energy buildings can set an example in achieving a goal of sustainability and Net Zero emission of 2070.

Net zero energy or zero energy building is a building with net zero energy consumption during its operation & maintenance on annual basis. Thus in a net zero energy building, total amount of energy consumed by the building on an annual basis is equal to the amount of renewable energy generated in the building. When generated energy in the building is more than the consumed, the building becomes energy plus or positive energy building.

Even though architects and engineers are aware of the benefits of the net zero and energy plus buildings, and technological expertise is available in the country, number of such buildings is far from satisfaction. Reasons of the same include high initial cost, neglecting life cycle cost, third party audit, lack of attitude of using green materials and technologies and non- availability of rating system in the public works organisations.

Thus in the present context, theme of the Seminar “Net Zero 2070 and Built Environment” is of great relevance so also the views of the experts expressed in the papers published in this Publication. Further, presentation and deliberation of the selected papers in the Seminar from those published in this publication at New Delhi during 10-11 June, 2023, will be of great value and immense interest to the architects and engineers attending the Seminar.

The papers published in this Preliminary Publication are from the experts working in this field and their contribution is gratefully acknowledged. It is also expected that the deliberations on the papers would be very useful to all the stakeholders and practicable recommendations would emerge for the benefit of all the stakeholders in construction industry.

I would like to thank all the Members of the Technical Committee for rendering their help in screening and selection of papers for this Preliminary Publication.

(Dr. K.M.Soni)

Chairman, Technical Committee, IBC &

Former Additional DG, CPWD

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CONTENTS

"NET ZERO 2070 AND BUILT ENVIRONMENT"

CONSTRUCTION OF CLIMATE RESILIENT BUILDING IN DEVELOPING COUNTRIES

Dr. Sunil Kumar Chaudhary*

Abstract

The past decade was the hottest in human history. Fires and floods, cyclones and hurricanes are increasingly the new normal, and emissions are 62 per cent higher now than when international climate negotiations began in 1990.The evidence is clear. We are in a race against time to adapt to a rapidly changing climate – one of the three planetary crises we face along with biodiversity loss, pollution and waste.

Accounting for 38 per cent of total global energy-related CO_2 emissions, the construction industry will play an important role in achieving our goal to limit global warming to well below 2^0C. According to some estimates, investing in more resilient infrastructure could also save humanity from climate change damages. Hence buildings and community spaces should be constructed to increase resilience, especially in developing countries, where settlements are largely self-built. In the present paper, author has made an attempt to present ways to make buildings resilient to climate change in developing countries.

INTRODUCTION

Decisions that are made about homes today will continue to have consequences for many decades till the expiry of life cycle of house.

Many people already consider their future situation when buying or building a home: for example, whether it can accommodate a growing family, or what its likely increase in value will be. However, only few people consider what the future climate will be like and whether the home will suit these conditions. If potential changes to the climate are considered when a home is being designed or altered, it is likely to remain comfortable for longer time. Therefore before buying building or renovating a home, change future climate should be kept in mind.

OUR CHANGING CLIMATE

It is difficult to predict precisely what impacts our changing climate will bring to different parts of the country. But research suggests that it is very much likely our average temperatures and sea levels will continue to rise, we will experience more days of extreme heat in summer and there will be longer periods of drought.

Scientists also anticipate there will be more days of extreme fire danger. And while reduced rainfall is predicted in winter and, it is likely there will be more high-intensity storms with heavy rainfall and strong, damaging winds.

We can learn more about the potential impacts for our local area and consider these when we are designing, renovating and building. This information can help us build a resilient, comfortable and adaptable home for the future.

RESILIENT HOMES; WHY WE NEED TO BUILD TO WITHSTAND CLIMATE CHANGE EVENTS

The effects of our changing climate aren't just coming anymore, they are here. Building resilient homes helps deal with climate change events, storms, floods, heatwaves, extreme cold, and saves us not only from wagery of weather but will also reduce the life cycle cost of our homes.

**Executive Engineer, Road Construction Department, Vaishali Road Division, Hazipur, Bihar*

PLANNING FOR CLIMATE CHANGE

Good design for a changing climate is design that is flexible enough to adapt to prevailing conditions while optimising the occupants' comfort.

CONSIDERATIONS

The National Building Construction Code sets out performance standards for houses built in areas that are prone to bushfires, cyclones and flooding. Adaptive strategies that go beyond these minimum standards should also be considered.

When designing or redesigning a home, consider the following questions:

- What are the local climate variables that could affect the building?
- Will predicted climate change impacts affect the site and the building?
- What are the likely consequences to the home in the event of extreme weather?

Building flexibility into the design of a house and considering where your home is situated on your block will help you manage changing climate conditions. Options might include:

- Ensuring that there is enough space on your site for extra rain or stormwater storage
- Building more substantial footings under a deck so that it can easily take the weight of a roof if more shade is needed around the house
- Creating a cool retreat in your home, ideally located on the cooler, southern side or in the central part of your home, with additional shading and insulation.

Strategies set in place early to adapt a house to a changing climate may reduce future costs. Seek professional advice (for example, from an architect) to identify adaptation options and compare them against other factors:

- How effective will the option be over the life of the house? Is it flexible enough to respond to the projected local changing climate conditions?
- How practical is the option, and is it easy and relatively inexpensive to maintain?
- Are there other benefits, or undesired side effects, that could arise from the option?

The best adaptation actions are those that offer other benefits. For example, concrete floors recover well should the house be flooded, and also have high thermal mass which can be used to reduce heating and cooling costs.

However, adaptation actions for one climate change impact could cause a home to be less well adapted for other impacts or could also create a home that is less liveable. These effects can be avoided or negated through smart design or material choices. The table below gives examples of smart design choices for adaptation.

DESIGNING FOR CLIMATE CHANGE

We can design or renovate our home to take into account the sort of climate impacts we expect to be most relevant for our area.Buildings should be designed and operated in such a way that they are responsible for fewer greenhouse gas emissions. They also need to be designed to cope with the impacts of climate change in coming decades.

Houses in developing countries have an average serviceable life of over 100 years. Buildings constructed today must therefore be able to deal with climate changes forecast for the long term.

Buildings emit greenhouse gases in the materials and processes used in their construction, and in the energy and other resources used over the life of the building for heating, cooking and washing. Good passive design can help to minimise energy use while maintaining a comfortable and healthy environment, so reducing greenhouse gas emissions. Installing high levels of thermal insulation and reducing volumes of waste are key measures.

The impact of climate change will vary from region to region. Designers will need to consider:

- Incorporating passive solar design features to reduce the need for heating in winter and air-conditioning in summer

- Designing buildings with more shading in response to increased solar radiation
- Structural design to deal with increased wind loading
- Designing buildings to make more use of natural ventilation
- Designing the roof, roof drainage and stormwater run-off to cope with higher and more intense rainfall
- Incorporating water-saving features in homes to reduce pressure on urban water supplies (see Water)
- Potential flood risk in low-lying areas
- Limiting building in flood-prone areas or coastal regions that are likely to experience increased erosion in the future.

REDUCING GREENHOUSE GAS EMISSIONS

Carbon dioxide and other greenhouse gases are emitted through the process of building construction and use including during:

- Material extraction, manufacture, processing and transportation
- Construction
- Occupation
- Demolition

Of these, the most significant is carbon dioxide emission through energy use. Limiting domestic greenhousegas emissions is essential to reduce the impact on the environment as well as for economical reasons.

Greenhouse gas emissions can be reduced in a number of ways including:

- Selecting a site that can take advantage of passive solar design
- Designing an appropriately sized home i.e. if too large, materials and energy will be wasted
- Incorporating passive design features such as orientation, insulation, and thermal mass to provide a comfortable internal environment while minimising energy use
- Selecting materials with fewer emissions over their life cycle
- Designing in a way that results in less material waste on site (for example by working to the standard sizes that materials come in to reduce offcuts)
- Specifying energy-efficient lighting, heating, water heating and appliances
- Incorporating rainwater collection and storage
- Installing water-use reduction fittings.

RESOURCES FOR CLIMATE-FRIENDLY DESIGNS

There are three carbon footprinting tools and two life cycle assessment tools:

- CO2NSTRUCT is a database of embodied carbon and energy figures for building materials and products.
- CO2RE covers greenhouse gas emissions for residential wall, floor and roof constructions (expressed as per m2 of the building element). It allows evaluation based on construction R-value and whole-of-life embodied carbon.
- CO2MPARE is a database of calculated greenhouse gas emissions for a set of reference residential and office buildings. It also contains carbon budgets for those buildings. It can be used for benchmarking and target setting.
- LCA Quick calculates environmental impacts of any building designs, with a focus on residential and office typologies.
- LCA Play is a concept-level exploratory LCA tool for commercial buildings

WAYS WITH EXAMPLE TO MAKE CONSTRUCTION CLIMATE RESILIENT

Following are five ways to make Building Construction Climate Resilient: -

- **Building resilience to heatwaves**

  Studies show that by 2050, 1.6 billion people living in more than 970 cities will be regularly exposed to extreme high temperatures. Coupled with the 'urban heat island effect' which makes cities warmer than the surrounding rural area, this puts urban dwellers at high risk.

  But nature provides powerful solutions. Communities can create urban forests and green spaces to reduce heatwaves in cities as trees and other plants cool the surrounding environment by offering shade and releasing water through their leaves.

  Structural designs can also help reduce heat inside buildings. Traditional housing designs such as the optimum orientation of buildings, high-rise rooms, and large openings improve ventilation. Trombe walls - heavyweight structures of concrete, stone, or other heavy material that capture solar heat are used in China, Chile, and Egypt. Green roofs and reflective surfaces can also reduce temperatures in and around buildings.

- **Building resilience to drought**

  Climate change is affecting rainfall patterns across the world. Rainwater harvesting and recharge systems that capture water on the roofs of buildings are commonly used to store water during drought and reduce flood risk during heavy rains. The collected water can be stored in tanks and used inside the building during periods of drought.

  Another cost-effective, nature-based way to address droughts and flooding is to plant trees or other vegetation around buildings. The roots of the plants act like sponges to recharge groundwater, and during heavy rainfall, the roots allow water to penetrate the soil and reduce the risk of flooding. In China, the Sponge Cities Project is piloting eco-engineering solutions to absorb and reuse rainwater in over 30 metropolises to reduce flooding risks.

- **Building resilience to coastal flooding and sea-level rise**

  By 2025, 410 million people in coastal communities could be at risk of coastal flooding and sea-level rise. In Kerala, India, flood-resistant houses are constructed on pillars to allow floodwater to flow underneath. On Malaysia's coasts, buildings elevated 2 meters above the ground allow waterflow and wetland vegetation to grow underneath, with houses and public areas connected through elevated passages.

  One approach proposed in Bangladesh is to build a buoyant multi-purpose building that would rest on pillars with buoyant tanks that raise it during floods. The building would function as a community center and also provide emergency shelter during flooding.

Proposal for the "Shelter of Kindness" - a buoyant multi-purpose building in Bangladesh

- **Building resilience to cyclones and strong winds**

  Cyclones and storms are expected to become more frequent and stronger with climate change. They can affect buildings in many ways, such as blowing off roofs and damaging the structures and foundations of the building. To mitigate this damage, communities can build round-shaped houses and consider optimum aerodynamic orientation to reduce the strength of the winds.

  Roof design also plays an important role. Strong connections between foundations and the roof are critical to building wind-resilient houses. Roofs with multiple slopes can stand well in strong winds, and installing central shafts reduces wind force and pressure to the roof by sucking in air from outside. Roofs that cover balconies or patios can also be designed to break during strong winds to prevent additional structural damage to the essential parts of the house. This is called frangible architecture or 'planning for damage' approach.

Typhoon-proof dome houses to rise in Dapitan, the Philippines

- **Building resilience to cold**

  Adapting to cold and temperate climates requires capturing heat and minimizing heat loss. Insulations in roofs, walls, ceilings, and double-glazed windows help to minimize heat loss and lead to more energy efficient buildings.

CONCLUSION

Recognizing which issues you are most vulnerable to and factoring that into our planning, design, technology and material can result in a more climate resilient home, which will last longer and add value. Any question about cost in that process should be carefully considered and calculated in relation to actual and projected savings over the homes lifespan. Having a resilient home will also offer improved security to your family. As we move into an uncertain future, our kids will need all the help we can give them, and being able to will them an autonomous and durable house in the future is a great start.

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STRATEGIES AND OPTIONS FOR MAKING BUILDINGS ZERO ENERGY

JIT KUMAR GUPTA*

Abstract

Buildings have close connectivity with human living and working. Buildings, as definers of character and fabric of any community and city, are known for their positivity, negativities, dualities and contradictions. Buildings have been credited to be large consumers of energy and resources besides generators of enormous waste. Buildings also remain anti-thesis to environment and ecology. Consuming half of the global energy, using majority of resources and generating 45% carbon emissions, buildings are responsible for climate change, damaging nature, rising temperature, ozone depletion and global warming. Sustainable Development Goals enunciated by UNO, have mandated critical role of buildings in controlling global warming and promoting global sustainability. However, majority of buildings are being planned, designed, constructed and managed without any concern for energy, resources, environment and bio-diversity. This calls for making buildings sustainable and least consumers of energy and resources. For making buildings least consumers of energy, resources and generators of minimum waste, traditional approach to buildings have to be changed and redefined. In search for appropriate solutions to make buildings sustainable, qualitative, liveable and more productive; paper looks at the strategies and options of; rationalising approach to planning and designing of buildings; relevance of site and orientation; options for energy and water efficiency; context of building materials, construction technologies and indoor air quality, to make buildings sustainable and zero energy.

INTRODUCTION

Preservation, conservation and making value addition to environment has been considered most valuable and critical elements for making planet earth safe. Accordingly, agenda for making environment qualitative, has been accepted as the goal and destination to be reached by all organisations, states and nations. Looking critically and objectively, there exists two kinds of environment on this planet earth, one created by nature, called natural environment and other made by human beings, called built environment (buildings). Gradually, manmade environment is gaining predominance over natural environment, due to ever increasing number of human beings and their increasing/changing needs and demand for buildings. McKinsey Global Institute, 'India Urban Awakening: Building Inclusive Cities -Report', has projected India, as a nation, will be needing annually 700-900 million sqmts of built space, to meet the needs of urban India by the year 2030. In addition to meeting the basic requirements of human living, buildings have also been recognised as the definer of human history, growth and development. It is also accepted that future journey of mankind will also be defined by buildings, which shall be created over a period of time.

Buildings remain vital for human growth because they are central to all human activities and known to deeply impact the quality of life. 80% of human life is spent within four walls of the buildings. Modulating quality of life, buildings are known to make human beings both healthy/sick, depending upon quality of buildings in which they are living. As polluter of environment /ecology and generators of large carbon footprints, buildings remain responsible for climate change, global warming and modulators of sustainability. Large consumption of resources

Founder Director, College of Architecture, IET Bhaddal, Chandigarh

and generation of waste can be attributed to the manner and approach by which, buildings are being designed, constructed, operated and maintained.

Making buildings sustainable is essential for preserving, protecting and making value addition to resources, environment and ecology. Considering the enormity of space and its implications, as consumers of energy and resources, buildings need to be planned, constructed and operated with utmost care and caution, with focus on energy conservation and sustainability; minimizing waste generation and promoting resource efficiency.

GREEN BUILDINGS

Known for its positivity, negativities, dualities and contradictions, buildings constitute a complex system of designing, construction, materials, resources and environment. Revolving around seven layers during its life-cycle (siting, designing, construction, operation, maintenance, renovation and deconstruction);increasing consumption (energy, water, materials, natural resources) and impacting environment (generating waste, polluting air/water, creating heat islands, increasing storm water runoff); buildings are credited with adversely impact human health, environment and precious resources.

Green Buildings

According to World Energy Council Report, 2016, buildings remain responsible for consuming over 40% global energy, 30% raw materials, using 25% timber harvested, 16% fresh water withdrawal, 35% of world's CO_2 emission, generating 40% municipal solid waste and 50% ozone depleting CFC besides promoting 'sick building syndrome'. Studies made of the lifecycle cost and energy used in buildings, have concluded that only 10% of total cost & 17% of total energy, goes into making of a building; whereas remaining 90% cost & 83% of energy is used in its operation and maintenance. Thus, buildings offer greatest opportunity to minimize energy consumption by merely changing the manner/approach, in which buildings are being designed, constructed and operated.

Looking at the entire gamut of built environment, Green Buildings emerge as the best option to make buildings sustainable, least consumers of energy and resources because Green Buildings are known for its advantages of minimizing use of water, optimizing energy efficiency, conserving natural resources, generating less waste and providing healthier space for occupants, as compared to conventional buildings. Green Buildings are also credited with saving energy upto 50%; reducing water consumption by 40%; reducing carbon emission by 35% ; lowering CO_2 by 8000-12000 tons and 3 MW of connected electric load / million Sqft building; besides reducing 70% waste. Green buildings provide financial, environmental and social benefits besides creating a win-win situation for both owners, occupants, communities, society and environment. Studies reveal that, 'Green Schools make learning easy and more meaningful'; 'Green Houses makes people happy and healthy' and Green Hospitals cures patients quickly'. Green building may initially cost more, but save more through lower operating costs incurred over useful life of building. Potential financial benefits of improving indoor environments exceed cost by a factor of 8 and 14.Green Building practices expands/complements building design concerns of: economy, utility, durability and comfort.

DESIGNING GREEN BUILDINGS

World Green Building Council has defined Green Building as a, "Building that, in its design, construction or operation, reduces or eliminates negative impacts, and create positive impacts, on our climate and natural environment. Green buildings preserve precious natural resources, improve quality of life and make our environment more qualitative and liveable. Green buildings are universally characterised by;

- Using efficiently; energy, water and other resources
- Using renewable energy including solar/wind/water/geo-thermal
- Reducing pollution/waste, involving refusing, reducing re-cycling,re-using
- Promoting good indoor environmental air quality
- Using renewable/non-toxic waste based sustainable materials
- Valuing environment, as integral part of design, construction and operation
- Ensuring quality of life for occupants

BASIC PRINCIPLES OF PLANNING

While options for planning and designing green buildings will vary from region to region and within regions, depending upon prevailing climate, site conditions, cultures, available materials, construction practices, building typologies, environment, economic and social priorities but the governing principles for making buildings green, remain universal. Buildings, like machines, are consumers of resources/energy, but a green building not only minimise/optimise use of resources/energy, but also ensures replacing the conventional non-renewable resources/energy with natural/ renewable resources.

Basic approach to green buildings invariably revolves around and involve; designing with nature, making optimum use of natural resources and adopting integrated approach to design. Planning with nature would essentially involve, making optimum use of Panchbhutas- Prithvi (site), Agni(energy), Jal (water), Vayu (air) and Aakash (Space), for meeting the basic needs of energy and resources for buildings. Integrated approach to building design by involving all the required disciplines together on a single platform would essentially revolve around, respecting site, rationalising site planning, rationalising built form; promoting building efficiency; making optimum use of sun and air for lighting, heating, ventilation; minimising waste; using local materials and optimising landscaping etc.

TEAM WORK

Making buildings Green, is never reckoned as individual professional responsibility but always considered as a group-based activity, involving professionals like; Architects, Engineers, Structural Engineers, Landscape Experts, Service Providers, Contractors etc.

together on a single platform on realistic basis. Accordingly, green building projects, shall involve, creating a dedicated team, right at inception, having knowledge, expertise, understanding, experience of designing green buildings in order to ensure that buildings is planned, designed and constructed in a holistic and integrated manner. Being a group based activity, creating such a team would not only help in making optimum use of available professional expertise, but will also go a long way in making building sustainable, cost-effective and resource- efficient.

ORIENTATION

Orientation has always been valued as the key for optimising nature and natural resources of sun and air, and it forms integral part of building design for making optimum use of the natural resources for evolving energy efficient building envelope. Since requirements of building design would vary in different climatic zones, accordingly buildings, with regard to climate, sun and wind, will have to be oriented differently and distinctly in different regions. In hot regions, the design option shall be to minimise heat gain and promote heat loss, if excess heat is gained by the building. However in cold regions, the design option shall be to capture and retain solar heat so as to make optimum use of solar radiation. Accordingly, north-south shall remain the best orientation in hot regions whereas north shall invariably be avoided while designing buildings in the cold regions. However, Architect, on its part has to adopt a passive approach to design, so that building gels with nature and makes optimum use of given orientation.

SITE PLANNING

Rational and innovative site planning has great bearing on making buildings green, for the reasons that it helps in determining the extent of building footprints, height/setbacks; built/ open spaces; making optimum use of land; preserving/protecting existing flora & fauna available besides ensuring adequate natural day-lighting, air and ventilation within the buildings. However, for rational site planning, context of site would invariably require detailed study and in-depth analysis in terms of location, orientation, wind direction, accessibility, size, shape, soil conditions, topography, vegetation, natural features, hydrology, precipitation, infrastructures etc. so as to make optimum use of the available natural resources.

DESIGNING BUILDING

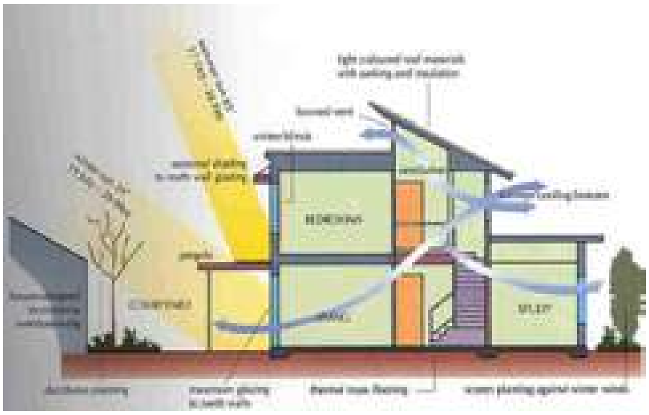
Based on the site analysis, green building design shall be the outcome of physical characteristics, slope, surrounding land uses/buildings, visual linkages etc. Principles governing the site planning shall involve; minimising foot prints of buildings; maximising open spaces; minimising damage to site; designing with local culture and using hierarchy of preservation, conservation and regeneration. In addition, planning of multiple use of space holds great relevance in making buildings green and energy efficient. Accordingly, planning of building shall be based on making optimum use of site conditions, orientation, flora and fauna; minimising wall to area ratio; achieving high building efficiency; positioning all habitable rooms in the best orientation; optimizing air and ventilation within and around buildings.

Design approach should invariably revolve around making buildings climate responsive. In hot regions, buildings shall be painted light to minimize heat gain besides using thick/hollow walls whereas in the case of cold climate, buildings shall be painted with dark colours to absorb maximum heat. If typology of open buildings is used in hot regions, making buildings compact shall be followed in cold regions. Further, building envelop would also require careful designing and should be guided by; optimizing solid-void relationship; careful positioning of openings, projections and shading devices; optimizing room size/building height, natural lighting and ventilations; green walls and green roof etc.

PROMOTING ENERGY EFFICIENCY

For promoting sustainability, buildings will have to be planned, designed and constructed considering life time implications of energy . Lifecycle operations of building involves two types of energy–Embodied Energy (energy which goes into making of building) and Operations & Maintenance Energy (energy consumed by building during its lifetime). Building construction together with construction materials involved only 16 % embodied energy whereas O&M operations involve rest 84% of energy. Accordingly, for making buildings energy efficient, both embodied and operational energy components will need reduction. Reducing embodied energy will essentially require; optimizing various systems; reducing structural loads; using low-energy construction technologies; creating slim and resilient structures; using local/natural/low energy materials; using building construction/ demolition waste. etc.

Properly orienting buildings and adopting passive/climate responsive design strategies; placing habitable rooms in best orientation;



Proper Orientation Planning of Building

sourcing natural light, proper positioning of windows, avoiding glare, using minimal glass on east/ west, installing high R-value wall/ ceiling insulation; will go a long way in reducing operational energy demand of buildings. Using properly sized/energy-efficient and rated lighting/heating/cooling systems in a thermally efficient building shell, will be pre-requisite for making buildings green.

In the past, strategy of building design has been focused on; making buildings energy efficient, which now should be taken to the next level of zero energy buildings before achieving the ultimate objective of making buildings energy positive. This would need dual strategy of minimizing energy consumption and making building net generator of on-site renewable energy from natural resources (sun, wind, bio-mass, geo-thermal). It would also involve daylight harvesting; promoting operational / maintenance efficiency through BMS (Building Management System); smart metering besides computer modelling (for optimizing design of electrical/ mechanical systems and building shell), coupled with using advanced lighting controls; motion sensors/dimmable lighting controls etc for making buildings energy efficient.

VALUING WATER CONSERVATION

Having merely 4% of world's water resources for supporting 17.7 % of global population and 20% of world's livestock (550million -Gangwar 2013), India remains one of the most water-stressed nation globally. Despite limited availability, India consumes one-fourth (24%) of global ground-water, more than jointly consumed by China & US besides being third largest exporter of groundwater (12 %). India currently ranks 120 among 122 countries in the water quality index. According to NITI Aayog, "India is suffering from the worst water crisis in its history, and millions of lives and livelihoods are under threat. Twenty-one Indian cities, including Delhi, are estimated to run out of groundwater, affecting million people by the next decade".

Known as elixir of life, water remains critical for both human living as well as for building construction. Buildings remain large consumers of water in its life-cycle including building operations, producing materials used in construction, curing and in operation and maintenance. Building sector is estimated to consume 16% of total fresh water withdrawal globally. Green buildings, known for water-efficiency, reduce water consumption upto 40%. Accordingly, for making construction sector water-efficient, green buildings shall be the best option.

Effective water management should revolve around four-fold strategy; protecting water, conserving water, protecting water quality and reducing consumption. Options for minimizing water consumption within buildings should involve; adopting water-efficient construction practices. Pre-fabrication technology is known for its water efficiency which needs leveraging effectively.

Water Management

Strategy for multiple uses of water through dual plumbing; in-house sewage treatment; adopting phytoremediation for sewage treatment; using grey water for flushing and landscaping; using water rated/efficient fixtures; rationalizing landscaping; using native flora & fauna; providing large porous spaces, can lower water consumption and increase ground water recharge. The intent should be to reduce the generation of waste water and potable water demand. Slow the flow, breaking water, creating mist by mixing air with water, are other options to reduce water consumption. From water efficiency, there is need to graduate to zero-water buildings and ultimately water-positive buildings by promoting rainwater harvesting, ground water re-charging, air based cooling and reinventing sanitation system which is not exclusively water based.

USING GREEN MATERIALS & INNOVATIVE CONSTRUCTION TECHNOLOGIES

Buildings consume three billion tons of raw materials annually, constituting 40 percent of total materials used globally (Roodman and Lenssen, 1995). Materials remain major determinant of embodied energy, cost, quality and maintenance of buildings besides posing serious environmental issues by extraction, transportation, processing, fabrication, installation and its disposal. Considering critical implications, choice of building materials should invariably revolve around; promoting conservation of non-renewable resources; minimising maintenance/ replacement costs and creating healthy indoor environment. Accordingly, materials used in buildings should essentially be resource efficient; natural, renewable; energy/water efficient; environment responsive; affordable; recyclable and preferably made from industrial/ agro waste. In addition, green buildings should also involve, using state of art, innovative and low-carbon construction technologies, which are cost-effective, speedier, material/ energy/water efficient, safe and generators of minimum waste.

ENSURING OPTIMUM INDOOR AIR QUALITY (IAQ)

With cost, quality and time becoming important, indoor air quality, despite its critical role and importance, remains muted, marginalised and diluted in buildings. Spending 80% of the habitants life span within building, IAQ becomes critical for making people healthy/sick. Good IAQ forms essential element of Green Buildings, because it helps in making work places more qualitative; reduces fatigue / tiredness among occupants; fosters better health and improves their work performance. Good IAQ is known for its positivity of creating optimum living conditions by avoiding CO_2 concentration. Poor IAQ is the outcome of the use of chemical/HVOC based building materials; poor ventilation; lack of natural light; smoke/ dust; moistures etc. As major determinant of IAQ, materials selected for building should be non-toxic; water based; moisture resistant and easy to maintain. Promoting good IAQ would require maintaining inside temperature range of 22 - 24oC, relative humidity (RH) below 70%; CO_2 levels < 1000ppm; exclude VOC with vapour pressures limited to restrict the fungal/ microbial/ pathogens growth. Natural daylight/ outside views/ good landscaping/ efficient ventilation and using indoor plants are known to improve the IAQ.

CONCLUSION

Looking at the enormous implications of buildings, in terms of energy and resource; planning, designing and constructing sustainable and energy-efficient buildings shall invariably remain critical and will hold the key to global march to tackling climate change, minimising global warming and reducing carbon footprints. World Energy Outlook (IEA, 2019a), has reported that; cost-effective, energy efficiency and decarbonisation measures in buildings could annually save 6.5 Gt CO_2 emissions by 2040.

Besides providing healthier, resilient and productive environment, decarbonising buildings presents enormous business opportunity estimated to be approximately USD 24.7 trillion by 2030 (IFC, 2019). Green buildings also remain fully aligned with the SDGs, because such buildings not only reduce/ eliminate negative impacts of buildings, but also promote sustainability and increased bio-diversity. Green buildings are also known to offer numerous economic/financial benefits in terms of; lower operational costs; increased occupancy rates; command 7% higher premium in value over traditional buildings; recording 101% increase in cognitive scores, sleeping 46 minutes more per night with 8% increased productivity.

Green Buildings offer best option for achieving global SDGs; addressing climate change; creating sustainable/thriving communities; driving economic growth ensuring environmental, economic and social benefits; minimising waste and maximising reuse; promoting health and well being and creating win-win situation for owners, occupants, communities and nations. However, decarbonising buildings would require dedicated policy framework, besides greater collaboration among policy makers, urban planners, architects, developers, investors and construction companies. Considering massive urbanisation and growing needs of built environment, India must immediately put in place an effective/efficient policy framework to retrofit the existing buildings and make all new buildings net- zero carbon by 2050, on the pattern suggested by World Green Building Council, to make "Sustainable India".

Source: United Nations Department of Public Information, Sustainable Development Goals.

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INDIA ON PATH TO NET ZERO EMISSION BY 2070

USHA BATRA*

Abstract

We are on pathway to global warming of more than double the 1.5-degree limit agreed in Paris. In 2021, at COP26, India announced its ambition to become a net-zero emitter by 2070 and now stands committed to reaching net-zero+emission by 2070. A growing coalition of countries, are pledging to get to net-zero emissions. More than 70 countries, including the biggest polluters – China, the United States, and the European Union have set a net-zero target. The path requires immediate and massive deployment of all available clean and efficient energy technologies along with new ones which are under research.Floor area in the buildings sector worldwide is expected to increase 75% between 2020 and 2050, of which 80% is in developing economies. Buildings have long lifetimes and around half of the existing buildings stock will still be standing in 2050. Energy efficiency and electrification are the two main drivers of decarbonisation of the building sector in the NZE . Transformation relies primarily on technologies already available in the market with improved energy efficient envelopes and technologies being developed in laboratories. To achieve this, more than 85% of buildings need to comply with NZE by 2050, meaning thereby that all existing buildings would also require to be retrofitted.Building energy codes covering new and existing buildings are required to be developed and strictly complied with to drive such changes.Governments will need to find ways to make Net Zero Carbon ready buildings and retrofits affordable and attractive to owners and occupants by overcoming financial barriers. The pathway to NZE by 2050 will require an unprecedented level of international cooperation between governments.

Case study of Indira Paryavaran Bhawan, first on-site net zero building and learnings from it are also included.

INTRODUCTION

Earlier, India submitted its Intended Nationally Determined Contribution (NDC) to UNFCCC on October 2, 2015 comprising of eight goals; three of these have quantitative targets up to 2030 namely -cumulative electric power installed capacity from non-fossil sources to reach 40%, reduce the emissions intensity of GDP by 33 to 35 percent compared to 2005 levels and creation of additional carbon sink of 2.5 to 3 billion tonnes of CO_2 equivalent through additional forest and tree cover.

As per the updated NDC, India now stands committed to reduce Emissions Intensity of its GDP by 45 percent by 2030, from 2005 level and achieve about 50 percent cumulative electric power installed capacity from non-fossil fuel-based energy resources by 2030.

**Former SDG, CPWD*

Reducing global carbon dioxide (CO_2) emissions to net zero by 2050 is consistent with efforts to limit the long term increase in average global temperatures to 1.5 °C. A huge amount of work is needed to turn today's impressive ambitions into reality, especially given the range of different situations among countries and their differing capacities to make the necessary changes.

Getting to net zero requires all governments – first and foremost the biggest emitters – to significantly strengthen their Nationally Determined Contributions (NDCs) and take bold, immediate steps towards reducing emissions now. Transitioning to a net-zero world is one of the greatest challenges humankind has faced. It calls for nothing less than a complete transformation of how we produce, consume, and move about.

Our pathway calls for scaling up solar and wind rapidly this decade, reaching annual additions of

630 giga watts (GW) of solar photovoltaics (PV) and 390 GW of wind by 2030, four times the record levels set in 2020. For solar PV, this is equivalent to installing the world's current largest solar park roughly every day. (Bhadla Solar Park spanning over an area of 14000 acres, is located in the Jodhpur district of Rajasthan).

As per Republic of solar dtd. 16.05.2022, Minimum 5 acres land is required for 1MW so 630GW will require 31,50,000 acres of land and as per NREL report of August 2009, many projects achieve capacity densities equal to or greater than 5 MW/ km2, land required for 390 GW will be equal to or greater than 78,000 sq km or 1,92,74,190 acres.

INDIA CLOSE TO ZERO EMISSIONS BY 2050

'Net zero emissions' refers to achieving an overall balance between greenhouse gas emissions produced and greenhouse gas emissions taken out of the atmosphere.It means cutting greenhouse gas emissions to as close to zero as possible, with any remaining emissions re-absorbed from the atmosphere, by oceans and forests for instance. As India's energy system continues to develop, the transformation to net-zero emissions will require fundamental change in how the country produces and uses energy – at a pace that will be highly challenging. There is large-scale electrification of end-use sectors such as buildings, transport and power. In this scenario, energy demand doubles, but India achieves a net-zero energy system by 2050 (Fig.1) with most sectors getting close to zero emissions with below mentioned areas of action in the next 30 years

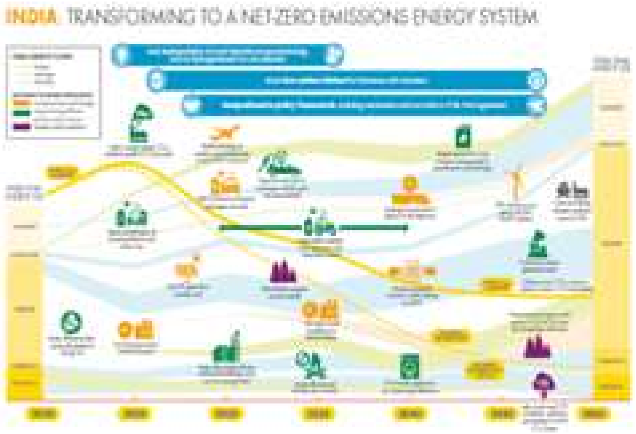

Fig. 1: India : Transforming to a Net-Zero Emissions Energy System

Accelerate clean technologies

- Grow the power sector by a factor of more than four in 30 years, dominated by renewables. (Fig 2)
- Target 13% hydrogen in final energy, including as a fuel for industry and transport.
- Transform bio-energy, with liquid bio-fuels surpassing petroleum products by 2040 to fuel industry and transport, including hard-to-abate sectors such as aviation.

Support energy-efficient and lower-carbon choices

- Invest in processes, technologies and end uses to improve energy intensity per unit of GDP by almost 60% by 2050, a rate of improvement nearly twice historical levels.
- Adopt economic mechanisms, such as carbon pricing, to drive the reallocation of capital and resources and support the commercialisation of new fuels and technologies.

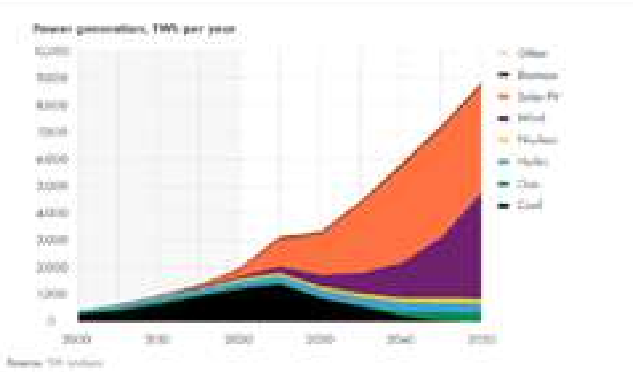

Fig.2: Power generation grows, dominated by wind and solar -2050

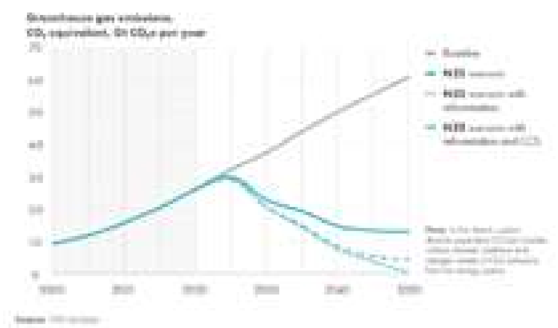

Fig. 3: Technology and nature required to remove remaining emissions

Remove unavoidable emissions (Fig.3)

- Capture and store 400 mega tonnes of CO_2 using CCS by 2050;
- Remove 0.9 giga tonnes of CO_2 every year by 2050.This requires at least 30-40 million hectares of additional forest cover (an area equivalent to Rajasthan) and plant more trees outside of forests.

ENERGY EFFICIENCY AND LOW-CARBON CHOICES IN VARIOUS SECTORS FOR NZE

Targeting net-zero emissions by around mid-century will require current energy efficient technologies and new more energy efficient technologies. Improvements in energy efficiency are particularly significant in the industrial, residential, commercial and agricultural sectors. The success of the NZE scenario lies in a complete shift to Net Zero Energy buildings with energy efficient/ climate sensitive building envelope by 2050. Furthermore, public infrastructure such as lighting including street lighting should meet the highest efficiency LED standards by 2050. In the residential sector, energy-efficient appliances with star-labeling can facilitate a complete switch to efficient electric appliances by 2050. In the agricultural sector efficient agricultural machinery including pumps, tractors and tillers. Electrification of transport sector drives significant efficiency improvements and emission reduction in the sector.

NET ZERO ENERGY/ NZE PLUS BUILDING

Net Zero Energy Building (NZEB) is one which produces as much energy as it uses over the course of a year. It means that the building has an energy utility bill of Rs0/- over the course of a year. Energy plus is one which produces more energy than it uses over the course of a year. Some buildings abroad are designed to produce 2-10 times of the required energy. Energy may be produced on-site or off-site. Efficiency of solar panels shows reduction of 0.5-1.0% annually, therefore all the buildings must be designed energy plus. Solar energy capture on-site / off-site may also not work in all locations. NZE Building may or may not be Green / Climate sensitive, so the correct approach for design of NZE Buildingis that it must be Green / Climate sensitive in order to harness the potential of Renewable energy generation.

Most Net Zero Energy Buildings are still connected to the electric grid, allowing for the excess energy produced from renewable energy sources to be exported back to the utility grid & used when renewable energy generation cannot meet the building's energy load due to weather conditions. Buildings that meet all their energy needs on their own and are not connected to an external source / electrical grid are described as off-grid.

CLIMATE SENSITIVE BUILDING ENVELOPE

As per report of (Confederation of Indian Industry) CII (IGBC), Green Buildings save energy to the extent of 40-50%. Climate sensitive Envelope alone

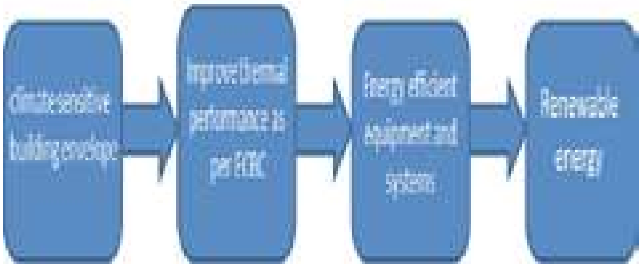

Fig. 4: Steps of Net Zero Energy Building Design

can contribute to 50% of this, meaning thereby that Energy saving potential of Energy efficient envelope alone is to the extent of 20-25%.

The building sector can significantly reduce energy use by incorporating energy-efficient strategies into the design, construction, and operation of new buildings and undertaking retrofits to improve the efficiency of existing buildings. It can further reduce dependence on fossil fuel derived energy by increasing use of on-site and off-site renewable energy sources.

Minimizing the energy use through efficient / climate sensitive building envelope design should be a fundamental design criterion and given highest priority of all NZEB projects as it is the most cost-effective strategy with the highest return on investment, and will minimize the cost of the renewable energy.

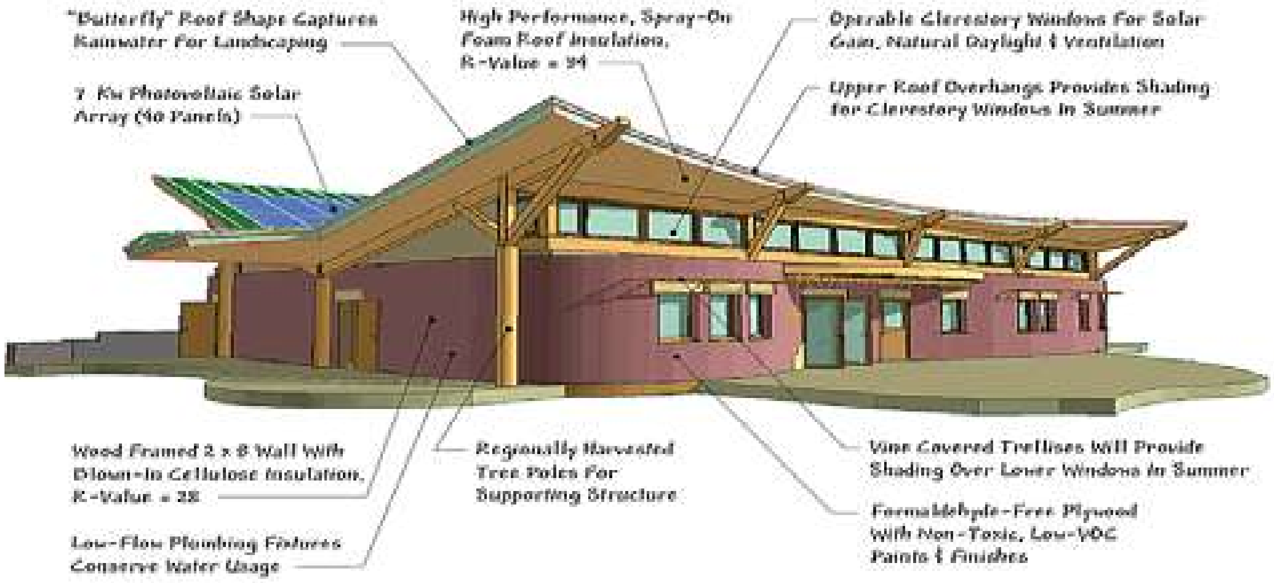

Fig. 5: Climate Sensitive Building Envelope

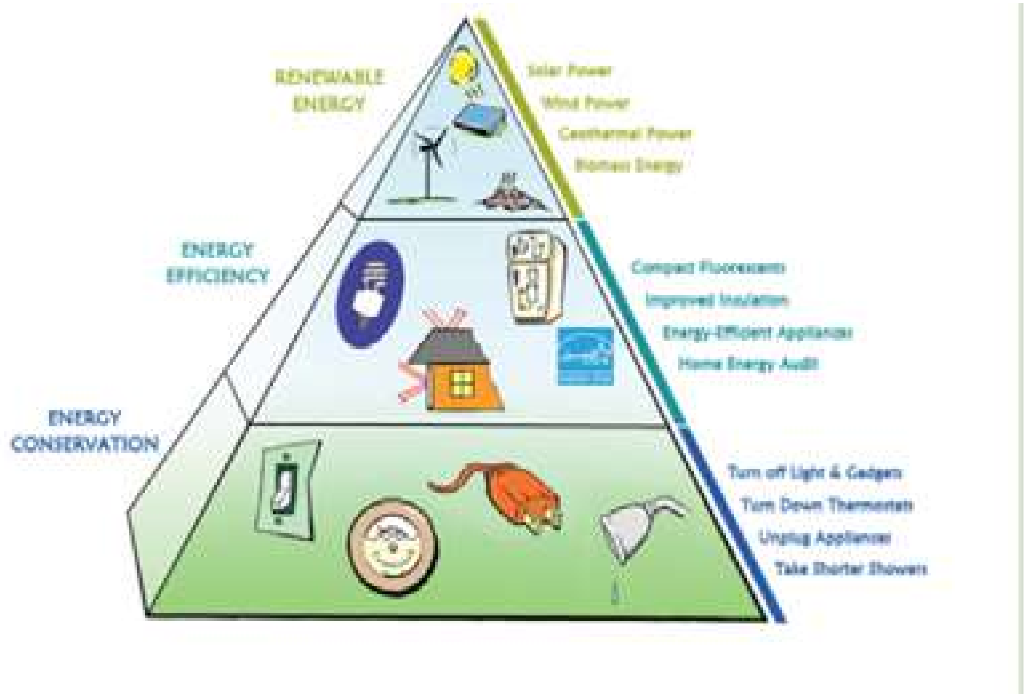

Fig. 6: Approach to Net Zero Building Design

Detailed steps / approach to design of Net Zero Energy Building (Fig 4 & 6) are:-

1. Design of Energy efficient / Climate sensitive building envelope (Fig 5) using the following:-

- Appropriate orientation & shape of the building with respect to sun and wind direction.
- Appropriate WWR for light & ventilation i.e. design that increases daylight to reduce the need for daytime lighting, at the same time avoids unnecessary glass area to restrict heat ingress.
- Shading devices & Landscaping to allow the desirable sun and cut-off the non- desirable sun as well as divert the wind direction wherever required.

- Use of landscape elements in altering the micro-climate, providing buffer for heat, sun, noise, traffic, and airflow.
- Use of balconies, verandas, courtyards, wind towers, skylights, cross ventilation and night ventilation.
- Use of Green building materials and water conservation technologies.
- Shading of walls and roof.

2. For further improving thermal performance, Second step is to insulate the envelope to increase energy efficiency by improving thermal performance of the envelope viz walls, roof and fenestration using appropriate methods as per ECBC norms for various climates.

- Use of Energy efficient equipment and systems. This may include energy efficient lighting, electric lighting controls, high-performance HVAC, and geothermal heat pumps.
- Saving energy while using building bychanging behavior e.g.switching off light, fan, heater, AC etc including street light when not in use can save huge amount of energy and avoid national wastage.

3. After all above is taken care, rest of energy demand can be met through Renewable energy on-site or off-site.

GLOBAL BUILDINGS SCENARIO IN NZE

2030- All new Buildings are zero carbon ready and 2.5% of existing buildingsfrom 2030 are retrofitted to be zero-carbon-ready each year.

2035- Most appliances and cooling systems sold are best in class

2040 – 50% of existing Buildings retrofitted to zero carbon ready level.

2050 – More than 85% of Buildings are zero carbon ready

A zero-carbon-ready building is highly energy efficient and either uses renewable energy directly, or uses an energy supply that will be fully decarbonised by 2050, such as electricity or district heat. This means that a zero-carbon-ready building will become a zero-carbon building by 2050, without any further changes to the building or itsequipment. Zero-carbon-ready buildings should adjust to user needs and maximise the efficient and smart use of energy, materials and space to facilitate the decarbonisation of other sectors.

This means that mandatory zero-carbon-ready building energy codes for all new buildings need to be introduced in all regions by 2030, and that retrofits need to be carried out in most existing buildings by 2050 to enable them to meet zero-carbon-readybuilding energy codes. Governments will need to find ways to make new zero-carbon-ready buildings and retrofits affordable and attractive to owners and occupants by overcoming financial barriers.

Fig.7: Net Zero Energy Buildings in India

Most of these buildings are in hot and dry, composite or warm and humid climate except for one in Uttrakhand.

TECHNOLOGY INNOVATION IN THE NZE

Innovation is key to developing new clean energy technologies and advancing existingones. Without a major acceleration in clean energy innovation, reaching net-zero emissions by 2050 will not be achievable. Technologies that are available on the market today provide nearly all of the emissions reductions required to 2030 in the NZE to put the world on track for net-zero emissions by 2050. The importance of innovation increases as we get closer to 2050 because existing technologies will not be able to get us all the way along the path to net-zero emissions.

CASE STUDY OF INDIRA PARYAVARAN BHAWAN, NEW DELHI

First on-Site Net Zero Energy Building

The building is G+7 (Ground + Seven) storeyed with three basements,35m height and plinth area of 32,000sqm with entrance of 4 storeyed height (Fig 8 & 9). The building is fully air-conditioned and designed with all essential services and special features like;-

Fig. 8:Indira Paryavaran Bhawan

- Energy Efficientbuilding envelope.
- Water conservation measures.
- Green Building materials.
- Fully automated robotic parking of 330 cars.
- Efficient HVAC system.
- Chilled beam system, Geothermal Heat Exchange system. All the un-conditioned spaces like Toilets, Stores, AC plant room, Pantries and Kitchen have been provided with mechanical ventilation system including all the three basements.

Fig. 9: Indira Paryavaran Bhawan

- 7 nos. Regenerative Lifts, Intelligent Building Management System to monitor all parameters of HVAC system and other services in the building.
- Usage of high efficiency lighting fixtures, Occupancy sensors and day lighting sensors to optimize energy usage.

Solar PV

- With solar power installation capacity of 800 KWH, using Mono crystalline solar panels of 20% efficiency, entire energy requirement of 14 lakh units per year is being generated thereby making it on-site net zero energy building.

January 2014 to 2023 March Actual Generation (Kwh) Monthly wise.

MONTH & YEAR	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
JANUARY	57,412.35	60,182.70	60,720.60	68,459.80	78,542.70	71,168.50	60,819.04	53,480.61	24,583.00	68,507.00
FEBRUARY	77,952.68	81,843.12	84,263.25	91,304.23	78,025.36	69,724.69	59,527.00	57,222.72	27,371.00	95,290.00
MARCH	116,868.60	102,213.07	112,780.73	121,184.64	98,302.82	115,833.46	67,359.00	61,874.79	26,755.00	104,985.00
APRIL	131,237.15	106,948.52	121,618.80	123,904.92	90,923.79	119,714.43	71,873.94	66,145.47	-	
MAY	130,061.06	109,951.73	115,175.27	112,839.91	65,153.87	95,167.32	71,179.00	64,319.12	-	
JUNE	119,636.78	105,762.37	105,415.27	106,440.08	100,180.26	112,173.29	73,057.00	41,273.17	-	
JULY	107,879.93	91,241.31	79,636.00	97,757.06	86,274.94	82,812.40	62,300.00	33,436.00	41,154.00	
AUGUST	111,081.64	103,465.00	92,813.33	93,916.26	79,510.77	84,926.00	56,391.89	33,761.00	102,769.00	
SEPTEMBER	110,600.18	111,081.64	107,362.30	107,752.95	87,686.00	84,282.00	61,888.00	30,186.00	90,935.00	
OCTOBER	96,638.63	103,654.69	94,739.75	95,166.72	98,763.15	79,757.00	66,365.85	31,814.00	45,423.00	
NOVEMBER	74,117.63	67,540.59	72,483.84	69,518.51	69,373.43	55,742.00	61,611.79	28,033.00	76,101.00	
DECEMBER	62,051.00	66,442.45	64,799.19	75,859.74	70,868.20	48,038.00	72,598.00	26,885.00	77,051.00	
	1,195,537.63	1,110,327.19	1,111,808.51	1,164,104.82	1,003,605.29	1,018,839.09	784,970.51	528,430.88	512,142.00	268,782.00

Fig. 10: (Table showing actual generation Jan 2014- March 2023)

- Area available at terrace for installation of Solar PV was 2200 sqm against required area - 6000 m2, so entire central courtyard had to be covered with space frame and additionally 6 m cantilevers all around and 12 m cantilever at four corners in addition to 6 m cantilever at fourth floor level on southern side had to be provided for completing on-site generation.

Details of Comprehensive maintenance and operation of the minimum 14 lakh units generation with 800 KWp of New Building for Ministry of Environment and Forest at Aliganj, Jor Bagh Road, New Delhi are shown in Fig 10 below:-

There were some equipment faults during year 2019-2021, hence generation was affected due to equipment faults.

Learnings

As a thumb rule, to generate entire energy through solar panels, area required for solar panels is minimum 30% plinth area of superstructure. It means that in any multistoreyed building, it is not possible to provide 100% on-site generation of energy unless special arrangements are made to increase the area for providing solar panels like in IPB by covering the entire central courtyard (2000 sqm) and cantilever projection not just at roof level (more than 6m all around) but 6m on southern side at 4th floor level. Providing these cantilevers also leads to reduction of natural daylight into the building, reducing energy efficiency in addition to special structural provisions with cost implications as well.

It is also understood that median solar panel degradation rate is around 0.5-1.0% per year, which indicates that the energy output of a solar panel will drop by 0.5-1.0% every year. Your panels may still be producing around 90% of their original output after 20 years. It is also observed in IPB generation table above, although it is not uniform degradation but it is little more than 0.5% annual rate. Therefore to achieve long term net zero effect, the building should be designed as energy plus.

SOME IMPEDIMENTS REQUIRING ATTENTION IN ACHIEVING NZE

- Huge amount of Research is required to find out ways to make all new buildings NZE and convert all existing buildings to NZE. It is not possible to have 100% onsite generation and lot of land will be required for off-site generation, not just land but this may also require cutting of existing trees which will negate the purpose / mission of NZE. Installation of solar power plants requires nearly 2 hectares land per MW capacity. Although Solar sharing , canal top solar PV, solar panel layers, solar trees, vertical solar panels, solar panelled roads, floating solar panels etc. are some of the options available to save land but how much load can be shared with these options is yet to be ascertained.
- Most of the Net zero buildings constructed in other developed countries are low rise with huge land around and good amount of roof area. (This kind of situation is very rare in India) Many of these are energy plus also. Some multistoreyed buildings are net zero with 90% off-site generation and only 10%on-site generation of renewable energy.

CONCLUSION

- India achieves a net-zero energy system by 2050 with most sectors getting close to zero emissions with defined areas of action in the next 30 years.
- Innovation is key to developing new clean energy technologies and advancing existingonesto achieve net-zero emissions by 2050.
- NZE Building may or may not be Green / Climate sensitive,so the correct approach for design of NZE Building is that it must be Green / Climate sensitive in order to harness the potential of Renewable energy generation.
- To achieve long term net zero effect, the building should be designed as energy plus.
- 30-40 million hectares of additional forest cover

is required to remove unavoidable emissions and millions of hectares for solar and wind energy production which would requireEfficient land use practices.

- New codes need to be developed and strategies for their strict implementation to fulfill the NZE mission.
- Hon'ble Prime Minister's vision of One Sun One World One Grid (OSOWOG),a transnational electricity grid supplying solar power across the globe in order to make use ofavailability of sunshine in different neighbouring countries at different times can be of great help to fulfill the NZE mission.

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NET ZERO ENERGY GREEN BUILDINGS

Dr. K. M. Soni

Abstract

The buildings consume considerable energy in construction and its operation & maintenance. A net zero energy building is the one which consumes energy in its operation and maintenance equal to the energy generated either onsite or off site. However, a building is constructed using large number of materials which have embodied energy and therefore to make a building energy efficient from the consideration of construction and operation & maintenance, green concept is also required to be followed in addition to make it energy efficient. Main features followed in a net zero energy building are energy generation from renewable resources and energy conservation. Some of the net zero features for energy conservation adopted are energy efficient building envelope, siting of the building to receive optimum energy, providing energy efficient lighting, air-conditioning system, lifts, pumps, fans, electrical and mechanical equipment, electric gadgets and geothermal heat exchange system. Energy generation is generally through solar, wind, bio mass, tides or similar renewable sources.

CPWD constructed first onsite net zero building in Delhi during 2013 which was also rated as a five-star green building conforming to Green Rating for Integrated Habitat Assessment (GRIHA) council of India. Green building features included by way of providing sustainable and energy efficient design and materials by appropriate architectural, civil, electrical and mechanical, landscape and horticulture designs.

The paper discusses the measures which can be adopted in a net zero energy green building.

INTRODUCTION

Net zero energy or zero energy building is a building with net zero energy consumption during its operation & maintenance on annual basis. Thus in a net zero energy building, total amount of energy consumed by the building on an annual basis is equal to the amount of renewable energy generated in the building either onsite or offsite. When such amount of renewable energy is generated at site, the building is known as onsite net zero energy building otherwise offsite net zero energy building. When generated energy is more than consumed, it is called energy plus or positive energy building. The objective of net zero or net zero plus buildings is to contribute in saving environment and contribute less in generating greenhouse gases during its operation while objective of green buildings is to construct eco-friendly energy efficient and water efficient building having comfortable hygienic indoor air quality. Therefore, ideally a building should be net zero energy green building conforming to sustainable development, environment friendly and for wellbeing of occupants.

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FEATURES OF A NET ZERO AND GREEN BUILDING

I. Features of Net Zero Buildings

- Building envelope and its orientation to minimize energy consumption and HVAC loads.
- Energy efficiency measures by adoption energy conservation through energy efficient fans, lights, ACs, electric pumps, and other electric equipment.
- Energy generation through renewable energy resources like solar, wind, bio mass etc.
- Regeneration of electric power through non-conventional sources like regenerative lifts, floor friction measures.
- Providing energy efficient gadgets and equipment requiring electric power.
- Bringing down the HVAC load by circulation of cool water in the cooling system for example through geothermal system.

- Providing sun reflective building materials, paints and coatings during summer and sun absorbing during winter.
- Providing energy insulation in the outer walls/ surface and roof.
- Energy efficient design of the building.
- Constructing smart homes avoiding wastage of energy.
- Reduction of carbon footprint

II. Features of Green Buildings

- Energy efficient
- Water efficient
- Comfortable and hygienic indoor air quality
- Green and sustainable building materials
- Waste minimization
- Structural efficiency
- Durability and safety
- Preservation of natural materials
- Reduction of air, water and noise pollution
- Welfare of construction employees at site and reduction of adverse health impact during its occupancy
- Innovations in adoption of eco-friendlymeasures

COST OF NET ZERO ENERGY BUILDING

Green buildings are reported to be costly compared to conventional buildings by 2 to 18% and payback period is reported to be varying from 3 to 7 years. Since life of a permanent RCC framed building is considered to be 75 years, in long run it always becomes economic. Vyas and Jha (2018) have reported that average increase in initial cost of green building is 3.10% for three-star rating and 9.37% for five-star green building. A five star rated building can be considered equivalent to platinum rated building. Further, they have reported that discounted payback period for green buildings is 2.04 to 7.56 years for three-star and 2.37 to 9.14 years for five-star rated projects. Thus, discounted payback period and additional cost in case of green buildings depend upon the green rating though it is obvious.

CASE STUDY NO. 1 OF INDIRA PARYAVARAN BHAWAN, NEW DELHI

CPWD constructed onsite net zero energy and green building, considered a first one onsite net zero energy building.The building is located in a plot of 9000 sqm in Aliganj area on Jor Bagh Road, New Delhi known as Indira Paryavaran Bhawan of the MoEF&CC, Government of India. As per the objective, the building was envisaged on the philosophy of conserving energy with minimum impact on environment by way of providing energy efficient design, and energy efficient materials simultaneously using non-conventional energy resources for generation of electricity meeting its total energy requirement from renewable energy sources i.e. solar power.

The building is G+7 (Ground+ Seven) storeyed with three basements having height of 35m and plinth area of 32,000sqm (Fig. 1) with entrance of 4 storeyed height (Fig. 2). The building was fully air-conditioned designed with all essential services like lifts, diesel generating (DG) sets, uninterruptable power supply system (UPS), integrated building management system (IBMS), fire detection and fire fighting systems, closed circuit televisions (CCTVs), access control, automated car parking, furniture, electrical services, landscaping, and horticulture services. The services like air-conditioning (AC)

Fig. 1: A view of the building

plant room, electric substation, DG sets, fire fighting pumps, car parking and sewage treatment plant (STP) were accommodated in the basements. To take advantage of natural ventilation across the building, a central courtyard was created between North and

Fig. 2: Entrance Atrium

South blocks. First basement was designed for car entry/exit lobby and puzzle parking system, while second and third for robotic dolly parking system.

As solar power was to be used for generating entire energy demand for the building, required area was calculated as 6000 sqm for installation of solar panels. To get such area, central courtyard was also covered with space frame of stainless steel tubular sections, and mild steel (MS) supporting structure was extended as cantilever over the roof and at fourth floor level of southern side.

The building envelope was made Energy Conservation Building Code (ECBC) compliant, most of the existing trees preserved during siting of the building, energy efficient and local materials used, waste management good practices adopted, and health and well being measures for workers and users provided. "Net zero energy" criterion was achieved through onsite solar power generation, and energy conservation by way of implementation of energy efficiency measures in construction, equipments and methods.

After the completion, the building was got rated from two independent Indian green building rating agencies. The details of green building parameters evaluated by GRIHA council and IGBC.

Materials and Method Used

Since the building was designed as a green and net zero energy building, building materials and products conforming to sustainable criteria were adopted. Some of the green materials used are Ready mixed concrete (RMC) in RCC, Portland Pozzolana cement (PPC) in concrete, masonry and plaster works, Fly ash Lime - Gypsum (Fal-G) bricks and Autoclaved Aerated (AAC) blocks in masonry work, Rockwool insulation of very low thermal conductivity in outer walls and concrete surfaces, coba treatment on roof with insulation of polyurethane over it and heat reflective tiles laid for solar reflectance.

To minimise use of natural wood, energy efficient bamboo/jute composites door frames and shutters, and hermetically sealed double glass un-plasticised Poly Vinyl Chloride (uPVC) windows were provided. Gypsum boards, fibre square tiles and calcium silicate tiles were used in false ceiling containing waste products. In internal painting, low Volatile Organic Compounds (VOC) paints were used to avoid toxic fumes. Water fixtures with low discharge and Sewage Treatment Plant (STP) for recycling waste water were also provided.

Energy efficient chilled beam system for air conditioning, geo-thermal heat exchange system to utilize advantage of lower temperature below ground level compared to ambient temperature, regenerative passenger lifts, thermostat controls for heat ventilation and air conditioning (HVAC), light emitting diode (LED) lights, and occupancy and Lux level sensors were used for energy efficiency in the building.

Mono crystalline solar panels of 20% efficiency were provided to generate entire solar power.

Grass paver blocks in pavements and roads, and hard areas, plantation and grassing in more than 50% of the area outside the building and rain water harvesting arrangements were provided.

To make the building green, steps taken included appropriate architectural design, selection of green and sustainable building materials, energy efficient equipment, potable and waste water management, energy optimisation and better indoor air quality. Net zero energy concept was implemented by maximisation of energy generation and minimising energy consumption.

Net Zero Energy Concept

Initially annual energy requirement was estimated to be 1.5 million units (KWh) requiring about 6500 sqm area for installing solar panels. Since the rooftop area was not sufficient to install solar panels to generate required power, cantilever projection of rooftop was extended by 6m all-round considering structural and architectural efficacy. As this also fell short of the requirements, central courtyard having span of 26m to 33m was covered with stainless steel space frame (Fig. 3), and cantilever projection provided on 4th floor level on the Southern side (Fig. 4) to accommodate solar panels for balance requirement. This resulted into availability of about

Fig. 3: Covering of Central Courtyard

Fig. 4: Extended Roof at 4th floor and Roof Level

6000 sqm area for installing solar panels capable to generate 1.4 million units against the requirements of 1.5 million units. This gap of 0.1 million units was then zeroed by minimising overall energy consumption by reducing energy demand by way of using additional insulation in the building envelope, geothermal heat exchange system, and "Thin client system" in which common servers, printers and photocopier machines up to a particular level of officers were provided.

Geothermal heat exchange system provided to minimise energy demand consisted of three subsystems as geo-thermal heat pump to move heat between the building and the water in the earth connection, an earth connection for transferring heat between water and earth, and a distribution subsystem for delivering water to the building by providing a vertical loop system with a network of 180 bore holes at 3m distance each to a depth of 80m in which water was circulated. One high density polyethylene (HDPE) U-loop of 32mm diameter was lowered into each borehole and back filling carried out with excavated soil. The vertical HDPE looping was terminated at 2m below ground level and the terminal points interconnected with horizontal pipe network of galvanised iron pipes of 32mm diameter. The horizontal pipe network in turn was connected with supply and return header MS pipes of 100mm diameter above ground level, running all along the boundary wall finally joined with condenser header pipes. Total 160TR of heat exchange capacity was obtained through such geothermal exchange system. Further energy efficiency was achieved by way of providing energy efficient elevators/lifts together with regenerative drive system.

Green Building Features of Indira Paryavaran Bhawan

The building was rated as a five-star green building of GRIHA scoring of 91 points out of 100 against 34 criteria consisting of sustainable site planning, water management, energy optimisation, sustainable building materials, waste management, health and well being, building operation and maintenance, and innovation grouped into mandatory and optional provisions.

These 34 criteria can be clubbed into eight categories as sustaining site planning, water management, energy optimisation, sustainable building materials, waste management, health and well being, building operation and maintenance, and innovation. Under sustainable site planning, the site was having connectivity with bus and metro stations, building having all necessary approvals from the local bodies, out of 79 trees existing at site before commencement of the work, 48 preserved, 20 transplanted and 75 new trees planted along boundary wall against 33 required in lieu of 11 removed, top soil removed from the site reused for landscaping, all the features of energy efficiency, open courtyard, required setbacks and vehicular movement for minimum disturbance adopted, entire parking accommodated in the basements, limited paved area, transportation and service corridors provided to avoid unnecessary cutting, trenching provided for all utility services, and utility service lines clubbed in three different locations qualified for the points.

Under water management category, 5 criteria are included. The parameters were reduction of 44.38% annual water requirement by adopting water saving measures like micro sprinkler and drip irrigation systems, and use of plants of native species, reduction of water use through installing fixtures like sensor based urinals, low water dual flushing water closets, low water flow faucets using aerators and by reduction of water demand in landscaping and make up cooling towers of air-conditioning, measures adopted for reduction of water by adopting efficient curing method and use of pre-mixed concrete, providing waste water treatment through sewage treatment plant of 30 kilo litres per day (KLD) capacity and treated water used for cooling tower make up water, toilets and irrigation, and two rain water recharge pits for water storage were constructed each of 36 cum capacity thus recycled water fully utilised.

Under energy optimization category, 5 criteria were included. 50 to 87 Lumens/Watt LED lighting fixtures with automatic controls powered by renewable source were provided for outdoor, security, street, landscape, and facade lightings against bench mark of 50 Lumens/Watt in addition to all outdoor lighting fixtures provided powered by stand alone solar energy panels, optimization of building design to reduce conventional energy demand was fulfilled through longer sides of the building facing North and South, WWR as 17%, effective SHGC of fenestration as 0.25, daylight area as 75.1%, wall and roof assembly including window glazing ECBC (ECBC 2007) compliant, and Lux levels maintained according to NBC. All mandatory requirements of ECBC were complied including provisions of occupancy and daylight sensors, dry type transformer of 1000KVA installed having losses of 10W only at full load, cooling towers provided with variable frequency drive fans, building management system installed for controlling HVAC system, and geothermal cooling system installed. EPI actually achieved was 24.13KWh/m2/yr against benchmark of 74.01KWh/m2/yr demonstrating 67.39% reduction in energy consumption. All such measures entitled full 16 points in this criterion. Criterion for renewable energy utilization and being net zero energy building resulted into all 5 points. Criterion for renewable energy based hot water system was fulfilled by way of meeting entire hot water demand of 1000litres/day from the installed solar water heating system of required capacity. Thus, all energy efficiency measures of a net zero building were also fulfilled.

Under sustainable building materials category, utilization of fly ash, reducing volume, weight, and time of construction by adopting efficient technologies through use of 30% fly ash mixed in cement, AAC blocks, and Fal-G bricks, use of low energy materials in interiors like gypsum boards, pre-laminated boards, fibre square and calcium silicate false ceiling, and bamboo jute composite doors were provided. It even resulted into 54.8% embodied energy reduction in non-structural members.

In waste management category criteria, waste segregation was implemented by providing prescribed coloured dust bins placed on each floor, space allocation made for collecting waste before transferring to recycling plant or landfill however all the points could not be achieved under this category.

In health and wellbeing category, facilities like clean and hygienic toilets, drinking water, first aid, rest rooms, crиche, pantry, signage, safety gadgets, fire safety measures, masks, and safety environment were provided for workers, air pollution during construction reduced by regular spray of water on roads, construction of brick bat temporary roads, covering of dusty materials, tyre washing of trucks, and use of dust barriers and masks, use of low VOC paints, adhesives and sealants, 100% Chlorofluorocarbon (CFC) and Hydro Chlorofluoro carbon (HCFC) free insulation, CFC free equipment for refrigeration and air-conditioning and halon free fire suppression system, providing water quality conforming to the standards, providing acceptable outdoor and indoor noise levels as per CPCB norms, framing and implementing tobacco smoke control policy within public areas and providing required level of accessibility for persons with disabilities qualified for scoring of points.

Other criteria for audit and validation, operation and maintenance and innovation included energy, water, waste, and noise level audits, efficient and effective maintenance and for uploading data on exclusive website. Thus, total 91 points were scored out of maximum 100 marks qualifying for 5-star GRIHA rating. The building was also got rated for platinum rating under LEED rating and achieved.

Another important feature of the building was net zero energy building with 100% on site renewable solar power generation having installed capacity of 930KWp. Energy generation was started from 19.11.2013 which is being fed into the grid from where supply is taken.

Cost Analysis

The fixed cost of the building was Rs 13900 lakhs including cost of energy efficiency measures. The extra cost on account of incorporating 5 star rated GRIHA green building features and enhanced comfort conditions (Central air-conditioning with heating system) was about 13% of the total cost. One of the major investments was on advanced system of air-conditioning (chilled beam system of air-conditioning) system being about 50% costlier than conventional air-conditioning system but energy consumption was almost half. Energy efficient regenerative lifts were about 20% costlier than the conventional lifts.

The annual energy consumption in a conventional building would have been 21 lakh units compared to14 lakh units per year in the building had the energy efficiency measures not adopted. Thus, there was an annual saving of nearly 7 lakh units per year due to adoption of energy efficient measures. Since the building was net zero energy and green building, it saved all 21 lakh units required in conventional building resulting into a saving of Rs 126 lakhs per year compared to a conventional building. Since HVAC provided in the building also catered the requirements of heating during winter, it also saved energy required in heating the building.

With solar power installation capacity of 930 KWH, entire energy requirement of 14 lakh units per year is being generated through solar power thereby making it onsite net zero energy building. Advantage of solar panels is that maintenance cost of such panels is negligible. The power generated is being fed into the grid as the timings of consumption of power vary with the generation and same amount of power being drawn from the grid as per the requirement from time to time. Therefore, there are no losses of generation of power even if there is no sufficient requirement during particular period or days and as such no security costs.

Since the power generation is through renewable source, there is no CO_2 emission in the generation while it is saving CO_2 emission of 14 lakh units of energy and net zero energy building is saving CO_2 emission required in generation of 21 lakh units which may be about 1300-1400 tonnes per year.

The return rate of capital or return on investment between a project that would use fossil energy and the present one based on renewal energy which has additional facilities like automated parking, furniture and enhanced comfort conditions is expected to be 14 years considering current rates of electricity.

CASE STUDY NO. 2 WITH SOLAR TREES

A solar tree is a metallic structure on which solar power system is installed on a single column like a tree trunk. Advantage of solar tree is that it can house many solar panels in various directions and also act as an artwork. These are generally planned in open areas like public places, parks, gardens and large campuses having open areas.

Fig. 5: Energy Conservation

Forty-one solar trees (Fig. 5) have been installed in the campus of National Salt Satyagraha Memorial, Dandi, Gujarat by CPWD which has become a net zero plus energy campus. The peak power generation of the system is 144kW, installed with generaion capacity of 182kWp. Out of this 90kW is planned as online system with net metering and other infrastructure, and 54kW offline system in two parts of 26kW and 28kW with battery backup. Each solar tree has 12 leaves. The main components of solar tree are trunk, branches and leaves with foundation.

Energy conservation is a better measure compared to energy generation hence energy conservation has to be given topmost priority. Measures like avoiding wastage of agricultural products, industrial products, construction materials, natural materials, electric power itself, water, and optimization of air-conditioning temperature have to be adopted religiously as they require considerable energy in their extraction, production, treatment, transportation and dismantling.

India's Commitment

India has promised to cut its emissions to net zero by 2070. Hon'ble Prime Minister Narendra Modi made the pledge and first time India has set a net zero target, at the Glasgow summit. Net zero, or becoming carbon neutral, means not adding to the amount of greenhouse gases in the atmosphere. India has large network of thermal power plants as such it has to switch over to carbon neutral power generation resources. Therefore, it is likely that hydro power plants will also be in the ambit of net zero mission of carbon free emissions including renewable resources like wind, solar, tidal and bio mass power generation. Net zero carbon emissions can be achieved through onsite or offsite green power generation.

Impediments in Adoption of Net Zero Energy and Green Buildings

Even though engineers are aware of the benefits of the net zero energy and green buildings, number of such buildings is not at all satisfactory. Reasons of the same include high initial cost, mindset of high initial cost among engineers, financial advisers and policy makers, requirements of engagement of external consultants resulting into avoidance of net zero energy and green buildings by planners and engineers due to procedural complicacy, lack of knowledge of green materials and technologies among all levels of engineers and availability of few rating agencies. There is a need of developing in house capability of planning, implementation and ratings of net zero energy and green buildings within various public works organizations.

CONCLUSION

Net zero energy and green buildings need to be adopted by all the public works organizations for eco-friendly and sustainable development. Therefore, all stakeholders have to make the process viable by way of planning, sanctioning, execution, and rating of net zero energy green buildings.

Even though, net zero energy and green buildings are initially costly, ultimately it proves to be economical, and environment friendly in long run. In case, these are adopted on large scale, the cost and discounted payback period will also get reduced.

Two case studies have been presented in the paper which indicate that the planning and execution of net zero energy and green projects can be implemented by the architects, and engineers engaged in the planning and supervision of the projects easily as sufficient knowhow is available with various organizations.

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INITIATIVES TO ACHIEVE NET ZERO ENERGY BUILDING IN OFFICE COMPLEXES

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Abstract

Climate change isn't a challenge for tomorrow. It is an imperative for today which can be solved only through an integration of will along with skill. Businesses, governments, investors and society need to work together to harness bold new ways to accelerate the race to net zero and tackle climate change head on.

The world is at the cornerstone of a paradigm shift in terms of the energy requirement and its fulfilment amidst strong narrative for decarbonising the planet to limit the rise in the global temperature. In recently concluded Conference of the Parties (COP)-26 at Glasgow, our Hon'ble Prime Minister announced that India is poised towards achieving net zero by 2070.

To meet the national target of net zero by 2070, organizations need to finalize a roadmap for implementing vision of net zero from their own campuses. To achieve that, engineering philosophy and business models need to be re-focused for long term sustainable growth by evaluating performance on the triple bottom lines of economic, social and environmental impacts. Every organization with built assets has to further develop core competency to evaluate and achieve short, medium, long-term targets at large for their net zero endeavours.

The current paper will focus on a vision and policy to achieve the target of Net zero in built infrastructure along with the other activities which can be identified for implementation under Net Zero initiatives by an organization.

INTRODUCTION

The world is at the cornerstone of a paradigm shift with respect to energy requirement and its fulfilment amongst strong narrative for decarbonising the planet to control global warming.

Considering the impacts of climate change, governments from across the world have come together in recent years with Kyoto Protocol, the Paris Agreement and the recent COP26 in order to try and mitigate the damages caused. As per the report by Climate Change Performance Index (CCPI), an independent monitoring tool that provides information on the Paris Agreement implementation phase, India has been ranked 10th amongst 65 nations due to its climate change policies and mitigating plans.

As a result of the vision set for India, our Hon'ble Prime Minister announced "Panchamrit" where in India has pledged to be a Net Zero emission nation by the year 2070 in COP26, Glasgow. Further, systematic implementation of steps must be undertaken to reduce emissions. Some of the goals are as listed:

- India will take its non-fossil energy capacity to 500 GW by 2030.
- India will meet 50 percent of its energy requirements from renewable energy by 2030.
- India will reduce the total projected carbon emissions by one billion tonnes from now till 2030.
- By 2030, India will reduce the carbon intensity

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of its economy by more than 45 percent.

- By the year 2070, India will achieve the target of Net Zero

All the processes in the building sector involve operations of built environment right from its construction to its occupancy and maintenance stage. The boom in the building sector resulted in tremendous direct and indirect impact on the environment through the use of non-renewable energy resources, poor building design, lack of sustainable thinking in urbanization and emissions of significant amount of CO_2 in the environment. Building sector represents more than 40% of overall energy consumption in both developed and developing countries.

As a result, it is imperative that for efforts related to reduction in CO_2 emission in building industry, the first and foremost step should be energy conservation planning and the execution of methods to decrease potential emissions.

WHAT IS "NET ZERO" IN BUILDINGS?

Net Zero offers a framework for high-performance buildings and spaces and reducing dependencies on non-green power through strategies impacting land, energy, transportation, water, waste and materials. Put simply, Net zero means reducing energy consumption through passive means, making building systems energy efficient, generating on-site renewable energy and finally cutting dependency on off-site Grid energy of any kind.

HOW TO ACHIEVE "NET ZERO ENERGY" FOR EXISTING OFFICE BUILDING COMPLEXES?

Since the building is already existing in its shape, form, orientation etc., to start with, a detailed Energy Audit of the entire building complex should be carried out to identify the opportunities in improvement of Energy Efficiency of the equipment and to promote reduction in annual energy consumption by effective equipment utilization. The objective to undertake an energy audit is to identify areas for energy saving, both with and without investment and also to prioritize distinct areas identified for energy savings depending upon saving potential, skills, utility along with time frame for execution, investment cost, paybacks etc.

Energy audit of the building complex should cover various areas of work for identification of saving opportunities in power consumption like review of present electricity consumption, fuel oil, estimation of reduction in energy consumption in various load centres like Building Area, Heating Ventilation and Air conditioning (HVAC) System, Lighting, Electrical distribution system, Diesel Generator sets and motors etc.

The various areas covered in the audit to be followed should be:

Lighting

- Review of present lighting system.
- Estimation of lighting load at various locations like different floors, cabins and other locations.
- Detail lux level survey at various locations and comparison with standards.
- Study of present lightning control system
- Analysis of lightning performance density, LPD watt/m^2
- Exploring the energy conservation options in lighting system.

Electrical System

- Study monthly electricity bill to suggest potential of cost reduction.
- Review of present electrical distribution system and study of reactive power management and options for power factor improvement.
- Exploring the Energy Conservation Options in electrical distribution system.
- Diesel Generator set - Exploring the energy conservation option in DG sets.
- Study of pump motor load current and energy consumption.

Heating Ventilation and Air conditioning (HVAC) System

- Study present HAVC system like package A/C, window A/C, split A/C.

- Performance assessment of window A/C, Split A/C etc. and suggest optimum temperature setting to achieve maximum efficiency at minimum power consumption.
- Performance assessment of cooling towers and package units.
- Analysis of HVAC performance like estimation of energy efficiency ratio (kW/Tr), specific energy consumption, condenser water pumps etc.
- Exploring the energy conservation options in HVAC system.

Building Area

- Air leakage of air-conditioned area in the building.

After the completion of various aspects of the energy audit report as listed above, the following initiatives should be undertaken to further achieve the target of Net zero Energy.

Reduction in demand side of the energy

The overall energy demand of the building should be firstly evaluated by analysing the building envelop and all installed systems within the building. All Mechanical, Electrical, Plumbing (MEP) building systems as required should be changed to efficient machines, fixtures so as to reduce the overall demand side of the energy used in the building. Alternatively, energy simulation of the existing building should also be carried out with software and existing building envelop properties evaluated for thermal performance. The improvement suggestions as derived from the software should also be implemented in terms of re-organising of internal spaces within the building, increasing the insulation of the building envelop, to reduce the cooling demand in case of HVAC system through using insulation panels on the internal walls or changing the glass properties on the faзade of the building etc. Use of energy efficient lighting systems, motors etc., should also be explored for further reduction in demand side of energy.

Reduction in energy use

The overall energy use should also be optimised through use of occupancy sensors etc., in cabins, conference rooms etc., of the building. Probable areas of air leakage through the building envelop should also be evaluated. The measures under this initiative can be as simple as installing door closer on all external doors to reduce cooling losses or as extravagant as changing normal glazed windows to energy efficient glazing to reduce the overall cooling load demand.

Behavioural/Active measures to reduce HVAC load

Certain additional measures to reduce the HVAC loads during office hours can also be explored which are directly related to the user comfort within the building. As per latest comfort guidelines and trends, the indoor room temperature can be set to at least 2 degrees more than the desired 24 degree C, thereby reducing the HVAC loads and subsequent achievement of reduction in electrical power demand. The increase in temperature can be done in fragments of 0.5 degree C every month to finally set the indoor temperature at 26 degree C after 4 months causing a smooth transition for occupants from 24 to 26-degree C. Accordingly, switch-on and switch-off timings of the HVAC systems can also be regulated in favour of reducing the power demand further. For example, the HVAC systems can be shut at least 30 minutes prior to the closure of office timings.

HVAC optimization and improving energy efficiency of HVAC system by implementing BMS Control scheme

Building Management System (BMS) Control scheme should be integrated with the existing HVAC system to further optimize the energy consumption. In case, individual Air handling unit (AHU) return air temperature is monitored in BMS and is controlled by maintaining closed loop control of chilled water flow control valve, so in order to improve the efficiency, it should be proposed to implement AHU speed control through Variable Frequency Drive (VFD) from BMS using return air temperature closed loop control, by keeping chilled water valve at maximum open position. This will provide faster response as well as energy saving. In case further temperature control is required even after the VFD speed reduced to minimum recommended value, the chilled water flow control valve opening can also be modulated, i.e., split range control should be provided through BMS. Additionally, temperature control with respect to outside Ambient Temperature can also be proposed.

For application of the above, VFDs should be introduced in air conditioning systems by providing variable flow chilled water system, chilled water pumps (including a standby) with variable speed drive to achieve variable water flow. Cooling tower should also be provided with drift loss eliminators. All AHUs should be variable volume type, double skin (for noise control) construction and should comprise of centrifugal fans coupled to variable frequency drive. All conference rooms should be provided with Variable Air Volume (VAV) boxes with Direct Digital Controls to regulate the primary air flow rate between the scheduled minimum and maximum values to achieve the specified comfort level. Any outdoor fresh air to be introduced inside the building should be cooled, dehumidified & filtered prior to adding to occupied space inside the building. Centralized fresh air treatment unit should be coupled with heat recovery arrangement.

Additionally, all split air-conditioners installed in the building should be replaced with 5-star machines as per the latest BEE guidelines in phased manner to have most optimum machines installed in the building.

In the nut-shell, all old and inefficient machinery, chillers, pumps etc., should be replaced with latest and most energy efficient ones and should be coupled with BMS system for energy efficiency and enhanced performance.

Evaluating the performance of renewable energy sources which can be implemented in the building complex

Once all the decisions on the energy demand and reduction side have been implemented and put in place, the next step is to generate the reduced energy requirement preferably onsite through renewable energy sources to balance the energy generated and energy consumed tables.

However, the most important part in this initiative is that the decision on options of alternate energy sources, which is very challenging for any organization. Firstly, there are several alternatives such as biomass, solar, wind, water, geo-thermal etc., which are available and can be implemented locally on the site itself depending on the geographical location of the site. But the fact still remains that any organization will have limited resources and cannot invest in all alternatives simultaneously and equally. It is also very difficult to predict which energy alternatives will be most beneficial in the long term.

Secondly, the development of energy alternatives depends on many factors such as geographic conditions, population, payback period, etc. which reiterates the fact that an"energy alternative" that is well suited for one building complex may be the worst choice for another complex.

Thirdly, there are many criteria's such as cost and security that dictate the selection of energy alternatives.

Therefore, it is very important to have a systematic approach for selection of most suitable kind of renewable energy alternative to be implemented at the office complexes. The same can be done by following the four-point assessment criteria as listed below:

1. Reliability of the alternative energy sources as per the geography
2. Overall life-cycle cost of the installation
3. Maximum Capacity which can be installed vis-a-vis output
4. Environmental Impact of the facility

As per the evaluation on the above parameters, a decision can be judiciously made for selection of one or more types of renewable energy installations which can be done in an office complex to off-set the reduced energy demand of the buildings through renewable sources. This would reduce the building's energy demand from non-renewable sources and main grid.

The best approach in this context would be to achieve renewable energy generation to an extent so as to reduce the grid demand of energy to zero thus making the campus self-sustainable in terms of energy and power demand.

CONCLUSION

With sincere implementation of all the above initiatives in a phased manner, it is easily possible for organizations to achieve "Net Zero Energy Building", particularly in case of large complexes wherein ample amount of land is available for generation of on-site renewable energy.

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EFFECTIVENESS OF RENEWABLE ENERGY MEASURES FOR ACHIEVING THE TARGET OF NET ZERO 2070

DR. SUSHMA* AND NARENDER SINGH**

Abstract

The sheer size and massive scope for growth of our country reflects that its energy demand is set to grow by more than that of any other country in the coming decades and we have to evolve alternate/ renewable energy sources to cope up with the situation. During the 26th Conference of Parties (COP-26) in Glasgow, Prime Minister made an announcement that India aims to reach net zero emissions by 2070 and to meet 50% of its electricity requirements from renewable energy sources by 2030. This aspiring target includes installation of 500 gigawatts of renewable energy capacity, reducing the emissions intensity of its economy by 45% and reducing a billion tonnes of CO_2 by 2030. The necessary infrastructure for the most popular renewable energy sources (Solar energy, Wind energy, Hydro energy, Tidal energy, Geo-thermal energy and Biomass energy) needs to be set up so as to effectively implement and efficiently achieve the target of net zero and fulfil the commitment of our country given before COP-26 in Glasgow. Achieving net zero is not just about reducing greenhouse gas (mainly CO_2) emissions; but also our energy transition needs to benefit the citizens, and well-designed policies can limit the potential trade-offs between affordability, security and sustainability.

In this paper, efforts have been made to elaborate the effectiveness of renewable energy sources to reduce the greenhouse gas (GHG) emissions and to achieve the target of net zero.

INTRODUCTION

The scale of transformation in India is astonishing. Its economic growth has been among the highest in the world over the past two decades, lifting of millions of people out of poverty. Every year, India adds a city equal to the size of London to its urban population, involving vast construction of new buildings, factories and transportation networks. Coal and oil have so far served as bedrocks of India's industrial growth and modernization, providing access to modern energy services to a rising population. The rapid growth in fossil energy consumption in our country has raised the annual greenhouse gas (GHG) emissions up to 7% and become the fourth highest GHG emitter in the world as shown in Fig. 1.

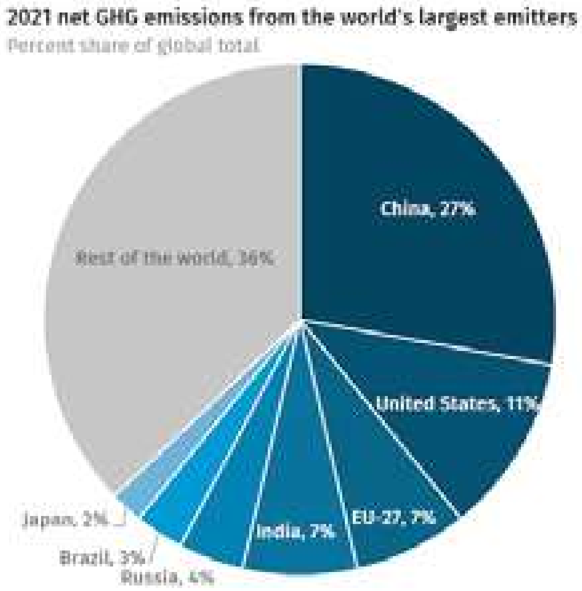

Fig. 1: Largest GHG Emitter Countries of World

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The greenhouse gas (GHG) is a gas that absorbs and emits radiant energy at thermal infrared wavelengths, causing the greenhouse effect. The primary greenhouse gases in Earth's atmosphere are carbon dioxide (CO_2) (72%), methane (20%), nitrous oxide (5%), water vapor and ozone (O_3).

The major sectors responsible globally for GHG emissions which lead to the climate change are shown in Fig. 2.

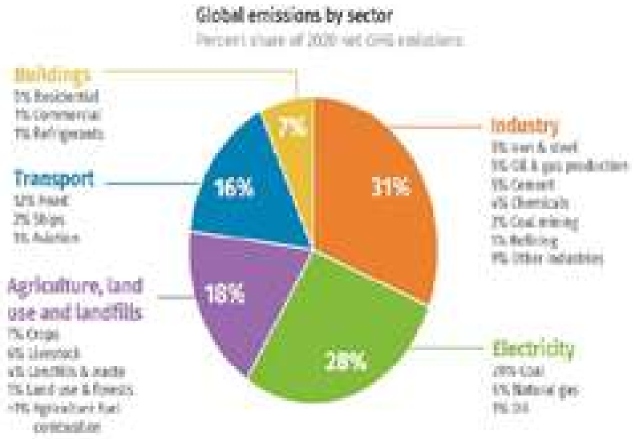

Fig. 2: Global GHG Emissions by Various Sector

It is the need of hour to evolve the alternate eco-friendly measures in all above sectors so as to curtail the GHG emissions and to achieve the net zero in the coming decades. Renewable energy is one of the best alternate to the traditional energy sources and is obtained from renewable natural resources (replenished naturally in a span of human life cycle). They are also referred to as clean energy as they do not contribute to carbon emissions which make them non-polluting. These energy sources mainly cater to areas like-generation of electricity, transportation, electricity services in remote off-grid areas, and heating of air and water. Fossil fuels cause GHG (mainly CO_2) emissions which are leading to global warming. In contrast, renewable energy sources are low cost, abundant and inexhaustible sources of energy and do not contribute to greenhouse gas emission. So, to prevent global warming and climate change countries are now switching to renewable energy measures. The major renewable energy sources (RES) are shown in Fig. 3.

Fig. 3 : Major Renewable Energy Sources (RES)

Owing to technological developments, steady policy support and vibrant private sector, the solar power plants are cheaper to build than coal ones. Renewable electricity is growing at a faster rate in India than any other major economy, with new capacity additions on track to double by 2026. Presently, the largest contributor to electricity production is hydropower (44%). Solar and wind energy together account for 50% of the total electricity share. Geothermal, ocean, and biomass-based power plants account for slightly more than 6% (Fig. 4).

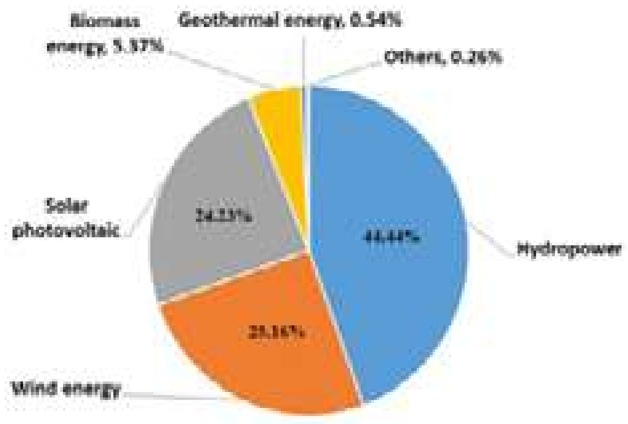

Fig. 4 Contribution of RES in India

India's robust energy efficiency programme has been successful in reducing energy use and emissions from buildings, transport and major industries. Government efforts to provide millions of households with fuel gas for cooking and heating are enabling a steady transition away from the use of traditional biomass such as burning wood. India is also laying the groundwork to scale up important emerging technologies such as hydrogen, battery storage, and low-carbon steel, cement and fertilisers. To reach net zero emissions by 2070, the International Energy Agency (IEA) estimates that $160 billion per year is needed, on average, across India's energy economy between now and 2030. That's three times today's investment levels. Therefore, access of low cost long term capital is the key to achieve net zero.

SCENARIO OF RENEWABLE ENERGY IN INDIA SINCE THE INDEPENDENCE

Being a developing nation at the time of Independence, India relied heavily on coal to meet its energy demands. However, India has always been committed to looking for more alternative energy sources for sustainable development. The beginning was made with hydropower, with major hydroelectric power projects appearing on the scene of India's energy arena. Over the years, many policy and regulatory initiatives have promoted hydropower development and facilitated investments. Today, we are 5th in the world regarding usable hydropower potential.

Bhabha Atomic Research Centre (BARC) was founded in the 1950s to secure the country's long term energy independence. Today, we are the only developing nation with indigenously developed, demonstrated and deployed nuclear reactors for electricity generation. This was made possible through several decades of extensive scientific research and technology development.Work on wind energy started in India during the 1960s when the National Aeronautical Laboratory (NAL) developed windmills, primarily for supplying irrigation water. Today, we have the 4th largest wind power capacity in the world, blessed with a constant movement of wind, especially in the Southern, Western and North Western regions.

Solar energy based applications have benefited millions of Indians by meeting their cooking, lighting and other energy needs in an environment friendly manner. Having achieved large scale success in solar energy solutions, India has spearheaded the International Solar Alliance (ISA) which is an action oriented, member driven and collaborative platform for increased deployment of solar energy technologies. The membership of the ISA is open to all member-states of the United Nations, and 107 countries are signatories to the ISA Framework Agreement at present. The Alliance aims to efficiently utilise solar energy to reduce fossil fuel dependence, thereby reducing greenhouse gases and control the climate change.

Biomass has also been an essential source of energy for India. It is renewable, widely available, carbon neutral and has the potential to provide significant employment in rural areas. Rapidly evolving technology has enabled thermal power plants to have more economical and energy efficient operations. India has co-fired biomass in thermal plants across the country to reduce its CO_2 footprint in thermal power generation. Biomass power/co-generation programme had been implemented since mid-nineties. Over 800 biomass power and bagasse/non-bagasse co-generation projects have been installed in the country for feeding power to the grid.

AIM AND OBJECTIVE OF INDIA TOWARDS NET ZERO 2070

Developed nations (which have contributed the most to the CO_2 concentration in the atmosphere and have the resources and capability to curtail emissions), are unwilling to take on the greater share of this responsibility going forward. Most developing nations feel that this is unfair, given that they have contributed less (or minimally) to the problem and are still being forced to contribute equally. Moreover, fast growing economies like Brazil, China, and India have ever expanding energy needs, considering the stage of development they are at. Their reliance on fossil fuels at this time will naturally be higher. The fundamental problem remains one of apportioning the responsibility or ownership of future efforts, as the available carbon space in the atmosphere needs to be vacated collectively by adopting the renewable energy measures effectively and efficiently so as to achieve the net zero target by 2070 (Fig. 5).

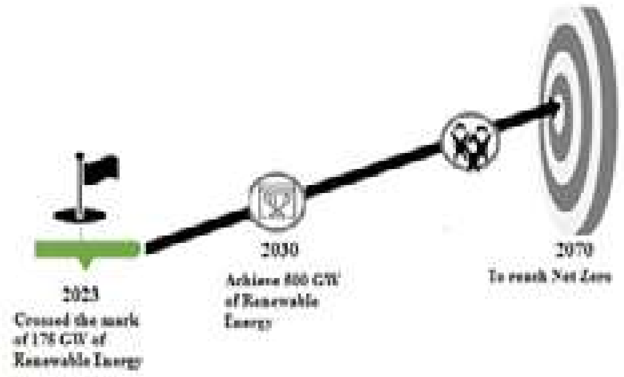

Fig. 5 India's Aim towards Net Zero 2070

Against the backdrop of this global competition for capturing carbon space, at the 26th Conference of Parties (COP-26) in Glasgow, Prime Minister made an announcement that India aims to reach net zero emissions by 2070 and to meet 50% of its electricity requirements from renewable energy sources by 2030. This aspiring target includes crossing the mark of 175 gigawatts (GW) of renewable energy in 2023 and achieving 500 GW of renewable energy by 2030 (Fig. 6). The focus for India will now be on increasing the share of renewable energy in energy production and generation both in relative terms and absolute volume so as to eventually phase down consumption of coal and fossil fuels taking place in the economy across various sectors, and improving the carbon sink.

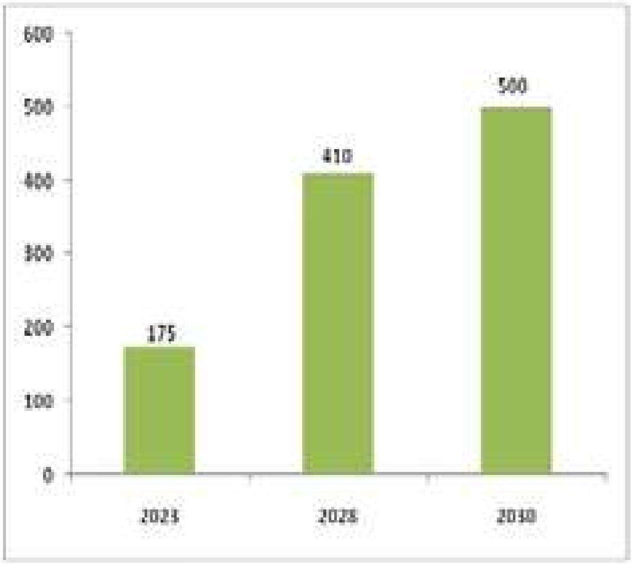

Fig. 6 Total Renewable Energy in GW

VISION FOR ENHANCING THE RENEWABLE ENERGY SOURCES

At present, the trouble with India is that the efficiency of renewable sources is low, which is why the actual uptake of solar energy in the energy system is not more than 10%. In other words, we are only able to use only 10% of the electricity capacity that is created with renewable sources. Even if we include the generation from nuclear or large hydro power in the small renewable sources, the share of renewable energy in the total electricity generation is still at about 22%, as compared to 78%with coal, oil, and gas.

Even if India is able to produce intermittent renewable energy at a low variable cost, there are other systemic fixed costs that need to be factored in. These include the need for meeting the baseload in the grid (that is, the minimum level of electricity demand over 24 hours), transmitting the energy, transporting it across different states and regions, and, in the case of solar, making it available when the sun is not shining. All of these require considerable investment in infrastructure & systems and today our domestic financial system alone is not capable of mobilizing finance at this scale.

Hence, the primary problem in making this energy transition is twofold. First, India needs to create technology for energy storage, which can meet the baseload in the grid and stabilize it when solar or wind energy is not available. And, second, we need to mobilize the finance at a scale that can help us to create a capacity of 500 gigawatts (GW) of renewable energy by 2030, and more as we go along.

There is another challenge that lies ahead. Certain industrial sectors in the economy (e.g. petrochemicals, steel, and cement) are extremely inflexible in terms of the kind of technology and energy that they need. So, even if we are able to reduce the emissions intensity of our GDP by improving energy efficiency and the proportion of renewable energy in our energy system, it is not going to be enough. As India grows and develops, its economic production and energy consumption will also increase. And, for these sectors, replacing carbon will not be possible without the availability of alternative fuels, which are necessary for certain industrial production and processes. Such fuels are necessary for transport and cement and steel production, which are likely to grow by three times.

Therefore, to make the transition, we need heavy investment in alternate low carbon fuels such as hydrogen and natural gas. We also require tech innovation at scale to bring down the cost of these fuels and enable the production of steel and cement at an affordable and competitive rate.In nutshell, India's mitigation efforts must revolve largely around mobilising funds and investing in tech innovation at a large scale.

CONTRIBUTION OF PUBLIC AND PRIVATE SECTOR

The intensity of global discussions has permeated into national strategies, such as India's. The successful execution of our strategies depends on political commitment, which already exists at the national and state level. State MPs and MLAs are now thinking and talking about climate change this was not the case 10 years ago. What we need now is for state & centre climate action plans (many of which exist) to incorporate a framework for mobilizing investments and measuring benefits and outcomes. Once this is done, it's only a matter of time before a climate lens is fully integrated into our development policies too.Once we develop a robust disclosure system that includes penalties and rewards for actions taken, we will begin to see a lot more movement in this area.

Corporate India has also woken up to their contributions to worsening climate change, and is beginning to shift their priorities accordingly. Many industry majors (such as the Tatas, Mahindra & Mahindra, Wipro, Shell India, and Dalmia) have announced net zero targets by 2040 or 2050. The SEBI has mandated 1,000 top companies listed on the stock exchange to follow a mandatory framework of business sustainability and responsibility reporting and make disclosures on some of the key environmental parameters. This is a step in the right direction to reduce the carbon emissions and to achieve the target of net zero.

When it comes to citizens, there are a few things that can be done. The first is to build our own awareness, and that of those around us, when it comes to climate change impacts. We must integrate the environmental consciousness into our education system. Doing this can help build community action against policies and actions that have adverse consequences for the environment. This is difficult but not impossible to do, given that young people today are much more environmentally conscious than the previous generations. The second course, of action, is to develop a deeper understanding of our own resource efficiency(i.e. how much we are consuming, recycling, or restoring). Earlier we would talk about three R's (Reduce, Reuse, and Recycle); now there are six R's (Rethink, Refuse, Reduce, Reuse, Recycle, and Repair) of sustainability as shown in Fig. 7.

Fig. 7 Six R's of Sustainability

We need to move towards a circular economy, which will require participation from all citizens as well as industry. India has a head start here, given that traditionally we have had a culture of recycling and reusing. Industry needs to move in this direction too and follow the norms for extended producers' responsibility. Improving resource efficiency, even in our own homes, will go a long way in making a difference to control the climate change and helps to achieve the target of net zero.

CONCLUSION

To meet out the continuous growing energy demand; India needs to optimize the renewable energy sources and also needs to create technologies for energy storage, which can meet the base load in the grid and stabilize it when solar or wind energy is not available. Further, we need to mobilise the finance at a scale that can help us to create a capacity of 500 GW of renewable energy by 2030. The strong political commitment, active participation of corporate sector and citizens for improving the efficiency of the available energy resources will certainly lead to the target of net zero.

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INTEGRATED DESIGN AND PROJECT DELIVERY: APPROACH TOWARDS SUSTAINABLE BUILDING DESIGN WITH FOCUS ON CLIMATE SENSITIVE BUILDING ENVELOPE

SANDEEP TRIBHUVAN NAVLAKHE* AND NACHIKET KESHAV APTE**

Abstract

Human civilisations are dependent on mother earth for providing their basic needs and have co-existed with other living species on earth for last six thousand years. However, over the last century of exponential growth in human population & technology advancement we have burdened and polluted earth's natural resources including other living species to the brink of existence. Over the last few decades, earth resource unbalance was projected in the form of natural calamity be it floods, wildfires, draughts, global warming, pandemics, climate changes.

INTRODUCTION

In this context, world community has realised the requirement of responsible and sustainable development. United Nations has taken lead to set time bound sustainable development goals aimed at socio-economic development of humans in dynamic balance with the environment & ecosystems involving other living being.

Source (Dusit International, Thailand website): https://www.dusit-international.com/en/updates/activities/304/10-reasons-why-sustainability-is-more-important-than-ever

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New Economic policy promoting liberalisation has stimulated India's growth to a great extend and as on date India is counted as one of the fastest developing and youngest nation. This also means that India has 4th largest share in CO_2 emissions @ 7% globally right behind China, USA and European union. Since 1990 the intensity of CO_2 emissions in India has increased at CAGR of 4.9% right behind China which is @5.4%.

SUSTAINABILITY CHALLENGE WITH FOCUS ON INDIA

Though it may appear that India is contributing immensely to the global GHG emissions in absolute terms and against per capita growth. However, if the emission intensity is compared against the coincident GDP PPP, which is the measure of development, the CO_2 emission per unit of GDP PPP has reduced by about 25% from 1990 to 2021. Thus, in India we have aimed as responsible development over the years and would continue to do so by achieving the "Net Zero Target set for 2070".

BUILDINGS AS SIGNIFICANT CONTRIBUTOR

The globalisation of Indian economy has lead to exponential growth in buildings and infrastructure sector. This growth had lead to more than 120% growth in the GHG emissions in Building Sector and it is expected to increase year on year by 7%. It is

Table 1 : Country wise share in global CO_2 emission intensity & y-o-y change over last 4 years

	Share in global	Change 2019-2020	Change 2020-2021	Change 2019-2021	CAGR 1990-2021
China	32.9%	1.5%	4.3%	5.9%	5.4%
United States	12.6%	-10.9%	6.5%	-5.2%	-0.2%
EU27	7.3%	-10.8%	6.5%	-5.0%	-1.0%
India	7.0%	-6.5%	10.5%	3.3%	4.9%
Russia	5.1%	-4.5%	8.1%	3.2%	-0.7%
Japan	2.9%	-7.6%	2.8%	-5.0%	-0.2%
Iran	1.9%	3.1%	2.9%	6.1%	4.1%
South Korea	1.7%	-6.9%	3.5%	-3.6%	2.7%
Indonesia	1.6%	-8.7%	1.9%	-6.9%	4.3%
Saudi Arabia	1.5%	-0.4%	2.0%	1.6%	4.0%
Canada	1.5%	-9.9%	2.8%	-7.4%	0.8%
Brazil	1.3%	-7.7%	11.0%	2.4%	2.5%
South Africa	1.2%	-9.1%	1.8%	-7.4%	1.1%
Turkey	1.2%	-0.1%	8.0%	7.9%	3.6%
Mexico	1.1%	-16.7%	4.3%	-13.1%	1.2%
Australia	1.0%	-7.4%	-2.4%	-9.6%	0.9%
Global		-5.3%	5.3%	-0.4%	1.7%

Source : Crippa M., Guizzardi D., Banja M., Solazzo E., Muntean M., Schaaf E., Pagani F., Monforti-Ferrario F., Olivier, J.G.J.,Quadrelli, R.,Risquez Martin, A., Taghavi-Moharamli, P., Grassi, G., Rossi, S., Oom, D., Branco, A., San-Miguel, J., Vignati, E. CO2 emissions ofall world ountries – JRC/IEA/ PBL 2022 Report, Publications Office of the European Union, Luxembourg, 2022, doi:10.2760/07904, JRC130363

thus essential that we necessarily design & build new buildings / retrofits with sustainable development strategies. In the next part of this paper we would focus on designing climate sensitive building envelopes through Integrated Design approach.

BUILDING ENVELOPE DESIGN AND SUSTAINABILITY GOALS

In this section we have tried to enlist the general functional requirements of any facility and that of building envelope. Further we would compare the principles of the sustainable infrastructure with functional requirements of facility & building

Table 2 : CO_2 emission intensity per capita & GDP (PPP) of India between 1990-2021

Year	CO_2 emissions Mt CO_2/yr	CO_2 emissions per capita t CO_2/cap/yr	CO_2 emissions per unit of GDP PPP t CO_2/kUSD/yr	Population
2021	2648.779	1.895	0.285	1.397G
2020	2396.337	1.732	0.281	1.383G
2005	1215.209	1.062	0.326	1.144G
1990	600.025	0.690	0.379	870.133M

Source : Crippa M., Guizzardi D., Banja M., Solazzo E., Muntean M., Schaaf E., Pagani F., Monforti-Ferrario F., Olivier, J.G.J., Quadrelli, R., Risquez Martin, A., Taghavi-Moharamli, P., Grassi, G., Rossi, S., Oom, D., Branco, A., San-Miguel, J., Vignati, E. CO2 emissions of all world ountries – JRC/ IEA/PBL 2022 Report, Publications Office of the European Union, Luxembourg, 2022, doi:10.2760/07904, JRC130363

envelope to establish the relation between the three, which is crucial for understanding the criticality of building envelope design.

GENERAL FUNCTIONAL REQUIREMENTS OF FACILITY / BUILDING

Whenever a facility is conceptualised the promotor of the facility to be build provides some functional requirements, which may differ with respect to intended use of the building and owners profile (for own use or sale). However, we may lay down a few common functionalities which have to be met by any building.

- The facility / building must be easily accessible.
- The built facility should be durable, safe and secure as it is generally meant to be operated or used for lifetime.
- The facility should meet the desired levels of health and hygiene.
- The facility should maintain comfort & acceptable indoor air quality for the occupants.

Table 3 : Sector wise growth of GHG emissions in India since 1990

	2021 vs 1990	2021 vs 2005	2021 vs 2020
Power Industry	+486%	+125%	+15%
Other industrial combustion	+303%	+146%	+12%
Buildings	+123%	+48%	+7%
Transport	+345%	+148%	+4%
Other sectors	+247%	+73%	-2%
All sectors	+341%	+118%	+11%

Source : Crippa M., Guizzardi D., Banja M., Solazzo E., Muntean M., Schaaf E., Pagani F., Monforti-Ferrario F., Olivier, J.G.J., Quadrelli, R., Risquez Martin, A., Taghavi-Moharamli, P., Grassi, G., Rossi, S., Oom, D., Branco, A., San-Miguel, J., Vignati, E. CO2 emissions of all world ountries – JRC/IEA/PBL 2022 Report, Publications Office of the European Union, Luxembourg, 2022, doi:10.2760/07904, JRC130363

FUNCTIONAL REQUIREMENTS OF BUILDING ENVELOPE

The building envelope is just like the skeleton and skin of human body. The building envelope comprises of foundations, walls, roofs, faзade, windows and doors, shades, blinds. The building envelope is designed to ensure following,

- To provide shelter against natural calamities such as flood, earthquake, dust storm& security to the occupants.
- To provide necessary fire resistance to inside / outside fire incidence to ensure safe passage to occupants to vacate the building at normal pace.
- To provide views to outside and let occupants visualise outdoor conditions.
- To give access to day light during the day
- To ensure solar and thermal control for the occupants from outdoor climate. (i.e to provide sunshade, rain / snow protection and provide warmth in cold climate & visa versa).
- To provide moisture & dust in gress / egress as the case may be – to maintain comfort humidity conditions inside against dry or humid climatic conditions. Thus, as a whole Building envelope takes care of indoor air quality.

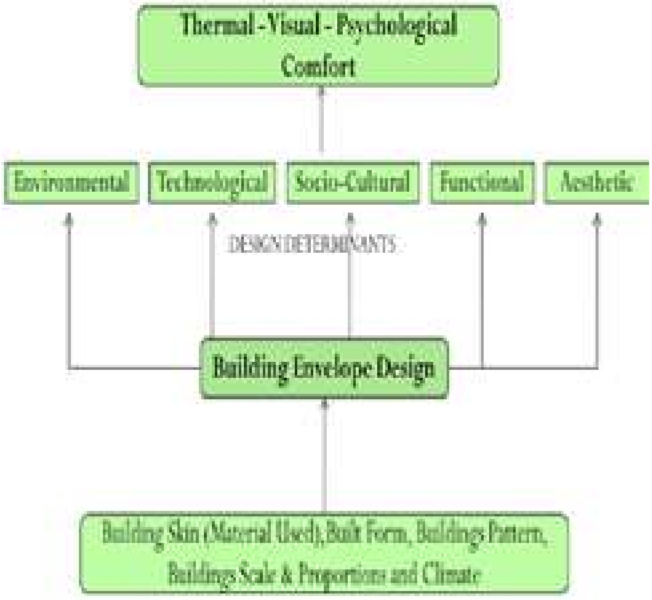


Fig. 1: Schematic view of Functional requirements of Building Envelope

- To provide protection against outside undesirable noise or to present noise propagation outside in case of noisy indoors
- The building envelope also gives building aesthetic looks.
- The building envelope should be cost effective since it has major share in the building construction & maintenance costs.

The functional requirements of the buildings mentioned above are dependent on the design of building envelope and hence the building envelope design is critical not only from the civil design standpoint but from MEPF design point of view as well.

FUNDAMENTAL PRINCIPLES OF SUSTAINABLE BUILDINGS

In addition to the above, as we are discussing about the sustainable building, let us understand what the primary objectives for building design are

The sustainable infrastructure aims to:

- Utilise the full site potential in terms of available land, preserving the trees & water bodies, excavated soil.
- Optimise the energy use during the design, construction, and operation of the facility.
- To have zero water discharge from the site. Designing facility with zero water discharge and minimal water intake.
- To use eco-friendly and green materials with low carbon impact on environment as much as possible.
- Enhance the end user experience by providing comfort, health, hygiene, and desirable indoor air quality.
- To provide simplified, intelligent and ease operation and maintenance practices through preventive diagnostics, integrated controls & automation through single window.

Understanding the above corelation between sustainability goals and functional requirements it is clear that the building envelope design involves close co-ordination between CSA, Services designers as building envelope is an enabler for energy efficient HVAC and lighting design at large. Optimally designed building envelope may bring down the HVAC and lighting load for the building considerably helping designers attain their sustainability goals such as minimal life cycle costs,indoor air quality requirements, reducing carbon footprint.

SUSTAINABILITY PRINCIPLES APPLIED IN DESIGN OF BUILDING ENVELOPE

As we design the building envelope with aim of sustainable infrastructure, the sustainability principles must be considered as the check points to comply to the best possible extent. This section elaborates these principles and the possible design approach with focus on building envelope design.

OPTIMUM UTILISATION OF SITE POTENTIAL

Whenever an architect / designer conceptualises development at a specific site, the designer must aim at conserving the eco system of the site as much as possible with optimal trade off with the geographical, functional, social, legal, and constructional constraints. As the basic principle of sustainability states, the building design should sync with available site geology & access, climatic conditions of the location, local developmental norms.

The building envelope design is directly governed by the site ecology and local developmental norms. At Tata Projects, our team did value engineering for one of our largest residential redevelopment project BDD, Worli in which we practiced above guiding principle.

CASE STUDY BDD, WORLI

The project concerned is Redevelopment of BDD Chawl at Worli, wherein we need to build 22 storied 87 rehab towers, 66 storied 10 sales towers and a 29 storied commercial tower with total BUA of 255 lakh sqft.

As per the original design for the project, most of these towers were to be built with 3 basements for parking and to house space for services. The site survey and soil investigation carried out by our design team after award indicated that moderate to hard rock strata at depth of 6.5 to 7 meters.

Thus, as per the original design if we were to build 3 basements each with height of 3.3 meters, we were required to excavate the virgin rock base to a depth of 7 to 13 meters and the total excavated rock volume would have been 8lakh cum. Such large excavation in the site sub strata would lead to following environmental issues,

Project Scope : Construction of following Infrastructure in place of Existing BDD Chawls at Worli		
Type of Building	Cluster	Configuration
Rehab Buildings	Cluster - 1 to 8	3 B + GF + P + 22 Resi. Fl.
SRA Building	Cluster – 9	1B + GF + P + 19/20 Resi Fl
School Building	Cluster – 10	1B + GF + 7 FL
Sales Building	Cluster – 11 & 12	3 B + GF + 8P + 66 Resi Fl
Commercial Building	Cluster – 13	3B + GF + 29 Comm. Fl.
Project Duration	8 years (with Price Variation Clause)	
Phase – I & II	Rehab – 10 – Ph-I & 14 – Ph-II	5 Sales (in Ph-II)
Phase – III & IV	Rehab – 26 – Ph-I & 22 – Ph-II	5 Sale & 1 Comm.
Phase – V	Rehab – 14 + 1 SRA	

- The site is located in densely populated area and such large excavation in hard rock would mean disturbance to the nearby habitats and specially schools and hospitals.
- The controlled blasting in the densely populated area such as Worli may be a risky proposal.
- The hard rock excavation may lead to lowering of water table, disturbance of natural drainages.
- The transportation & disposal of the material generated during excavation poses big environmental issue.
- The construction time for the building increased as excavation can only be done in restricted time.

The above impact was avoidable if the available sub-soil strata was effectively utilised for construction by avoiding the basements and providing additional podium parking space. Our designers came up with the proposal to increase two additional podiums above ground and to build only single basement to house the services alone.The proposal was well received by client.

The impact of above decision was no disturbance to the site eco system, rock excavation reduction upto 99% and 20-25% reduction in total construction time. In addition to above, as we eliminated the basements, the energy costs towards the basement ventilation and to an extent lighting (due to reduction in operating time) was reduced as secondary benefit.

OPTIMUM BUILDING ENERGY CONSUMPTION & INDOOR AIR QUALITY

In general, it is perceived that the building energy consumption can be optimised by choosing the energy efficient equipments and using advance control and monitoring strategies. The equipments and controls play a significant role in reducing the energy consumption, however, a very well-designed building envelope may reduce or eliminate the requirement of energy for lighting and cooling, which downsizes the equipment capacity leading to considerable life cycle cost and energy saving.

The various strategies adopted for building envelope design being Passive Solar architecture and the renewable fazade design. In the below section, we have tried to briefly explain the design approach for both these strategies.

PASSIVE SOLAR ARCHITECTURE

As we understand clearly the major cooling / heating load of the residential or commercial building is due to the outdoor design conditions or the direct / indirect solar load. The exception to this may be data Centers, factories, process industries wherein equipment loads dominate the cooling requirements. In addition to the above, with the current experience of global pandemic, the focus on indoor air quality is also getting highlighted.

The passive solar architecture blends the conventional architectural principles with the inherent thermal properties of building material, local climatology and heat transfer principles. This Passive solar architecture studies annual solar path and orientation at the site geographic location, takes into account the surrounding climatic conditions, building orientation, building envelope materials, fenestration and shading details and is effectively being carried out through a simulation technique known as building energy simulation in which following steps are performed.

a) Analyse and finalise building orientation based on site location, surrounding buildings shadow effect, latitude, longitude and annual sun path tracker to maximize the daylight in building and minimize the solar heat gain effectively reducing the lighting and cooling loads;

b) Selection of building envelop material, fa3ade, shades, fabric for blinds to ensure reduce convective solar heat gain in the building through building envelope;

c) Suggest requirement of thermal insulation and thermal mass in case of cold climate to maximize the storage of solar energy in the building envelop, thus reducing the heating loads;

d) Placement, size and orientation of fenestration, selection of glass material, location and construction to maximize daylight with minimum direct solar radiation;

e) Strategies to reduce heat Island Effect: by covering the exposed roof / fa3ade through reflective paints, green cover etc.;

f) To conceptualise natural ventilation paths in hot climates through suitably placed,sized and oriented fresh air and exhaust louvers to minimize forced ventilation, and improve the indoor air quality and give passive cooling effect.

Thus, the aim of the building energy simulation is to optimise the annual building energy consumption at conditions in which the proposed building once built would operate as per the surrounding external annual climatic conditions by combination of variables such as building orientations, building envelop materials, fenestrations, thermal insulations, shading material configurations.

Thus, the optimised design of building envelope would in turn result in:

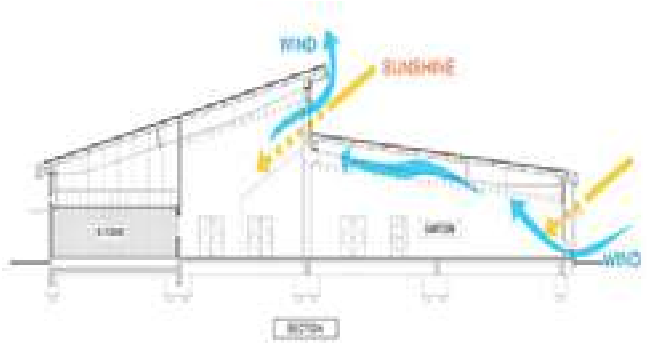
a) Reduced overall heat load for the building, thereby optimising the overall HVAC and electrical energy consumption;

b) Reducing or eliminating the heat is land effect;

c) Optimised lighting load for the plan thereby reducing the operational cost and electrical demand loads;

d) Benchmark energy consumption for operations, correct operating set points for equipments to monitoring and preventive maintenance of the building;

e) Optimised Building life cycle cost.



INDOOR ENVIRONMENTAL QUALITY

The global pandemic over the last 2 years has underlined the importance of Indoor environmental quality for human health and hygiene. The current average AQI for India is 100, which is far worst from the recommended AQI of 5 by World Health Organisation. In general, all the designers recommend PM2.5, 10 filtration for all air takes in the building, which generally increases the static pressure & power consumption of air handlers and leads to additional operating costs.

The necessary level of filtration may also be achieved through green walls incorporated in building envelope, which not only filter the particulate matter but precool the entering air. In India, the use of Vetiver khus curtains is very common, specially in hot & dry climate for air filtration and precooling. These are all green techniques and can be incorporated as part of the building envelope at the locations of air intakes. In addition to the above, we may also improve the indoor environmental quality through adequate day lighting and natural convection through the building, which keeps the air moving inside the building.

GREEN MATERIAL FOR BUILDING ENVELOPE

Sustainable infrastructure calls for building design with materials which do not impact environment. There are multiple ways in which we may comply with this requirement.

- Use of recycled steel, refurbished wood, bamboo material, bricks made of refuse material such as fly ash which have been tested for required strength.
- Another criterion of building material selection is to use the locally available material which reduces the transportation of material to site thereby helping reduce the carbon footprints.
- Generation of energy is one way of conserving energy, sustainable building envelope design also suggests use of solar PV faзade and roof top PV. The location and qty of solar PV depend on building orientation and shadow effects of surrounding buildings, plants.
- Reducing the wastage while construction may also be considered as a way to conserve the resources. This can be effectively achieved by using modular design concept and offsite fabrication under controlled environment.

The modular construction approach is gaining momentum as it enables faster & leaner construction of the building with improved quality and ease of installation.

However, while selecting the material for the building there is always a trade off between the required stability, reliability and design life viz a viz the sustainability requirements.

INTEGRATED DESIGN APPROACH FOR CLIMATE SENSITIVE BUILDING ENVELOPE

As discussed in the above sections, to build a climate sensitive building envelope and achieve the sustainability goals for the building is a complex and multi-disciplinary exercise. In order to finalise the optimal design for the building envelope, the designer needs a unique design platform on which a multi-disciplinary team needs to work simultaneously in precise co-ordination with each other.

To adopt this approach, the lead designer must identify the required stake holders such as,

- Owner's representative.
- Project Management Consultant
- Principal Architect
- Structural consultant
- Services design consultant
- Green certification agency representative
- Principle contractor
- Services contractor
- Facility management team of the owner

All of the above stake holders form a multi-disciplinary team known as the integrated design team, which each of the team member contributing their inputs about the functional, legal, civil, services, security, constructability, maintainability and operability, statutory and green requirements on a single platform from conceptual design phase.

The goals for the integrated design team are as follows,

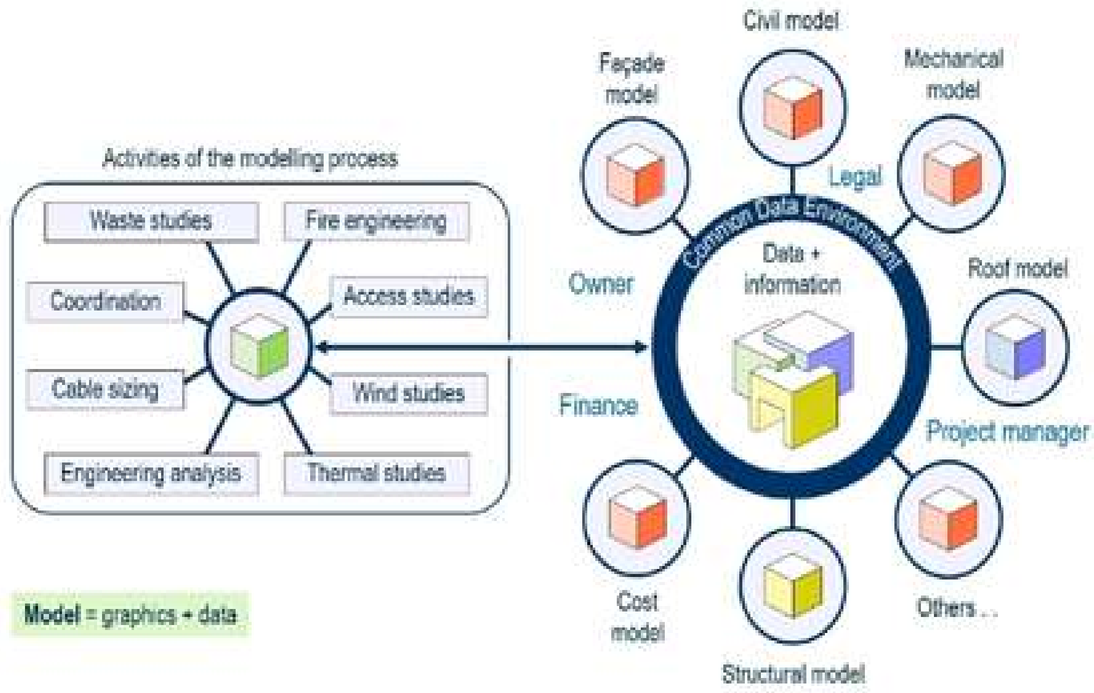
- Lower Life Cycle cost of Facility
- Sustainable Development
- Best Quality & EHS Practices Implementation
- Design Innovation
- Construction methodology Innovation
- Fewer changes
- Less wastage of resources & time
- Agile & focused team

The team chooses a single working tool or platform such as BIM or building simulation modelling platform to arrive at the final sustainable and climate sensitive building envelope.

CONCLUSION

In developing country like India with largest world population and equivalent aspirations to grow under the conducive socio-political environment, buildings would be the significant source of energy consumption in the future. Thus, it is mandatory to build technologically advanced futuristic buildings with low impact on the environment to stimulate growth and simultaneously achieve the NET ZERO 2070 goal.

The building envelope plays a major role in reducing building energy demand and improve on the indoor



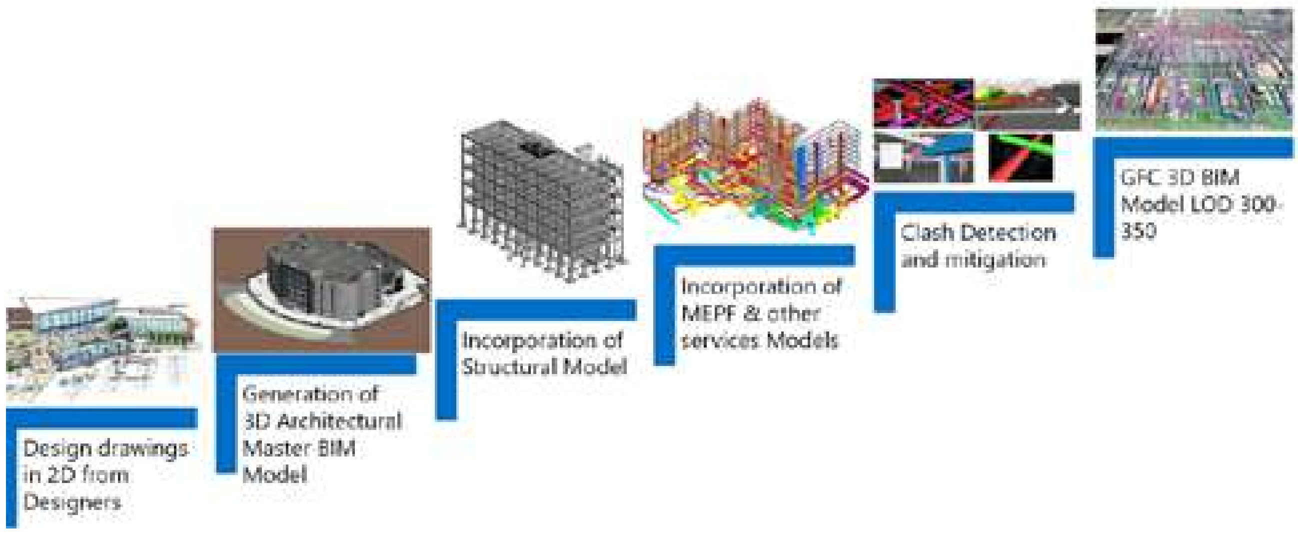


Fig. 2: Integrated Design Delivery using BIM Platform

environmental quality. An optimised building envelope selection may result in low building life cycle costing, conservation of site eco system, improved daylight, indoor air quality, reducing construction wastage, Electricity generation, low impact on environment and improved building aesthetics and views.

The design of building envelope is a complex and multi-disciplinary optimisation problem. Low Environmental impact buildings may be designed successfully by finalising the climate sensitive building envelope design using building simulation techniques and integrating the influential stakeholders from the conceptual design stage to channelise their expertise towards a common and noble goal.

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AUDITING, MONITORING AND EVALUATION OF CO2 IN TALL AND MEDIUM BUILDINGS TOWARDS NET ZERO 2070

Dr. Mutyala Rajagopal Prakash*

Abstract

"There no genius in life like the genius of energy and industry"....Mitchell.

The human community is living on planet earth from time immemorial. 'Energy and Industry' have been the pivotal in achieving different levels of growth and development includes; human habitat. Human habitat is considered as prime mover for rapid enhancement of key variables of development which include, Agriculture, Industry, Construction, Transport, Live Stock, Services, Trade & Commerce, ...,etc. Undoubtedly all these sectors depend heavily on energy generated by human, non human and machines. The dominant role in integrating these productive sectors is being carried out by the "Technology". Though technology is considered as neutral & disguised input and supportive factor, the same got the boost by combining with the 'Information' as product. The human society is budging fast towards "Informative Machines" which are capable of performing faster than humans in reasoning, auditing, monitoring, evaluation and many more. The present paper focuses, the newly emerging pattern of AI technology in auditing, monitoring, and evaluating CO_2 factor in "Tall and Medium Buildings".

INTRODUCTION

India has been exploring the new research area in the arena of Human Habitat and Buildings called Net Zero 2070 and Built Environment(1). There are 'supertalls buildings' numbering 173 and, megatalls buildings numbering 3 only globally. India has a few Supertall residential buildings having a height of above 250-320 meters (Annexure A). Most of the Supertall Residential Buildings are built in Mumbai (Maharashtra) in the years 2019 to 2022 barring a few in he previous years. The Supertalls are considered if, a building achieves a height of 300 meters (1984 feet) and Megatalls upto 600 meters (984 feet). Burj Khalifa has the height 2720 feet which is known as on today tallest building in the World followed by Canadian National Tower. India is yet to make a mark in construction of tall buildings especially in residential category.

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Though India is lagging behind in construction of "Supertall & Megatall buildings"; in a way it is blessings in disguise, that India shall learn from mistakes committed by others. India can now adopt the research findings from other nations who have already constructed several supertall buildings. The paper is dedicated to explore the various issues and problems of supertall buildings, before one attempts to construct such buildings and other structures. In a way India is positioned very well in information technology and experiments in AI (Artificial Intelligence) technology owing to the strong IT base[1]. A review of AI technology indicates that, it is no more complex to implement AI in building technology, as compared to others owing to the reason that there are several aspects involved including human lives. The tall residential buildings are known as city within city therefore it encompasses, variables directly related to humans.

Annexure A: Supertall Residential Buildings in India (Mumbai Maharashtra) and No where Else in

Name	Pinnacle Height In Metres	Year
Palais Royale	320	2022
World One	285	2022
Trump Tower Mumbai	268	2021
World View	285	2020
Lodha Park Parkside	268	2021
Lodha Park Marquise	268	2021
LodhaAllura	268	2021
LodhaKiara	268	2022
Nathani Heights	262	2021
Three Sixty West Tower B	260	2021
The 42	260	2017
Imperial 1	256	2010
Imperial 2	256	2010
Three Sixty West Tower A	255.6	2019
One Avighna Park	251.3	2017
Ahuja Tower	250	2019

India The present paper attempts to focus on issues relevant to Auditing, Monitoring & Evaluation of CO_2 synoptically, considering the limitations of the length of paper. One might agree to the fact that, tall buildings construction and maintenance is complex phenomenon. Almost all the Tall buildings are prone to impact environment challenges as they produce maxim CO_2 singly as compared to small and medium buildings. The construction industry is accounted to the 35% share in consumption of energy and producing similar percentage share in emitting CO_2 in to atmosphere[(2)]. Following are the areas which required to be considered, as they are directly responsible in generating CO_2.

- Construction activity before and after completion of buildings
- Air Conditioning systems
- Heating systems
- Water supply systems
- Drainage systems
- Electrification –Lighting systems
- Internal transport systems such as Elevators, Lifts, Drones, Delivery Vehicles, Garbage Collecting systems
- Repairs and Periodical Refurbish system
- Albedo Effect due to opens surface areas(3)

W.K Hui, W.y. Ng and G.Powell assessed that, "superstructure of office building (i.e it does not embrace foundation or basement) on average, had a foot print of 215.1 kg $CO_2/m^{(2)}$. External walls and upper floor construction had the highest CO_2 footprint, followed by suspended ceilings and finishes. These three elements altogether accounted for an average of 84.2% of the CO_2 footprint associated with the superstructure[(4)].

CONCEPT OF AUDITING, MONITORING AND EVALUATION

Accounts is part and parcel of auditing system while preparing the financial statements of an activity. Accounting system is generally based on numerical algorithms. Audit is the process of examining, the accounts statement generally in the form of profit & loss, Classification of income and expenditure, balance Sheet presentation by incorporating assets and liabilities of an activity, no matter one is a company, or not. Usually auditing and accounts means business control of the company, or partnership venture or proprietorship. One may prepare annual report based on the audit of an activity, here in this case CO_2.

The auditors point out the deficiencies in accounting system and policy deviations in operating an activity. Such deficiencies are to be monitored and the rectification measures are to be initiated. Monitoring is a sort of watch and control the deficiencies. The concept of evaluation is part and parcel of feedback mechanism. The evaluation enables to prepare strategies to overcome the deficiencies.

In context to CO_2, where CO_2 is a product and resultant of an activity. The CO_2 product is measured in terms of PPM (Parts per Million). Similar to Rupee as unit of measurement, in financial statements, CO_2 is measured and shown as PPM in environmental balance sheet. Such statements are useful in environment auditing. The Audit system of a company (Building) consists of (1) Internal Audit (2) Statutory Audit and (3) Proprietary Audit where such audit is being carried out by Government Departments(5).

In the case of environment audit, internal audit is carried out by the company (Building) by the environment experts paid by the company (Building) and the Statutory Audit is being carried out from third party who are no way connected to the administration of company (Building). The statutory auditors can be the "Green Buildings" accreditation team who are invited by the company (Building administration) in a periodical intervals. The final audit is carried out by the Government Departments or agency who are authorised to submit their environment audit report.

CONCERNS AND COMPLICATIONS IN CARRYING OUT ENVIRONMENT AUDIT SYSTEM

The conducting of environment audit for tall buildings is not easy. The physical verification of structures, machines, and other components related to environmental audit is huge and data inputs are not easily accessible. In case of CO_2 assessment, the auditors need special training which is not easily imparted by educational system. The computational task in assessment process is highly complicated and storage of data sets can not be done either manually or even by the available software packages. One needed to develop special software suiting to each of the building in assessing accurately CO_2 production. Following are impediments in carrying out the environmental audit for Tall buildings(6).

- Unaware of use of digital tools in environmental audit
- Interdisciplinary collaboration lacking
- Shift in focus of environmental audit hide facts
- Reluctance in support of audit program
- Poor audit preparation and access to documents
- Non cooperation of management and staff
- Failure in publishing audit reports on time
- Non compliance to the audit deficiency

MONITORING OF CO_2 IN TALL BUILDINGS

The tall buildings are susceptible to produce continuous CO_2 and fluctuating round the clock due to the components of tall buildings and their structure. The environmental audit cannot monitor the CO_2 all the time. The data generation is huge and voluminous to store in a device. The cloud technology storage and hard disks are recommended, but technically, they do not have automation virtues. However the question arises as to how honest are these tall buildings to enable storage of data though generated? The second question is how accurate is the CO_2 collected by tall buildings? These two questions may challenge the method of monitoring CO_2 and reliability. The environmental audit is heavily dependent on these two fundamental issues. Most of the tall buildings attempt to meddle with the monitoring process once the accreditation of Green Buildings are received until the next renewal. Following are reasons as to why the monitoring and measuring of CO_2 is necessary:

1. CO_2 is highly fatal and people might be killed due to breathing problems;
2. CO_2 might decrease productivity of people as

they lose vitality of body functions due to poor breathing;

3. CO_2 increases rapidly Tall Buildings as they do not have windows or outlets for natural air;
4. CO_2 might become hazardous if the sensors of CO2 fails and that being not detected;
5. The motive for energy saving attitude by the tall buildings, by meddling or manipulating the Demand Controlled Ventilation (DVC) might result in adverse effect on inmates of tall buildings;
6. The Green Building score appear to be high while the audit of environment is conducted and there is no surety in maintaining the same after the auditors have left the premises as the CO_2 levels and their controls are manual and not automatic;
7. The monitoring of CO_2 is carried out with help of desktop LCD (Liquid Crystal Display) read-out showing CO_2 levels. Many of the visitors to the building are not aware of such monitoring through desktop LCD devises. This implants hidden dangers to the health. LCD monitors are one of the most dangerous electronic devices to discard. They contain toxic metals such as lead that can harm humans and the environment.

EVALUATION PROCESS OF CO_2 IN TALL BUILDINGS

The evaluation process starts once the input data is compiled or retrieved from storage system. The data size in terms of bytes are huge and the processing of CO_2 generation can only be carried out with the help of super computers. The data compilation further involves fixing sensors in appropriate locations of the tall buildings to collect data on CO_2 variation. With regard to outer surface of the tall buildings the Albedo effect[3] can be quantified, having the information of area of surface and quantum of sun rays which are variable depending upon the natural clouds in the atmosphere. Once again CO_2 emission due to Albedo effects[3] is highly complicated to quantify and compile.

ADOPTION OF 'INPERSPECTIVE' COMPUTATIONAL TECHNOLOGY IN AUDITING, MONITORING & EVALUATION FOR CO_2 FACTOR IN TALL BUILDINGS

Human civilization witnessed several transformational technologies since year 1900 A.D. After witnessing two world wars successively in between 1914 to 1934, the World entered in to era of industrial revolution, followed by technology revolution and in recent past we adopted to information society or information revolution. Shortly we tend to encounter with another biggest revolution known as "Artificial Intelligence" - abbreviated as "AI" era.

SLAVE MACHINES

The slave machines are those which were set up near the major rivers to transmit flood data and send warning alarms. Master/slave is a model of asymmetric communication of control where one device of process (the "master") controls one or more other devices or processes (the "slaves") and serves as their communication hub. These machines have limitations as they cannot store, analyse and enable decisions.

DISCOVERY OF INFORMATIVE MACHINES

The third decade of post millennium might probably known for "Informative Machines". These machines are built with "AI" factor. "AI" is used in search engines (such as Google search), targeting online advertisement, recommendation systems (offered by Netflix, You Tube or Amazon), driving internet traffic ,targeted advertisements (AdSense, Facebook), virtual assistants (such as Siri or Alexa), autonomous vehicles (including drones, ADAS and self driving cars) autonomous language translation (Microsoft translator, Google translate), facial recognition (Apple's Face ID or Microsoft's Deep Face), image labelling (used by face book Facebook, Apple's iPhoto and TIKTOK), spam filtering and Chatbots "(such as Chat GPT) [5]".

APPLICATION OF AI TECHNOLOGY FOR AUDITING, MONITORING AND EVALUATION OF CO_2 GENERATION IN TALL BUILDINGS

Tall buildings are high tech buildings right from excavation to final touches of a completed buildings.

The tall buildings produce CO_2 both inside structure and outside the buildings. The auditing of CO_2 is complex phenomenon, as CO_2 unlike other products vary on the scale of minutes and hours. To compile the data one needed to fix sensors similar to CCTV at appropriate location. The collected data needed to be computed and decisions to control CO_2 needed to be taken which is not an easy task to undertake manually. The AI which has specialised software can compute and enable the decisions such as controlling CO_2 or advising for maintenance. Besides this, the AI carries out monitoring and evaluation simultaneously.

REGULATIONS

Human civilization is bounded by the rules and regulations to ensure harmony within people. The rules and regulations are formulated, by constitution of different countries and the legislative provisions. We are caught in cross road when we deal with rules and regulations for humans versus informative machines who have no rules and regulations to follow. The machines with AI technology are signalling that machines might be more smarter, efficient, intelligent and even independent in thinking and taking decisions, but not subjected to jurisdiction of courts either in native country or international courts.

The traditional goals of AI research include, reasoning, knowledge representation, planning, learning, natural language processing, perception, and ability to move and manipulate objects. General intelligence (the ability to solve an arbitrary problem) is among the fields long term goals[3].

CONCLUSION

- Without AI Technology , it is herculean task to conceive, implement 'Net Zero 2070' in 'Built Environment', and in other sectors of economic activities in India.
- In context to AI technology is concerned, the Government regulations can be formulated and enforced similar to building regulations. All the buildings which use the AI technology is required to appoint regulator appointed by Government to oversee the use of AI technology in buildings.
- AI technology is better positioned to audit, monitor and evaluate CO_2 anywhere , including Tall Buildings.

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CLIMATE - RESPONSIVE ARCHITECTURE: THE FUTURE

Dr. Ponni M. Concessao* And Dr. Oscar G. Concessao*

Abstract

India is now in intensive development, which will bring with it many new and varied changes, economically and socially, for the general well being of the population. Over the last decade there has been a heightened consciousness toward the environment, which can also be attributed to measures taken by the world governments as well as the tangible effects of climate change that are being felt at large. Increasingly architects and designers are realizing that building designs need to reflect the conditions of the area in which they are located.

The climate-responsive architecture uses designs that take seasons, sun path and solar positions, rainfall, humidity, natural geography, and climate data into consideration. By doing so, an architect can design practical, efficient edifices that are responsive to their surroundings. Climate having implications on humans, their surroundings, and architecture, it has become imperative to create more sustainably efficient homes and buildings that employ natural topography to their advantage and lower carbon footprint. The goal of this architectural practice is to provide a comfortable interior that relies less on artificial energy.

INTRODUCTION

In India right from ancient times buildings are schematically designed based on Vastu Purusha Mandala, Nav-graha Mandala, Nav-Rasa, etc. Kautilya has showcased many town planning modules based on "Eight Orientations and Vastu Purusha Mandala ". But in Modern Era buildings are designed many times by overlooking the sun-path, climatic aspects, and wind directions. Majority of time such buildings rely on mechanical aspects to get comfort. In India, there is a millennia-old reservoir of knowledge that can help reduce energy consumption in buildings today. Ancient Indian spiritual thought integrates humans with the cosmos, presenting an understanding that the processes of the cosmos are directly related to human existence. With this understanding, ancient Indian civilization has always respected its environment. Typical principles include climate-responsive design, use of local and sustainable materials, water harvesting, etc. Climate-responsive architectural design is especially sophisticated, with thousands of years of refinement. Architectural elements like courtyards, clusters, wind towers, roof terraces and jaalis (stone lattices), among others, are used for effective climate control and have become social and cultural elements. The challenge is to reconcile these ancient methods with modern technological innovations.

REALITY FOR SUSTAINABILITY IN INDIA

India is now in intensive development, which will bring with it many new and varied changes, economically and socially, for the general well being of the population.

On this background there are many choices with the developer and designer:

- Non-sustainable, copying the conventions, fashions, and mistakes of the 'developed world'.
- Sustainable, developing fresh, original, appropriate patterns of development, responsive to the needs of Indian society and resources, contributing to the "New world environmental order".

*Architects

SUSTAINABLE ARCHITECTURE

How are we going to achieve architectural sustainability? Certainly not through following "conventional" western design patterns, copying stylistic fashion, or adopting inappropriate technological fixes from other climates, regions, or cultures. The rigid bureaucratic controls help in achieving this in diverse countries like India. But the real solutions must come from "within", by following:

- Select diverse and locally adapted solutions for development.
- Use of locally available appropriate resources suitable to local climate response.
- Design for local social customs, conventions and aspirations.
- Use original thinking based on vernacular aspects rather than adopting or copying readymade ideas.
- Conserve non-renewable energy – limit it to use highly efficient, essential functions, understand the need of massive consumption.
- Introduce incentives for energy efficiency, climatically responsive developments, by understanding micro climate, sun-path, wind flows.
- Utilize energy performance equipment and systems.

Buildings have to provide physically comfortable, healthy and safe conditions for their occupants and, at the same time, to satisfy their aesthetic (mainly visual) needs. Transforming these demands into physical conditions, occupant's physical comfort and health is maintained primarily through the indoor temperature, air, light and noise conditions, safety mostly depends on the building structures, while visual comfort highly depends on the architectural form. In vernacular architecture, buildings were built to have optimum indoor environmental conditions due to the appropriate orientation, architectural form, proportion, spatial layout, building materials, etc., based on the accumulated knowledge of several generations. It can therefore be said that architectural form - beyond satisfying aesthetic needs - was also supposed to serve indoor comfort and health. With the development of technology, however, traditional passive methods - that sometimes proved to be inefficient - were gradually replaced by efficient building equipment for an additional increase of indoor comfort, making architectural form free from the environmental circumstances. The freedom of architectural expression encouraged architects' freakish intellectualism, and led to the degradation of the aesthetic quality of the built environment. On the other hand, active methods were soon proved to be immensely energy-consuming, necessitating new sustainable design strategies that require not only the critical examination of active methods but also their combination with reconsidered passive methods. Such sustainable design strategies are thus commonly expected to result in a new architectural aesthetics through re-relating architectural form to indoor comfort and health issues.

Sustainability has emerged as the most important keyword in almost every aspect of contemporary lives. In contemporary architecture, it is a common recognition that the main principles of sustainable architecture are rooted in the environmental conditions of the building site, including its climate, and based on this recognition, there is a renewed interest for climatic considerations.

HOW BUILDINGS WILL BECOME MORE CLIMATE-SENSITIVE

Over the last decade there has been a heightened consciousness toward the environment, which can also be attributed to measures taken by the world governments as well as the tangible effects of climate change that are being felt at large. Increasingly architects and designers are realizing that building designs need to reflect the conditions of the area in which they are located.

IMPROVING THE QUALITY OF SUSTAINABLE DESIGN

Because sustainability is more in demand now than ever, clients will be looking for better options, driving architects and designers to evolve by reducing their carbon emissions and creating healthier spaces for their inhabitants. Architecture also plans need to focus on the internal environment quality, especially for residential structures and commercial buildings. From sun orientation and indoor climatic conditions to natural ventilation and harnessing energy, architects have many ways to design more livable and greener buildings. Using the sustainable building materials is equally important to creating quality designs. Traditional and low-quality construction materials can directly contribute to toxic emissions and reduced structural integrity.

THE FUTURE OF SUSTAINABILITY AND ARCHITECTURE

Architects and designers need to understand the core concept of sustainability at the strategic level. The preliminary stages of research and strategy need to ensure the minimal wastage of materials as well as the elimination of polluting construction practices. This is where technology solutions come into play. The next few years will be significant when it comes to implementing technology-based project management and remote connectivity solutions that not only improve planning, procurement, and operational efficiency but also help architects achieve their sustainability goals. Acquiring highly sustainable materials, leveraging smart energy management tools, and reducing construction waste will be critical goals for the year as firms transition towards more sustainable execution. Additionally, novel site informatics via drones, 3D printing, and robotics will empower architects to design more renewable spaces integrating digital twins and real-time analytics solutions.

In the coming years sustainability will be increasingly seen as a design philosophy and architects will develop buildings based on the core tenets of eco-friendliness. The benefits of sustainability are evident as it can directly lead to long-term cost savings, reduction in environmental impact, and higher quality of living for residents. Architects are focusing on the role of design strategy and green design principles to ensure buildings are increasingly self-reliant, green, and compliant with global sustainability norms. It is essential for architects worldwide to consider natural greenery, waste reduction, material optimization, and other core aspects of sustainability as high-priority areas in construction and development. With architects uncovering new strategies to design greener buildings, it's so wonderful to see more structures being developed in synchronization with the natural world.

EVOLVING WITH ECO-FRIENDLY AND SUSTAINABLE BUILDING TECHNIQUES

Now, what is climate-responsive architecture? The term reflects the weather conditions of a precise area while focusing on providing a comfortable interior that is naturally energy-efficient. Aiming to lower the environmental impact of architecture, architects and designers are creating designs that will work well in the local climate.

WHAT IS CLIMATE RESPONSIVE ARCHITECTURE?

The climate-responsive architecture uses designs that take seasons, sun path and solar positions, rainfall, humidity, natural geography, and climate data into consideration. By doing so, an architect can design practical, efficient edifices that are responsive to their surroundings. Climate having implications on humans, their surroundings, and architecture, it has become imperative to create more sustainably efficient homes that employ natural topography to their advantage and lower carbon footprint. The goal of this architectural practice is to provide a comfortable interior that relies less on artificial energy. There are several elements that play a role in limiting a building's energy utilization based on its geographical location. For instance, the building envelope (exterior walls, foundations, roof, windows, and doors) is an important factor impacting a home's or buildings condition.

SIGNIFICANCE OF CLIMATE-RESPONSIVE ARCHITECTURE

Climate-responsive architecture seeks to reduce the adverse impact on the environment. It enhances efficiency and moderation in the use of materials, energy, and the development of space. This kind of architecture has become the need of the hour as it creates sustainable homes while taking environmental conservation into account.

It applies to both residential and commercial structures and can provide benefits like natural ventilation, cool roofs, and comfortable interiors. It also promotes climate adaptability and uniqueness. These buildings have become significant as by using vernacular architecture and local materials, the climate-responsive design is cost-effective. It lessens transportation costs, material costs, and maintenance costs while reducing the building's reliance on artificial energy.

ARCHITECTURE CLIMATIC RESPONSE DESIGN CONSIDERATIONS

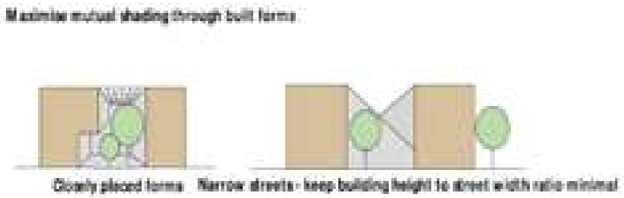
- **Perform a Site Analysis**

  Determine the weather patterns, climate, soil types, wind speed and direction, heating degree days, and path of the sun. Look at the water flows, habitat, and geology of the site. Document each with a qualified team of professionals to understand the ramifications of building in that specific place. It is an approach which considers the best environmental sustainability practices.

- **Layout and Orientation of the Building on the Site**

  Using an integrative design process, use a basic massing of the building layout to determine specifically on-site the most optimal location for the building to be situated. Factors to consider here are access to infrastructure, staying at least 100 feet clear of any watershed, not building within a floodplain and in a habitat with endangered species. Asking what trees and other existing geological features should be avoided or how water flows across the site can dictate the location of the building.

- **Plan with the Sun in Mind**



Shading of the Building

  It's all about the sun; so, plan to place the structure based on the cardinal directions. The goal is to maximize the amount of sun that heats space in the winter (resulting in using less energy to mechanically heat), as well as decreasing the amount of sun that cools the building in the summer (resulting in less energy to mechanically cool).

- **Window Considerations**

  South facing facades should utilize a window area appropriate to its orientation, and glazing should utilize a double or triple-paned glass with a Low-E coating. It minimizes the amount of heat transmitted into space in the hottest months while keeping heat inside during the cooler winter months. For example, south-facing glass window wall will heat up the occupants inside during the hot summer months if care is not taken to provide shade on the fasade.

- **Building for Geographic Area**

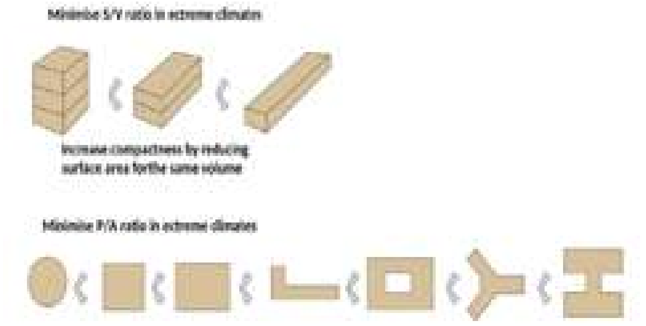
  When designing the envelope of the building, factors such as insulation, vapor barriers, and air barriers will vary radically depending on whether the project is in the cold, snowy north, the hot and humid south or the arid desert.

- **Minimize the Building Footprint**

  Question the true needs of the program. Do you need that much space? Are there ways that spaces can become multi-functional? Do we need that many private offices if some staff can telecommute occasionally and share offices? Once your team is set on the minimization program, take a look at the size of your footprint. Is it possible to add extra stories to make the footprint smaller? That way, the building will have fewer excavation costs and more wall area that can benefit from the warming effects of the sun and an increase in natural day lighting.

- **Design for Natural Ventilation**

  Since warm air rises, a building can be cooled by designing for stack ventilation by drawing cooler air from openings low in the building, while carrying heat away through openings in the top of the space. The rate at which the air moves is a function of the vertical distance between the inlets and outlets, their size, and the difference in temperature over the height of the room. It could prevent occupants from experiences of sick building syndrome.



Design of Foot Print of Building

- **Relax the Occupants Comfort Standards**

  Most buildings in this day and age are designed to keep occupants fairly comfortable, at around 78 degrees Fahrenheit. However, with climate responsive design, reducing the amount of energy used to cool and heat the building can result in using natural systems, meaning the sun and the wind. With these, if building occupants are open to adding or removing layers during the seasons, it's amazing how much energy can be saved. Adding a sweater in the winter or relaxing the company dress code to shorts in the summer can be enough to eliminate mechanical heating and cooling altogether, saving a bundle of money and the environment.

- **Conduct Modeling and Analysis**

  Energy modeling, lighting models, day lighting studies, computational fluid dynamics are all tools that designers can and should use to understand how the design best integrates with the local climate and micro-climate features specific to the site. Again, having the right team members with modeling expertise and software is the trick to keeping costs down while exploring the best options for the design.

EXAMPLES OF CLIMATE-RESPONSIVE ARCHITECTURE

The climate responsive architecture has the sole purpose of lessening the building's ecological footprint, through energy efficiency, climate adaptability and environmental conservation.

- **Telangana State Secretariat at Hyderabad – a Celebration of Climate Responsive Architecture**

  The Planning concept for the New Telangana State Secretariat designed by Architects Ponni & Oscar + Rahul is based on Vaastu. The architectural styles are pre-dominantly Classical Deccan Kakatiya which symbolizes the secular and heritage continuity of contextual architecture. The ideas and inspirations of the domes on the fa3ade of the imposing Telangana Secretariat are from the temples and palaces of Telangana.

The design inspiration is twofold, one is the cultural and harmonious blend of heritage architectural style of Telangana and the other source of inspiration is of course Lord Shiva with specific reference to the Neelakanteshwara temple located close to Hyderabad and Wanaparthy Palace. The dome and allied architectural features are inspirations from Temples, dedicated to Lord Shiva and a wonderful example of Hindu Deccan Kakatiya architecture, and also dome inspirations from Hanuman Temple at Salangpur and " Expressing Democracy in Architecture" and Grandeur, Simplicity, Beauty.

The overall design philosophy and the exterior architectural character and style are the fusion and synthesis of the diverse cultures and heritage of the dynamic history of Telangana. The exterior podium cladding is red sand stone and the central tower will be with beige Dholpur sandstone cladding, the beige color psychology is reliable, dependable, flexible and color beige is neutral, modern, urbane, calm and relaxing.

The other areas are in white color and the psychology of white is purity, new beginnings, and integrity. The building scale is more compact with site. The scale and proportion of the building gives feel of monumentality and classical symmetry. The

Telangana State Secretariat, Hydrabad

distribution of entrances, cores, service cores and toilet are as per Vaasthu Shastra. Alongside design for all lifts, fire staircases, utility rooms have been planned.

The plan is designed in rectilinear fashion with respect to the site. The building has 11 floors and the total building area is approximately 10 lakhs square feet. The building has grand imposing entrance with 15 feet high entry podium with a 3 storey arrival grand portico.

The grand entrance is a 2 storey entrance atrium which is the centre of the building and the interiors with "Telangana Mural Art" and LED wall Showcasing Telangana Developments", and overlooks a large landscaped central courtyard. These green spaces help in control of air as well as the reduction of carbon emission from the building. The large interior courtyard which is the "Brahmasthanam" has the Red sand stone podium wall.

Even though the basic principles of planning is Hindu heritage architecture with a synthesis of all other styles of architecture that is native to Hyderabad, the electrical, mechanical and plumbing systems are space age with the latest cutting edge technology. Sustainability, covid proofing the building using Green architectural norms and futuristic technology are the hallmarks of the design. Provisions have been made for interfaith worship by virtue of building a Temple, Mosque and church at the secretariat campus showcasing Indian diversity.

CONCLUSION

In developing countries like India, the architectural designs can be made very sensible at the planning stage only by understanding sun path, micro climate of the site, wind directions, locally available material and vernacular aspects like culture, social and economical impacts of the society, to conserve energy for every development. With buildings contributing nearly 40% of all global carbon emissions, it is more critical than ever for the construction and design industry to put a focus on sustainability for a greener, brighter future. A key tenet that more designers now uphold is the attention to ecological balance, construction longevity, and a focus on implementing innovative sustainable practices. Sustainable construction focuses on several distinct parameters, including the use of recyclable materials, effective layout and orientation, solar energy use, carbon-neutral construction, and energy conservation. By leveraging smart materials, bio-friendly orientations, energy conservation, and intelligent facades, designers create a sense of balance through their expression.

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NET ZERO 2070 - THE DECARBONIZATION CHALLENGE
CITIES, BUILDINGS AND BUILDING MATERIALS

V SHOBHANA*

Abstract

The building sector alone accounts for ~ 40% of total global energy consumption that comes out to almost one-third of global energy consumption. According to recent statistics, the building sector alone accounted for 39% of total CO_2 emission through 36% of total global energy utilization.

The built environment generates significant carbon emissions accounting for almost 39% of gross carbon emissions worldwide.

In India rapid urbanization owing to the rural – urban migration dynamics that is adding to the woes of an already deteriorating urban environment brings built environment to the core of strategic thought on wellness, sustainability and resilience.

INTRODUCTION

Cities are responsible for 75% of global CO_2 emissions – buildings and transport being the main contributors. Environmental sustainability is one of the core principles of urban planning so as to build urban resilience and mitigate and adapt to climate change - particularly in Asian regions that are urbanizing at a rapid rate thus becoming the world's most climate vulnerable regions on the one hand while growing as major emitters of greenhouse gases (to the tune of 40% of the world's total on the other. To perform at optimum efficiency, cities need to target creation of systems for energy issues such as transportation, water, energy, buildings and security and integrate them for cumulative efficiency. To achieve the goals of sustainability and liveability smart technologies are to be evolved and innovated in three key areas – buildings, water and energy.

India's cities a significant contributor to its GDP growth as well as its carbon footprint. Achieving Mission 2070 Net Zero calls for coordinated urban development strategy and policies enabling carbon efficient cities of future. The key lever to enable India's transition to greener cities to adapt to the net zero goal would be a national focus on low-carbon buildings and infrastructure in addition to a relevantly renewed approach to urban planning. The framework of strategies and policies for urban development towards carbon-efficient cities of future will need to be complemented by innovations in developing energy-efficient building materials and technologies that are affordable too.

With more than 700 to 900 million square metres of built environment projected for addition to Indian cities every year to fully harness the economic potential of individual cities, industry has identified construction technology as key to achieving India's target of net zero emissions by 2070.

THE CONTEXT

At the COP26 UN Climate Change Conference in 2021 India presented its five- fold strategy 'Panchamrit' to tackle climate change thus:

i) To increase non-fossil energy capacity to 500 GW by 2030.

ii) To meet 50% India's renewable energy requirements using renewables by 2030.

iii) To reduce the projected carbon emissions by one billion tonnes by 2030.

**Director, Military Engineer Services*

iv) To reduce the carbon intensity of the economy to 45% by 2030.

v) To achieve net zero emissions by 2070.

The green transformation of India envisaged thus will involve leap frogging its increasing GHG footprint through low/ no emissions technologies in five sectors:

i) Energy

ii) Mobility

iii) Industry

iv) Green Buildings

v) Agriculture

THE NEED FOR TRANSITION TO GREEN

More Indians are exposed to the negative effects of climate change and extreme weather events than any other nationality - determining development choices. Unprecedented urbanization and formalization of the economy have seen increase in carbon intensive consumption and production. The transformation of specific high- emission sectors is essential if India is to realize its sustainable development and climate ambitions.

BUILT ENVIRONMENT: A CASE FOR DECARBONIZATION

Transforming India's built environment in the context of the threats of climate change and unsustainable development is necessary to provide a healthy and resilient living environment. Following emerge as drivers of transformation in the built environment:

- **Democratization:** Democratization aims to be inclusive of diversity in geography, culture and uniqueness.
- **Digitalization:** Digitalization aims to provide digital tools and model frameworks connecting multiple sectors of built environment.
- **Decarbonization:** Decarbonization aims to control the exponentially aggregating carbon footprint for a net-zero emissions built environment by 2050.

(a) Reduction in projected carbon emissions by 1 billion tonnes and the carbon intensity of economy by 45% by 2030 and (b) net zero emissions by 2070 were the targets announced by India at the UN Climate Change Conference in 2021.

With 80% of India's energy needs being met from coal , oil and biomass which are significant contributors of GHG emissions, decarbonization thus is the core of climate action. And the built environment that constitutes nearly 40% of energy-related GHG emissions represents the largest impact opportunity for transformative action.

In India where half of the buildings that will stand in 2050 are yet to be built and considering their life as 50-100 years, building level decarbonization riding on building technologies and materials scores as a long-term, cost-effective and easy-to-adopt solution for deep carbon reduction as compared to other energy consuming sectors.

WEF's Net Zero Cities mission is to create a clean energy and circularity with the aim of urban decarbonization and resilience through fostering collaboration between energy, built environment and transport sectors. Decarbonization in cities is a real opportunity to keep global warming below 2°C and cities in India can make a substantial contribution in reaching this goal.

India's top 25 cities contribute to more than 15% of India's estimated GHG emissions. The growing need to plan and build low-carbon buildings , infrastructure and thus cities hinges on two critical levers:

i) Efficient urban planning – in this context creation of large green open spaces that can serve as sinks contributing to carbon sequestration

ii) Design of carbon efficient new buildings, retrofitted existing structures, adoption of low-carbon construction processes and use of low-emission materials.

However in the larger picture the capacity of cities to implement decarbonization is bound by current planning processes which are non-comprehensive in vision and scope with too many actors involved. Existing initiatives of government like Atal Mission for Rejuvenation and Urban Transformation, Smart City Mission, Climate Smart Cities Assessment Framework act as advisories and fail to mainstream climate action or decarbonization strategies on green and energy efficient buildings among other green infrastructure.

EMBODIED CARBON EMISSIONS: CONCEALED CARBON CONCERNS

Emissions from a building has two dimensions:

i) **Embodied Emissions –** Emission during manufacturing and application of building raw material in construction.

ii) **Operational Emissions –** Emission during energy consumption in building for utilities and thermal comfort requirements.

Reduction in both of them can contribute to reduction in global warming potential and CO_2 emissions attributed to building sector. The built environment generates 40% of annual global CO_2 emissions – the share of building operations being 27% and that of building and infrastructure materials and construction being 13%. Embodied carbon refers to the latter - carbon emissions associated with the production, transportation and construction of building materials.

In 2040 approximately 2/3 of the building stock will be buildings that exist today continuing to emit CO_2 emissions – calling for intensive existing building decarbonization across the globe. The critical role played by embodied carbon can be gauged by a look at the magnitude of increase of floor area by new construction that is projected to take place between now and 2040. Unlike operational cabon emissions which can be modified/ reduced over time by energy-use upgrades, embodied carbon emissions are locked inherently as soon as the building is built. Embodied carbon thus is an issue to be addressed imminently if zero emission buildings are to be achieved by 2040.

REDUCTION IN EMBODIED CARBON (EC) EMISSION: THE CRUCIAL ASPECT OF BUILDING MATERIALS/ TYPOLOGIES

The manufacturing of building materials is an energy-intensive and resource- intensive process. With India's urbanization rate in rapid transition that is expected to rise to 40% by 2030-31 and construction underpinned by bricks, steel and cement, greenhouse gas emissions associated with these three sectors are expected to rise phenomenally. Additionally, while India's building-related CO_2 emissions have more than doubled between 2000 and 2017, the indirect emissions have almost tripled. India's EC emissions will be responsible for almost half of the total new construction emissions between now and 2050.

The building sector has a significant responsibility for reducing greenhouse gas (GHG) emissions and thus an excellent opportunity to create/ use low embodied carbon building materials consolidating India's clean and renewable energy strategies for decarbonization to meet the climate commitments at COP26. Carbon intensive materials and unsustainable construction practices could irreversibly lock in high energy use and inefficiencies for decades defeating the EC emission reductions achieved by green electricity grid and energy efficient retrofits while depleting air quality by causing air pollution.

Between 40-50% of resources extracted across the world for materials are used or housing, construction and infrastructure - and India is no exception. Around 20-25% of India's total energy demand comes from building material manufacturing industries. IEA estimates that deploying currently available solutions using low-carbon and carbon sequestering materials (hitherto termed sustainable materials) can bring down EC emission rate by 60% in the coming 2-3 years.

Strategies that can be adopted at various stages of construction/ execution are summarized below:

(i) DESIGN

- Reuse and refurbishment of existing assets (retrofitting)
- Resource efficient designs
- Design for circularity with deconstruction and reuse as intent
- Limit carbon intensive materials

(II) PROCUREMENT

- Choose local materials
- Choose low-carbon alternatives
- Use secondary raw materials
- Use carbon storing/ sequestering materials

(III) OPERATIONS

- Use high recycled content materials
- Minimize waste
- Promote recycling of C&D waste
- Reuse and repurpose structures for second life

Policy, design, material selection and specification are key to reduction in embodied carbon emission from built environment. The basic principles guiding the path to zero embodied emissions are:

- **Reuse** – renovating existing buildings, using recycled materials, designing for deconstruction.
- **Reduce** – material optimization, specification of low to zero carbon materials.
- **Sequester** – use of carbon sequestering materials, carbon sequestering sites.

THE PATH TO DECARBONIZATION: BUILDING LEVEL

(I) Building materials to develop and validate

- Low-embodied robust materials and assemblies amenable to circularity
- High performance alternatives to steel, aluminium and cement
- Low-embodied energy building materials that are vernacular, biogenic, and remedial
- Alternate building materials that aid carbon sequestration (capture, utilization and storage of carbon) in buildings to design processes and assemblies for
  - Rapid, modular, prefab EE construction
  - Envelopes for fa3ade/ glass/ shade/ cladding
  - Improved insulation, coatings and sheeting devices
  - Building integrated photovoltaics
  - Passive and active EE technologies

(II) Building Typologies to build

- Low-carbon, region-specific, durable and disaster-resilient building typologies
- Integrated with cost-effective passive and active resource-efficient technologies for thermal, visual, acoustic, daylight and ventilation performance
- Innovative vernacular construction to develop
  - digital repository of regionally relevant building science and technology – climate, construction and cultural practices

CARBON SEQUESTERING AND LOW-CARBON BUILDING MATERIALS

Utilizing carbon-sequestering and low-carbon materials and products and building technologies using them in buildings is one of the simplest and practical options for the building sector to reduce embodied carbon. Carbon sequestering materials are mainly sourced from sustainably harvested wood products (HWPs). This includes flooring and cladding materials, window frames, doors, structural columns and beams. Traditionally used bamboo/ laminated bamboo has recently regained attention as a carbon sink material for use in building structures, screen walls, roofing component and flooring. Low-carbon materials are sourced from materials with low-embodied energy and low carbon in production or produced from recycled products. Some broad examples are :

- Low carbon bricks - using upto 40% flyash
- Green Concrete – Portland Cement substituted by flyash and granulated blast-furnace Slag and aggregate by recycled granite
- Green tiles – using over 55% recycled glass and other materials
- Recycled metals – full recycling or melting/ remoulding

In India, an exhaustive repository of such building materials and building products has been compiled by various agencies/ organizations involved in green building and sustainable construction.

UTILIZATION OF LOW-CARBON MATERIALS/ TECHNOLOGIES IN MES

Criteria for Selection of Materials for Reducing Carbon Emissions

1. Minimize use of natural resources by minimizing quantity – materials should be used efficiently in suitable quantities in the construction process. High energy materials that generate a lot of scrap should be avoided. Reduction in volume of construction and use of cost-effective products results in minimization of resource-quantity.
2. Maximize the use of renewable and sustainable materials (like wood plant fibre, geo- textiles) over non-sustainable equivalent products
3. Adoption of low-energy materials and construction systems – Low-energy materials and systems that reduce the embodied energy costs involved in the whole life-cycle of the building should be selected over high-energy materials and systems that are refined or processed.
4. Maximize the use of regional materials and locally manufactured products – Regional materials that are best suited to climate and support to region–specific construction practices should be maximized. Local sourcing of materials and manufactured products reducing transportation costs be preferred.
5. Selection of materials based on their maintenance requirements and life–cycle costs (LCCs). Materials with low maintenance costs and replacement requirements over the useful life of the building should be selected
6. Material-based pollutants affect occupants' health and productivity as well as indoor air quality. Emission levels of building materials should be checked at the time of product installation and through maintenance practices and kept to acceptable / prescribed levels.
7. Materials that facilitate recycling, have a long life (durability) and products flexible to accommodate varying requirements (adaptability) of occupants should be selected so that wastage owing to redundance is minimized.

RECOMMENDATIONS FOR ADOPTION IN MES

Study of Parameters

Based on the division of administrative theatre of MES the Commands were translated into geographic regions and studied on their climatic zone, type of soil, low- energy material options and the tectonic pattern – so as to recommend for low CO_2 emissions, resilience and relevance.

The same is tabulated below :

SNo	Command	Climate Type(s)	Soil Type(s)	Industrial/ agricultural waste	Seismic Zones
1	**Eastern**	Cold Warm Humid Composite	Clayey red and lateritic Clayey red and yellow Loamy alluvium derived Clayey red loamy	Flyash Rice husk Alumina Blast furnace slag	V
		*(Cyclone prone)	Loamy brown and red hill soil Clayey coastal deltaic alluvium		
2	**Northern**	Cold	Loamy brown forest and podzolic soil Shallow skeletal Loamy skeletal	Rice husk Gypsum	V/ IV
3	**Western**	Cold Composite	Clayey coastal alluvium derived Loamy brown Forest and podzolic soil Loamy alluvium derived Loamy terai soil Loamy red and yellow	Flyash	V/ IV/ III
4	**South Western**	Hot Dry Warm Humid	Loamy grey brown	Gypsum	IV/ III
5	**Central**	Cold Composite	Loamy terai soil Loamy red and yellow Loamy alluvium derived Clayey red and black	Flyash Rice husk Bagasse	V/ IV/ III
6	**Southern**	Hot Dry Warm Humid Composite *(Cyclone prone)	Coastal alluvium derived – loamy/ saline/acidic Clayey red and lateritic Clayey mixed red and black Deep red loamy Clayey deep black Yellow red loamy Sandy black, littoral (in Islands)	Flyash Rice husk Alumina Blast furnace slag Gypsum Bagasse	V/ IV/ III/ II

CONCLUSION

Carbon footprint and emanating carbon emissions pose an enormous challenge underlying climate change and national objectives to address and mitigate their effect on human wellness. While the built environment carries the single largest footprint in construction and operation, it also holds the largest opportunity for decarbonization. For maximum effectiveness the built environment thus needs to embrace sustainable strategies that involve local resource and energy dependencies. That is where the case for carbon sink and low-carbon material comes in - among other high-impact measures for both embodied and operational emissions.

A national level strategy to decarbonize the built environment by promoting the use of low-carbon sustainable materials with demand driven by aggressive implementation of Green Building rating systems and energy codes can play the harbinger of resilient, healthy and thriving communities world over.

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ECO HOMES: A SUSTAINABLE SOLUTION FOR MODERN LIVING

SNEHAL PATEL*

Abstract

The concept of an Eco-house (or Eco-home), an environmentally low-impact home designed and built using materials and technology that reduces its carbon footprint and lowers its energy needs, is an upcoming and intriguing concept. Presently, around 40% of the carbon footprint is generated by construction and buildings industry due to various processes like lighting, cooling, and heating of building materials (outlook India), it is imperative to explore concepts like Eco-homes that supports in meeting sustainability needs such as conserving water, reducing wastes, controlling emission, generating energy, and supporting its conservation, thereby reducing building's carbon footprint. The paper presents and discusses one of the success stories of such eco-home and elaborates its building service system.

INTRODUCTION

The evident results of climate change and global warming including erratic weather changes have made people more aware about the impacts of their activities on nature and its cycles. Enhancing awareness has led to many global trends to work towards more sustainable and environmentally conscious practices. Energy efficient and sustainable homes is one among many practices that have gained much popularity in recent years. Eco homes, also known as sustainable homes, offer a practical solution that enables people to live in a manner that is both comfortable and environmentally sustainable.

The philosophy behind eco homes is that one can live a comfortable lifestyle without degrading the environment. Eco homes are built with the aim of reducing the impact that homes have on the environment. Unlike traditional homes, which are designed primarily for comfort and aesthetics, eco homes are designed to incorporate sustainable materials and techniques that reduce energy consumption. They offer an opportunity to live in surroundings that are free from toxins and waste, thereby ensuring a healthy living environment. Moreover, eco homes offer significant energy savings, which translates into lower utility costs. With the use of sustainable materials, eco homes are also able to minimize construction waste and reduce the need for maintenance.

Eco homes are designed to utilize natural resources, such as sunlight and wind, in order to provide cooling, heating, and lighting. Some of the common techniques used in the construction of eco homes are:

- **Passive Solar Design:** Passive solar design makes use of the sun's natural energy to provide heating and cooling. This design incorporates features such as large windows, insulated walls, and a well-ventilated roof, all of which are aimed at regulating the temperature inside the home.
- **Insulation:** Thorough insulation in walls, ceilings, and floors plays a critical role in the energy efficiency of eco homes. Insulation minimizes energy loss and ensures that the home stays cool in the summer and warm in the winter.
- **Rainwater Harvesting:** Rainwater harvesting entails the collection of rainwater for use in various domestic purposes such as toilet flushing and irrigation. By utilizing rainwater for domestic purposes, eco homes are able to conserve water and minimize the need for expensive water supply methods.

** CEO, Satt Engg. Ltd.*

- **Use of Sustainable Materials:** The use of sustainable materials such as bamboo, reclaimed wood, and recycled glass is a hallmark of eco homes. These materials are eco-friendly and durable, making them an ideal choice for a sustainable home.

SUCCESSFUL CASE STUDY

One of the prime examples of eco-home in India is the residence of Mr. Snehal Patel, the author of this paper, a renowned environmentalist, designed with support of architect Falguni Desai. The land on which the house is constructed was a barren field with not a single tree on it. All the trees present today are planted after 1996. At present there are more than 500 full grown trees on the premise which consist of more than 70 different varieties and about 30 varieties of fruit tree. The area of the premise is 16000 square metres.

IMPORTANT FEATURES OF THE ECO-HOUSE

The house features an open plan design, allowing natural light to flood in and creating a feeling of spaciousness. The interiors are decorated with a minimalistic approach, with neutral colors and simple furnishings that spotlight the unique architectural design of the house. The living room features floor to ceiling windows that offer unobstructed views of the gardens and outdoors. The furniture used indoors is majorly made from cane or bamboo with cotton upholstery, and the curtains used are made of jute, which can be used for composting once its designated life is over. The sloping roof of the house ensures that the indoor temperature is maintained using the stack effect - where the hot air rises and exits through the highest point of the roof and is replaced by the cool air in the lower habitable level. The indoor temperature is also regulated using the indoor ponds which offer a way to cool the interiors by adding moisture in the air.

Fig. 1: Mr. Snehal Patel's residence (Surat, Gujarat)

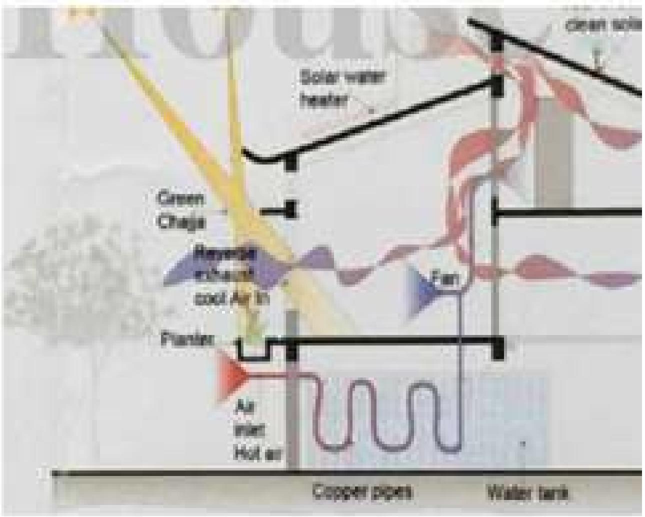
1. Zero power-

- Solar and wind power – The roof angle is selected in such a way that solar panel can be laid directly on it without having any fabricated structure which looks artificial. The Solar Panel capacity is 7.5 KW. A hybrid system installed for producing enough electricity throughout the year. One small windmill is also installed to cater to the house's needs during monsoon when sky is cloudy, and the Solar output is lesser. The windmill runs almost 24 hours a day during monsoons due to the wind conditions. A part of

the solar power is stored in the battery and the rest of it is fed back into the grid.

- Passive solar principles- The residence is designed with passive solar principles, which ensures that the home remains cool in the summer and warm in the winter, in turn reducing the electricity requirement. The large windows oriented towards the south captures maximum sunlight, while the roof is designed to provide shading during the summer months.
- Natural air-conditioning- another innovative system has been adopted for cooling the bedrooms. Pipes are passed through the rainwater storage tanks on the ground floor. The pipes have a six-inch diameter, and one end of the pipe opens in the room where a 30-watt fan with six-inch diameter is fitted, and the other end of the pipe opens in the basement after passing from underground water tank. When the fan is switched on, air which is sucked from the basement will flow through the pipe which is submerged in water, where this air will get cooled down and will enter the room serving as Natural air conditioning.

  Additionally, roofs are painted with special ceramic paint on the top side which keeps the roof cool by 3-4 degrees, by reflecting the sunlight. Then there are creepers on the open area of the roof which prevent sunlight directly striking the roof thereby helping it keep cool.
- Water heating- solar water heater is also installed on one of the roofs of the house which has a 23° south facing slope, eliminating the requirement of any stand to make the angle appropriate. Innovative system has been incorporated to reduce the hot water wastage. The hot water pipes coming into the bathrooms is going back to the hot water tank. There is small water circulation pump connected in between this. Whenever hot water is required, the pump is switched on which works on a timer and keeps it on for 5 minutes. During this time, all the cold water from the Water Line goes back into the



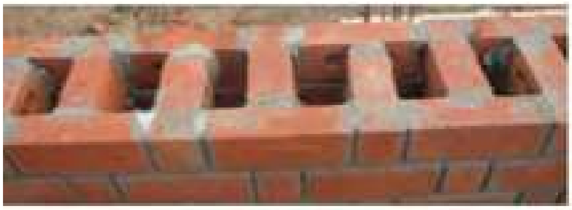
hot water storage tank so that after five-minutes when you open the water tap, you get hot water immediately. All the hot-water pipes have triple layer insulation. As the first layer, asbestos rope is wrapped around the pipe, the second layer is insulation material, (same as used in AC cooling pipes) and the third layer is of aluminum foil, ensuring the hot water does not get cold inside the pipes.

Additionally, all the electrical gadgets including refrigerator, driers and washing machines are energy efficient with the five-star rating. The

fans are of 50 Watt which are below the usual fans whereas the lights are LED based.

2. **Sustainable materials-**One of the most unique features of the villa is the use of eco-friendly materials. The house is constructed using locally sourced materials such as stone,

brick, and concrete, which are known for their durability and sustainability. Mr. Patel has also made use of recycled materials such as reclaimed wood, which adds a touch of rustic charm to the house. The walls of the house are constructed using stone and exposed bricks and designed using a type of wall construction known as rat-trap bond. In this type of wall construction, there is a hollow cavity that provides insulation to the indoor environment from the outdoor environment. Certain intricate elements such as adding holes in the walls to accommodate bird



nests make the residence even more appealing. Mr. Patel proudly calls them as "Living walls".

3. **Water requirement-** Water requirement is fulfilled by capturing the water from the rains that fall on the roof, and the water is stored in tanks that are placed above living room, which ensures that the water comes down through natural gravity and maintains adequate water pressure. The excess water, after passing through three-chambered filter using sand, gravel and charcoal medium respectively, is stored away in an underground tank of 2,00,000 lakh liter capacity for domestic consumption. These three chambered filters are constructed with RCC. The first chamber comprises of a SS sieve over bed of gravel which will remove leaf and other such impurities. Second chamber has wood charcoal under a layer of sand while the third chamber again has SS sieve again which does not let sand flow into the tank. Then there is a system of groundwater recharging as the water falling on the rooftop is either collected in the water tank or goes into the earth after passing through the filter comprising of bricks and gravel.

Drinking water requirement is met by using a "five-pot" water purification system, where the water is made to seep through five pots which have limestone chips, coconut shell charcoal, fine sand in the second, third and fourth pot. In the fifth pot, which has drinkable water, a silver coin is placed. This system naturally removes off impurities such as sediments and e-coli bacteria besides adding crucial minerals and ensure that the water is fit for drinking.

Greywater generated in the house is treated in-house only through natural means. The water from the bathrooms and wash-basins in the house is treated using 'Root-bed method' in a 'three-tub-system' where the first tub consists of sand and kena plants - which ensure that the water impurities such as soap and hair are filtered by the sand and kena is a good water purifying plant as well; the second tub consists of plants like duckweed, water lettuce and water hyacinths - which further purify the water, and finally the water flows into the final tub which consists of water umbrella and lily pond and fish in it which helps adding oxygen to the water. The fish in the third tub act as indicators for determining whether the water is sufficiently clean, before the water is being used in the vegetable garden.

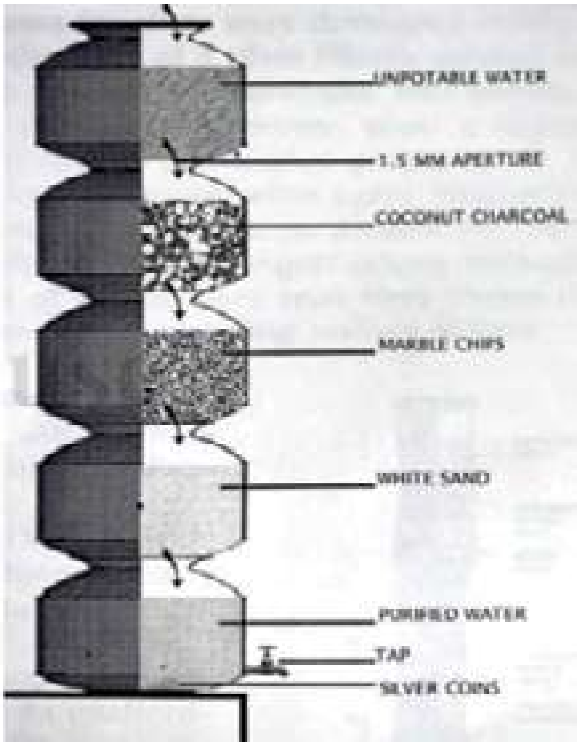


Fig. 2: Rainwater Harvesting pipe(left) and drinking water filtration unit (right)

The washing water released from the washing machine as grey water is collected in a tank below the washing machine and is used for flushing house-toilets. The house does not have any Flush tank attach behind the toilet as the washing machine water should not be stored for more than 24 hours as it will start stinking. Hence, a spring-loaded flush valve directly attached to the pipeline fitted to the toilet tub is used so that water will come directly from the grey water tank maintained on the top of the house.

The black water from toilets is taken into settling tanks where solid material gets settled in first and second tank. In the third tank, aerobic and anaerobic reactions take place and in the fourth tank, again root bed treatment is affected. The water after purification is used in the kitchen garden.

One of the most significant installations that has been incorporated in this house is the development of a pond in the lowest contour of his site, which acts as an aquifer and recharges the ground water with the rainwater that falls in the rest of his site, apart from the home terrace. This residence is a remarkable example of contemporary and eco-friendly design and use of locally sourced and recycled materials adds to the sustainability of the project while the outdoor spaces with more than 500 trees of around 70 indigenous tree species offer a serene and peaceful environment.

CONCLUSION

With the discussed case study, the benefits of eco-home are evident. The design concept of eco home is a win-win for all as it not only strengthens the philosophy of environmental benefits and support sustainable development but would reduce the operation and maintenance costs and dependency on the city infrastructure, bringing benefits to the individual as well as city administration. While the design is economically viable, it supports environmentally conscious net-zero construction. Thus, it is imperative to adopt this concept as the design philosophy since the very beginning of the project to throughout its life-cycle. Creating a grid of such buildings can, therefore, become a transformative development, making building construction industry an active contributor in India's dream to become net zero economy.

So, let's be the change we want to see in the world.

BUILDING A SUSTAINABLE FUTURE TOGETHER

SHARING EXPERIENCE OF RECYCLING CONCRETE DEBRIS

Anup Mathew* And Abhijeet Gawde**

Abstract

According to UN research, every year approximately 50 bn tonnes of sand, aggregates and gravel are extracted, enough to build a wall 27 metres high by 27 metres wide around the planet. These billions of tonnes of natural resources cannot be replenished as quickly as they are being consumed. Given the extent and growing awareness that we have limited resources, across industries ranging from construction to IT manufacturing and a number of other booming sectors, the industry stakeholders have realized that we need to adopt more sustainable ways of using depleting natural resources.

This requires us to reconsider the 'waste' what we discard, viewing it as an opportunity to 'Recover, Reuse and Recycle' rather than discarding any material after its use. To maintain the right balance between the adverse effects of rapid urbanization, growth in population, increased natural resource consumption and the challenge of climate change, it is imperative to adopt a circular economy in our journey of economic growth.

INTRODUCTION

Globally, the construction sector is amongst the largest consumers of natural raw materials. A sector which is vulnerable to raw material supply problems and price volatility, it does make sense to focus on resource efficiency, and the reuse of materials. With new buildings and infrastructure projects, construction work is on rise, the demand for construction materials is expected to significantly increase. However, there is crisis looming up on the construction sector as there is growing shortage of building materials. Globally, it is now established that adopting Circular Economy is the need of the hour to deal with this issue. It can help by both addressing increasing emissions by reducing the need for the production of new virgin components, and potentially holds further benefits such as cost-savings or offering a solution for effective disposal of Construction & Demolition (C&D) waste.

Adopting improved construction process could reduce the adverse impacts on the environment and, reusing Construction & Demolition (C&D) waste is a viable alternative to address the growing concern of depleting sources of raw materials and disposal of C&D waste

**Senior VP & Business Head, Godrej Construction*

***Head of Business Development & Marketing, Godrej Construction (GC)*

C&D WASTE – A RESOURCEFUL OPPORTUNITY

As per UN estimates, with the urban population expected to more than double its current size by 2050, globally cities would need to accommodate for 8.5 billion people by 2030. More than 1.5 billion people of India are expected to live in urban areas by 2030. As the cities are growing, the rate of municipal solid waste including Construction & Demolition (C&D)waste is also significantly increasing, this is emerging as one of the major cause of concern for cities around the world.

As per an estimate prepared by Building Materials and Technology Promotion Council (BMTPC) and the Centre For Fly Ash Research and Management (C-FARM) in the year 2016, the construction & demolition (C&D) waste generated in India was approximately 165-175 million tonnes annually.

While Delhi NCR generates about 5,000 tonnes of C&D waste daily, Mumbai generates about 3,000 tonnes, followed by Kolkata at 2,000 tonnes and Chennai at 1,500 tonnes per day. Management of C&D waste has become essential for government to ensure sustainable infrastructural growth across the globe. The major proportion of C&D waste comprises of debris generated from the demolition activities, and their inadequate management could have a significant adverse impact on the environment.

According to a report released by the Centre for Science and Environment (CSE) in 2020, India recycles only one per cent of its Construction and Demolition (C&D) waste. The official recycling capacity available in India is a mere 6,500 tonnes per day.

A bulk of the C&D waste is discarded in landfills and for reclamation activities. However, C&D waste offers opportunity to use our resources much more efficiently with a potential of 70% of waste that could be recovered using the appropriate methods and guidelines during the demolition activity. C&D waste reuse and recycling rates in the European Union (EU) and United States of America (USA) have reached 79 per cent and 70 per cent respectively. Some EU members (individually) and smaller nations like Singapore have reported over 90 per cent recycling and reuse rate. Assessment of the structure before demolishing to recover most of the materials for recycling using suitable demolition method and segregating the waste generated at the source are key factors for high level of C&D waste recovery.

In terms of waste streams, concrete often forms a significant portion in the overall C&D waste generated. The composition of C&D waste is however highly, depending upon the type of project, construction technique and location of the project.

GODREJ CONSTRUCTION INITIATIVE -'RECOVER, RECYCLE AND REBUILD'

Godrej has always been committed to preserving the environment and aims for a more sustainable development. In line with our core values Godrej Construction (GC) has implemented various initiatives across its lines of business. This helps GC achieve its objective of sustainable and responsible construction. Some of these initiatives include, establishing an automated Recycled Concrete Materials (RCM) manufacturing plant in Mumbai.

At Godrej Construction, we are putting the principles of "Recover, Recycle and Rebuild" for recycling concrete debris to produce various prefabricated concrete products. We recycle concrete debris to produce recycled products such as building blocks, pavers, culverts, OTE ducts, and other customized precast concrete products of superior strength. These products are in fact just as good as any other concrete products made using virgin aggregates in terms of its quality and durability parameters. The recycled concrete, which uses Construction & Demolition (C&D) concrete waste for making Customized Prefabricated Concrete Products such as Box Culverts and Ducts are being used in some

Paver Blocks made of C&D

of the major infrastructure projects in Mumbai. Godrej Construction has recycled almost 30,000 metric tonnes of concrete debris by implementing circular economy principles in their construction materials line of business. We are one of the first in the country to work jointly with Bureau of Indian Standards (BIS) to receive BIS certification for few variants of our recycled concrete blocks. We are also collaborating with reputed entities in Norway to help test and develop these products as per international standards and global best practices. Godrej Construction has provided guidance and support to several representatives from the State Government / Municipal Corporations within the State of Maharashtra, Goa, Karnataka & Kerala in their endeavour to set up such C&D Waste Recycling facilities.

EMBODIED CARBON–A BLINDSPOT

As per the World Green Building Council's report, together, building and construction are responsible for 39% of all carbon emissions in the world, with operational emissions (from energy used to heat, cool and light buildings) accounting for 28%. The remaining 11% comes from embodied carbon emissions that is associated with materials and construction processes throughout the whole building lifecycle. Broad-based recycling of construction materials coupled with smart design could substantially reduce CO_2 emissions generated by buildings.

Godrej Construction is a pioneer in adopting sustainable construction practices in India and we are committed to minimize the impact of construction on the environment. All our building construction projects are designed using Green Building principles. Many of our buildings are certified as Platinum or Gold rated Green Buildings.

Our Ready-Mix Concrete (RMC) plant, Recycled Concrete Materials (RCM) plant and the common areas of Godrej Business District building in Mumbai are now powered by 100% renewable energy. Godrej Construction is one of the first in the RMC industry to switch to 100% green energy.

Godrej Construction has received the 'Green Pro' certificate from Indian Green Building Council (IGBC) for their RMC products such as Enviro TUFF, Xtra TUFF, Easy TUFF and other construction materials such as TUFF Blocks AAC, Recycled Concrete Blocks & Pavers making them beneficial for use in Green Buildings. Our 3 RMC plants in the Mumbai-MMR & Pune region have been commended with the GreenPro Certification by Indian Green Building Council (IGBC).

FULL SCALE DEMONSTRATION PROJECT ON USE OF RECYCLED CONCRETE AGGREGATES (RCA) CARRIED OUT IN COLLABORATION WITH SINTEF, NORWAY-

A successful demonstration project was conducted on the RCA in form of fine aggregates produced at Godrej Construction Recycled Concrete Materials plant, Vikhroli Mumbai. SINTEF, headquartered in Trondheim, Norway, is an independent research organization and one of the leading organizations in scientific research on C&D waste practical applications. A new Indo-Norwegian project had been initiated between Central Public Works Department and SINTEF, where the aim is to increase the treatment and recycling capacity for construction and demolition wastes in India.

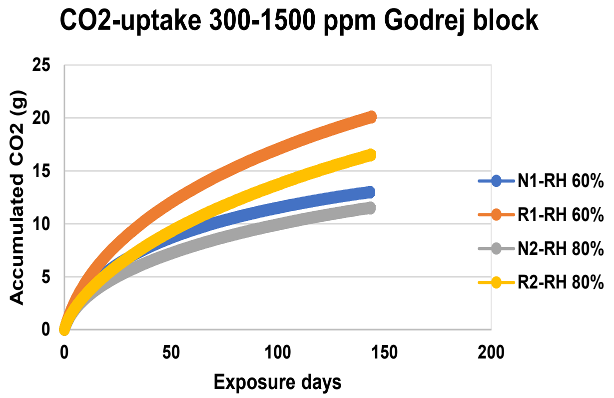
As part of this project, a full-scale demonstration was carried out with an objective to: -

- Demonstrate the added value of using RCA in making of recycled concrete materials,
- Assessment of natural CO2 Binding property of RCA.

The demonstration project was carried out in two phases.

In the first phase, the concrete blocks made with RCA and blocks having natural aggregates produced at the plant were separately sampled for CO_2 binding measurements and shipped to SINTEF Laboratory in Norway. The blocks were crushed and were exposed to CO_2 exposure into patented test apparatus in Sintef laboratory. The exposure was based on varying Relative Humidity (RH), exposure days and pressure. The results were observed and tabulated as per the defined frequency of readings.

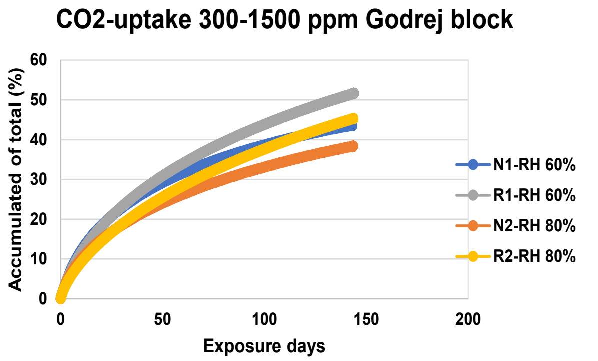
N1,N2 – Blocks made using natural virgin aggregates



R1, R2 – Blocks made using recycled concrete aggregates produced at Godrej Plant

RH – Relative Humidity in % during infusion of carbon dioxide

N1,N2 – Blocks made using natural virgin aggregates



R1,R2 – Blocks made using recycled concrete aggregates produced at Godrej Plant

RH – Relative Humidity in % during infusion of carbon dioxide

The above test results reinforce the theory that recycling concrete debris results in increased surface area and thereby likely to have higher CO_2 binding due to increased ageing owing to carbonation.

In the second phase of the demonstration project, concrete debris was collected from a demolition site of a hotel building in Mumbai. The structure was 8 to 10 years old and was approximately 6.5 kms away from the recycling plant. Carbonation test were carried out on the site before collecting the debris to ascertain the quality of in-situ concrete. Ultrasonic Pulse Velocity and Carbonation Test instruments were used conforming to the procedures as per BS EN 14630 (2006) and standard literature.

The concrete debris was then pulverized in the recycling plant and RCA were produced. RCA sampling was done at defined interval during the production, being collected 5 times in an hour from different batches of production. The hourly sample were collected and sorted in different bags labelled properly for ease in identification. Another set of hourly samples were mixed with each other to make composite sample for testing.

These samples were tested at 3rd party Quality laboratory for checking various physical properties of RCA produced for tests such as Sieve Analysis as per IS 2386, Part 1, 1963 RA 2016 and Physical Test as per IS 2386, Part 3, 1963, RA 2016. The test results were encouraging and demonstrated that the RCA produced through good quality feedstock and well controlled production process is having equivalent properties as that of natural sourced aggregates.

The RCA in form of fine aggregates produced were used in making solid concrete blocks. These recycled solid concrete blocks were further tested in 3rd party laboratory to check for strength and other quality parameters. Tests were carried out as per IS 2185, Part 1, 2005, RA 2015 for ascertaining average Compressive Strength in N/mm2, Water Absorption in %, Dry Density in kg/m$_3$, dimensional accuracy, Drying Shrinkage in % and Moisture Movement in %. The test results demonstrated that the quality of recycled concrete solid blocks produced using RCA were at par in all the quality parameters and acceptance criterion as compared to normal solid concrete blocks made with naturally sourced aggregates.

EXPLORING NEW SUSTAINABLE TECHNOLOGY SOLUTIONS – CONSTRUCTION 3D PRINTING (3DCP)

Construction 3D printing (3DCP) technology is revolutionizing the way we think about construction, offering a sustainable, cost-effective, and highly customizable alternative to conventional building methods. 3DCP allows for high design flexibility, it's easy to achieve a balance between form, function and aesthetics. 3DCP technology offers significant potential to increase efficiency and productivity.

Use of robotics and automation in 3DCP lowers the chances of design errors and worker injuries, also requires less manpower for execution. Construction time is reduced significantly. Its environmental benefits are additionally endless. It – minimizes material use, uses natural, organic or recycled materials, generates less waste, decreases transportation needs as well as reduces carbon footprint.

Godrej Construction has partnered with Tvasta Manufacturing Solutions, an indigenous start-up founded by IIT-Madras alumni, to introduce and commercially deploy an innovative 3D Construction Printing (3DCP) Technology in India. To promote adoption of Circular Economy principles in the Construction industry, Godrej Construction, along with Tvasta have developed for the first time a very sustainable concrete mix design comprising

3D Printed Bus Shelter

of approximately 30% of Recycled Concrete Aggregates (RCA), sourced from concrete waste debris, recycled at the Godrej Recycled Concrete Plant, at Vikhroli, Mumbai.

Addressing the growing needs of the Real Estate and Infrastructure sectors of India, Godrej Construction and Tvasta have collaborated to develop a Proof-of-Concept (image above). The Bus Shelter was 3D Printed within a span of 32 hrs and assembled on site within 8 hrs.

The unique structure has a distinct physical design – a curvilinear geometry to showcase the aesthetic versatility, structural advantages and excellent potential that this technology has to offer to the Construction Industry. It is designed to be completely energy efficient with independent solar panels for lighting the bus shelter and it's commercial signages at night.

Based on recent laboratory trials, Godrej Construction and Tvasta together have developed concrete mix designs comprising of 50% as well as 100% RCA which can be used in 3DCP. Such sustainable method of using recycled concrete materials in 3DCP is unique, globally. Very few companies across the world offering 3DCP materials, have been able to develop such practical use cases of using recycled concrete materials.

ENCOURAGING THE USE OF RECYCLED CONSTRUCTION MATERIALS

Going forward, environmental and material challenges associated with the C&D problem needs strong policy support from the Government/ Regulatory Bodies. The Construction and Demolition Waste Management Rules notified in 2016 by the Ministry of Environment, Forests and Climate Change (MoEF) have provided detailed guidelines to all concerned stakeholders including the State governments to address the growing concern of C&D waste. However, on ground implementation of these rules has witnessed multiple challenges. MOEF had proposed a 3 year action plan in 2019 for better governance, reduced landfill use, effective management of construction waste through recycling and to increase the focus on resource efficiency. Concerted efforts by Niti Aayog, MOEF, State governments and Urban Local bodies (ULBs) along with recent critical policy developments are expected to accelerate effective C&D Waste management across various Indian cities.

To promote higher uptake of recycled products made using C&D Waste in construction sector, there needs to be more emphasis put by the government by development of public procurement policy, lowering GST slab rates for recycled products, incorporating new guidelines in relevant building design codes and standards to encourage use of C&D waste right at the design stage of any project.

Incentivizing all stakeholders involved in C&D waste management would provide financial benefits for better implementation of C&D waste rules and framework.

The government should also mandate the use of recycled products from C&D waste in all private and public infrastructure projects encouraging circular economy. Ministry of Road Transport & Highways (MoRTH) have recently taken few steps to finalize guidelines for value engineering during preparation of feasibility reports of proposed highway projects for promoting use of C&D waste.

ABOUT GODREJ CONSTRUCTION (GC)

Ever since our inception in 1948 as a Construction Division for Godrej & Boyce, the flagship company of the Godrej Group, we have been guided by an unwavering commitment towards customer centricity and sustainability approach across all our lines of businesses.

GC specialize in Real Estate Leasing, Real Estate Development, Manufacturing & supply of sustainable Construction Materials. We develop and maintain Corporate Real Estate assets, provide environmental engineering, horticulture and wetland management services across Godrej & Boyce.

We are passionate about positively contributing to the environment and building a greener world. As part of that responsibility, we develop innovative products and build projects with the least possible ecological footprint. All our building and real estate development projects have been designed and recognised as Green Buildings, and our products have received a 'Green Pro' certified by the Indian Green Building Council., recognizing our commitment towards building sustainable future.

Over the years, we've come to be renowned for our quality-focused, customer centric, and sustainable construction business practices. In recognition of our outstanding Business Performance, we were awarded the "CII EXIM Bank Award for Business Excellence" for two consecutive years -2021 and 2022 – making us the first company in Real Estate and Construction Industry to win this recognition.

CONCLUSION

Godrej Construction's Recycled Concrete manufacturing plant is one of the rare few and perhaps the largest such unit in the country. As cities like Mumbai grow older, Construction & Demolition waste management will become a major cause of concern for ensuring sustainable development within the city. We have made an early start to clearly demonstrate our commitment towards sustainable development and hope many others in the industry will follow in the endeavour to build more sustainable construction products for the benefit of our future generations. The mindset of the industry needs to change towards cleaner production of raw materials and better circular construction methods to help reduce energy intensity and environmental footprint of the construction sector.

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A SUSTAINABLE APPROACH FOR BUILT ENVIRONMENT TO ACHIEVE NET ZERO EMISSION EARLIER THAN 2070

MAJ. GEN. DR. SHRI PAL, VSM (RETD.)*

Abstract

The present study describes a recently developed new technology in India, by which India's target to achieve Net Zero can be fast tracked. This technology removes CO_2, Total Volatile Organic Compounds (TVOC), other toxic gases, particulate matters and other pollutants from the outdoor and indoor air. The saturated material from filters are used to produce "Minerals Rich Organic Manure (MROM)" which is used by plants and trees. The CO_2/TVOC and Pollutant Removal Systems are so designed that these can be easily used in a house, offices, hospitals, Malls etc. The proposed system also helps in reducing the air conditioning load of the buildings by 20 to 30% by cutting down the requirement of air changes per hour. This technology not only provides a clean and healthy living environment both indoors and outdoors, but it will help eradicating the problem of rising pollution, climate change and global warming from the entire world and make this planet earth liveable for our present and future generations.

INTRODUCTION

Post 9/11 trauma and increasing threats by terrorist activities world over, created alarm in the minds of not only Govt agencies but in Business Houses and Private individuals too, for some increasing demand for highly protected facilities for few years. But, as the time passed, the simplistic "low cost" model took over this approach again. Now the recent trauma created by COVID-19, has again shaken the minds of public world over to understand the importance of the desired safety and protection in case of such disasters whether natural or man made. People in most countries have now realized that the concepts like Lock Down, Button UP, Close Door Isolation are no more the myths but these are the realities of life which can be forced upon us any time in future due to the changing environment world over and as recently experienced by them so practically in their own personal life.

PROPOSALS AND FINDINGS

Emergency Homes: Evolution of a New Concept

People in many countries (mostly rich and big businessmen) are now ready to spend a part of their money on strengthening/hardening of their existing houses/bungalows against such disasters and even to construct a separate hardened emergency home or a shelter for them where they can easily shift with their families in case of any such emergencies.

Some companies like Bunkerman[1,8,9], have come up to provide their expert services for such construction of Private Houses, Bungalows, Farm Houses, Flats, Basement Houses, Deep Under Ground Houses etc; and they even modify/upgrade the existing ones which can be safe and protected for use in any such emergencies. Following Specialised Services are generally provided in such houses/ facilities:-

a) To protect the house against any biological/ chemical threat in the environment outside, the house is sealed with air/gas tight doors and windows from all around, so that no air from outside can enter the house during the "Button Up Period" of 7 days, 10 days, 15 days or even upto 30 days in some cases as per requirements of the clients.

b) A "Button Up Period" is defined as the

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period during which no outside air is taken for human inhalation (being contaminated or suspected to be contaminated) and the occupant's safety and survival are ensured by maintaining the indoor air quality in the house as per the international standards and guidelines prescribed under such crisis situations.

c) The proper Heating, Ventilation and Air Conditioning (HVAC) system is designed and provided in the house.

d) In addition to the HVAC System, other custom made systems like CO_2 Removal System, Oxygen Replenishment System, Compressed Air System, Odour Removal System, Filtration System, Communication and Control System, Environment Monitoring System (EMS), Building Management System (BMS) and other such important systems are designed and integrated with the HVAC System of the house so that a safe, comfortable and working environment is ensured inside the house during desired "Button Up Period", thereafter during "Filtration Mode" and finally once the Biological/Chemical threat is over and the house is switched over to "Normal Mode". All this is done as per laid down international standards and norms for such important facilities to remain safe and functional before, during and after such disasters.

e) A positive overpressure is maintained inside the house during "Button Up" period and also during "Filtration Mode" so that no outside contaminated air can enter the living area through any possible leakages.

f) Adequate supplies like food, water, oxygen, compressed air, consumables, spares, medicines, first aid kits, protective masks and suits, stand by power supply are also designed and provided as per customer's requirements.

g) Special attention is paid to arrangements of waste disposal, sewage disposal, waste water disposal, cleaning, hygiene and sanitation inside the facility particularly during "Button UP" and "Filtration Modes".

h) Education and Training on following the Standard Operating Procedures (SOP) and Operation and Maintenance of the facility in Automatic, Semi Automatic and Manual Modes are also provided.

j) Any addition facility or service as felt necessary and as per client's requirement.

More details of these are available at www.bunkerman.in/EmergencyHomes.php.

Dual Home/Multiple Home Concept

Dual Home and Multiple Home Concept are though not the new concepts but it has caught the attention of the public for its importance during the recent COVID-19 crisis. It were not only the daily wagers and migrated labourers who rushed from big cities to their native villages in COVID-19, but many rich and well to do families (both service and business class) also shifted to their alternate family homes to feel more safe and secure and to help each other in the case of any further crisis. In countries like India, many joint families which got defragmented into number of smaller individual based families over the years (due to compulsion of seeking employment in various cities), were again found vacating their individual accommodations and shifting to their joint family houses during this crisis.

It is for consideration of such joint families that they must think of providing the emergency facilities in at least one of their such primary or secondary homes which can come handy to their entire joint family in case of such disasters.

Composite Homes

Most rich and well to do people have big and luxury houses comprising of 4 or more bed rooms. In cases where such houses are generally occupied only by few members (2 to 4), it is easier and economical to convert such houses into composite homes. In a composite home, while in the normal case, the entire house is occupied by its occupants for their normal use, but the house is so designed that in the case of any emergency, only the minimum essential area of the house is provided with the emergency facilities and services to make only one or two bed rooms with connected wash room(s) and kitchenette functional during the Button Up Period.

Work From Home (Normal & Emergency)

Work from Home is a fairly new concept which was initially forced upon the people and corporates by the calamity of COVID-19. But after going through this concept once (though by compulsion only), many people and corporates are finding it to be more practical and economical now. While the individuals are viewing that this concept is more convenient and productive for them, the corporates find it equally productive yet more economical since it cuts down the unnecessary extra cost of creation/ hiring and maintenance of their office premises.

Therefore, the requirement is even felt for the homes used for Work From Home (whether small or big), to be designed in such a way that they remain functional both during normal and emergency periods. No corporate will desire that its employees who work from home are not available to them or they get cut off from them during emergencies like natural or man made disasters. Similarly, no employee will like to lose his/her job due to being cut off from his/her employer due to disruption of certain services/facilities to them due to such disasters. They will certainly like firstly, to be safe and protected and secondly, to continuously remain in communication with their employers and discharge their duties even in such disasters. In fact, the employer-employee relationship becomes more essential and crucial during such crisis situations and continuity of the same must be ensured at any cost to effectively fight out the disaster and come out of it as soon as possible.

Indoor Air Quality Management During "Button Up Period"

It is a well-known fact that normal atmospheric air generally contains 79.03% Nitrogen, 20.94% Oxygen and 0.03% Carbon dioxide by volume. Nitrogen is not absorbed by lungs and in human respiration it goes into lungs and comes out as it was inhaled as part of the air. Exhaled air, however, contains a higher percentage of Carbon Dioxide (an average of 4.38%) as compared to the percentage of CO_2 in inhaled air. During inhalation, a small percentage of Oxygen is permanently consumed by lungs and it goes into the blood cells inside the human body [11, 12, 13, 14].

Therefore, when a facility goes into a "Button Up Mode" in closed up Conditions, the following things happen inside the facility almost simultaneously or in some sequential manner:-

a) Oxygen level keeps on depleting with time.

b) CO_2 level keeps on increasing with time.

c) Overall volume of air keeps on reducing with time (since some oxygen is permanently absorbed by lungs).

d) This fact theoretically and practically creates a negative pressure in the closed chamber.

e) Above changes take place inside the facility almost every second as the occupants inhale & exhale the air.

The rate of change in overall composition of air is not a simple phenomenon but it is quite complex in nature and it depends on following factors:-

a) Number and Nature of occupants.

b) Density and distribution pattern of persons in different areas inside the facility.

c) Movement and working pattern of occupants inside the facility.

And hence to monitor and control this highly complex phenomenon, there is always a requirement of having a computerized fully automated Indoor Air Quality Management and Control System comprising of the following sub systems duly integrated with one another:-

a) CO_2 Removal System.

b) Odour/TVOC Removal System

c) Oxygen Replenishment System.

d) NBC Filtration System.

e) Compressed Air System

f) Facility Management System.

All these six systems are required to operate not independently but in coordination with one another so as to always maintain the desired CO_2, Oxygen and pressure levels in the facility for human inhalation and not to allow any inward leakage of contaminated air from outside environment by maintaining a positive pressure inside the facility.

Control by Sensors

The CO_2 Removal System is designed to maintain the permissible exposure limit of CO_2 for its occupants not greater than 1000 ppm (0.1%) for the desired Button Up Period as specified by Bhabha Atomic Research Center (BARC) Mumbai. Activation of CO_2 Removal System shall be based on the signal from the CO_2 sensor located in the return air duct of the air handling units serving the buildings. The threshold value of CO_2 to start the CO_2 Removal System has been kept at 800 ppm (0.08%), as per recommendations given in TM 5-858-7: Designing Facilities to Resist Nuclear Weapon Effects. As soon as the CO_2 content in the indoor air exceeds 800 ppm, the sensor sends the signal to the inbuilt Facility Management System of the CO_2 Removal Unit to start filtering the air for CO_2 removal and returns it back to the facility through the Air Handling Unit. This way, the contents of CO_2 are automatically lowered in the facility to level desired by users. To economise on the use of electricity and filters, the CO_2 Removal System automatically stops once the CO_2 level comes below 400 ppm or any other value in the facility as desired by users. The Indoor Air Quality Management System automatically functions with least human intervention. The entire system, therefore, works as an intelligent system based on the concept of Fix and Forget type.

The schematic Diagram of the Indoor Air Quality Management System is given in Fig.1 below.

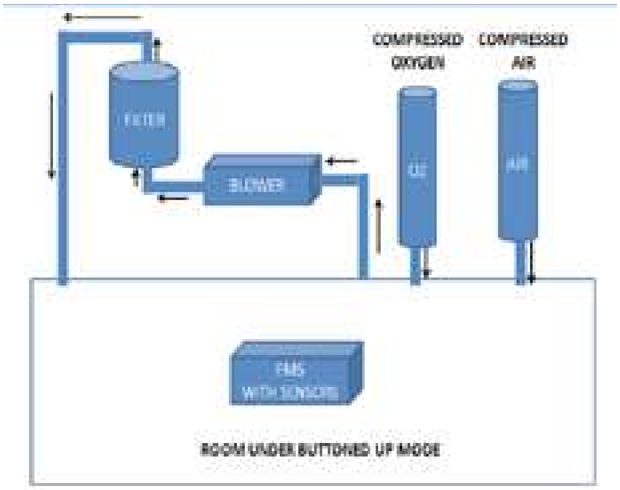

Fig. 1: Schematic Diagram of Indoor Air Quality Management System

TEST RESULTS

The tests on materials, filters and equipment were conducted in the following sequential manner:-

a) Tests on materials (Bunkerman absorbents, Bunkerman Adsorbents, Bunkerman Molecular Sieves etc) developed buy BUNKERMAN for absorption and adsorption of CO_2.

b) Tests on Bunkerman brand Filters (CO_2 Scrubbers) both Regenerative and Non-Regenerative Type.

c) Tests on Complete System under Simulated Button Up conditions.

d) Tests on Complete System under Real Button Up conditions.

The test results for testing of materials, filters and complete Indoor Air Quality Management Systems can be found in other references[1,8 to14].

DISCUSSION

It is observed from the test results that the Indoor Air Quality Management System invented by BUNKERMAN performs well during Button Up Period. The CO_2 level was automatically maintained in the room by the FMS between 600 ppm and 800 ppm as per the settings selected by the users, While the ventilation system is off, the value of CO_2 inside the closed room was found to be continuously increasing and the moment it touched the maximum value of 800 ppm set by the user, the CO_2 Removal System started automatically At this time the CO_2 level initially increased slightly beyond 800 ppm but it soon started reducing and it never went beyond 1000 ppm as prescribed by the codes and technical manuals on the subject[2to7].

Similarly, the oxygen level in the room was always kept within the selected range of 17% to 21% by the user.

The proposed system also helps in reducing the air conditioning load of the buildings by 20 to 30% by cutting down the requirement of air changes per hour (Refer Table 1). This technology not only provide a clean and healthy living environment both indoors and outdoors, but it will help eradicating the problem of rising pollution, climate change and global warming from the entire world and make this planet earth liveable for our present and future generations. It also provides a ecologically balanced system as shown in Fig. 2.

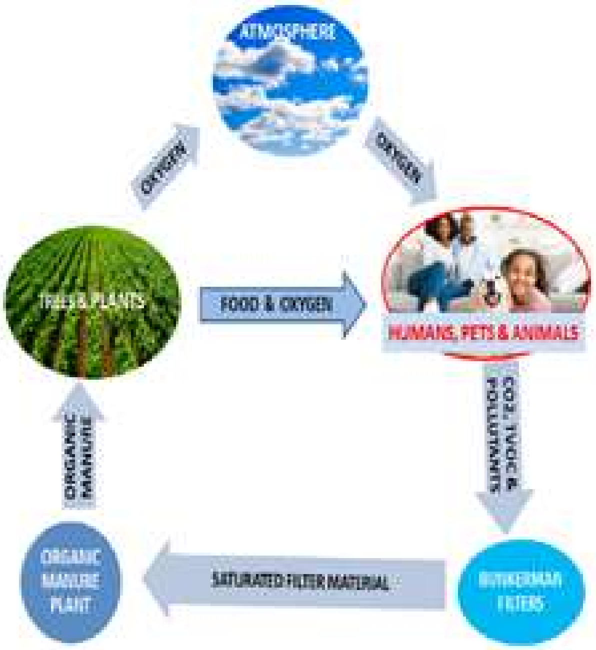

Fig. 2: Sustainable Eco System

Table 1: Comparison of Estimated Heat Load

ESTIMATED HEAT LOAD COMPARISION													
SL NO	LOCATION	ODU TEMP	ODU TEMP	Area-ICU room	ESTIMATED HEAT LOAD WITH FRESH AIR AS PER STANADRD		ESTIMATED HEAT LOAD WITH CO2 REMOVAL SYSTEM		HEAT LOAD DIFFERENCE WITH CO2 REMOVAL SYSTEM		%REDUCTION IN PEAK HEAT LOAD WITH CO2 REMOVAL SYSTEM	
		SUMMER	MONSOON		SUMMER	MONSOON	SUMMER	MONSOON	SUMMER	MONSOON	SUMMER	MONSOON
		DEG C/% RH	DEG C/% RH		TR	TR	TR	TR	TR	TR		Peak Heat Load
						Peak Ht Load		Peak Ht Load		Peak Ht load reduction		% Peak Ht load reduction
1	DELHI	43.3/20%	35/60%	1400sqft.ht 3.5m height with underdeck Insulation 15 Patients	8.56	9.47	7.51	7.51	1.05	1.96	12.3%	20.7%
2	MUMBAI	35/60%	29.4/88%		7.25	7.3	5.39	5.39	1.86	1.91	25.7%	26.2%
3	GUWAHATI	34.6/51.2%	31.3/81.7%		6.73	7.31	5.31	5.31	1.42	2.00	21.1%	27.4%
4	Peak Heat Load reduction range											20-30%

CONCLUSION

Based on the above results and discussion, the following important conclusions are made:-

a) The concepts of Emergency Homes, Dual Home/Multiple Home, Composite Homes and Work From Home (Normal & Emergency) are the need of the present day world and Button Up Concept is essential to safeguard the health and life of the people both during normal and emergency periods.

b) The Indoor Air Quality Management System invented by BUNKERMAN and presented in this study, ensures the desired levels of CO_2, Oxygen and Positive Pressure inside the facility during Button Up Mode. In the present case, the CO2 level was maintained between 600 ppm and 800 ppm as per the setting selected by the users. The TVOC levels was maintained below 50 ppb. The oxygen level was also maintained by the system within selected range of 17 to 21%.

c) The proposed system also helps in reducing the air conditioning load of the buildings by 20 to 30% by cutting down the requirement of air changes per hour.

d) This technology not only provide a clean and healthy living environment both indoors and outdoors, but it will help eradicating the problem of rising pollution, climate change and global warming from the entire world and make this planet earth liveable for our present and future generations.

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NET ZERO ENERGY BUILDINGS

THE OPPORTUNITIES AND CHALLENGES

S. Karthikeyan*

Abstract

The building sector in India is growing at a rapid pace and contributing significantly for the increase in energy demand. The increase in energy demand leads to increase in Green House Gas (GHG) emissions and hence global warming. The building industry is responsible for 38%, or around 14 gigatons, of all energy-related GHG emissions each year. Global decarbonization trajectories indicate that the industry needs to reduce these emissions by 50% by 2030 if it is to reach net zero by mid-century and achieve the climate goals of the Paris Agreement. We need to work on the strategies to achieve the goal of net zero in the committed time. This paper discusses the IGBC net Zero rating system, strategies to achieve net Zero Energy status, besides benefit of Net Zero benefits

INTRODUCTION

The building sector in India is growing at a rapid pace and contributing significantly for the increase in energy demand. The increase in energy demand leads to an increase in Green House Gas (GHG) emissions and hence global warming. The green building movement in India, led by the Indian Green Building Council (IGBC) has contributed immensely for reducing GHG emissions by improving energy efficiency in buildings and utilizing renewable energy sources partly for meeting their energy requirements.

The next step is to achieve Net Zero energy in buildings. Net Zero energy buildings are those that are energy efficient and meet all their energy requirements through renewable energy sources. The building may be connected to Grid, but on annual basis the net conventional energy consumed from the grid is zero.

Net Zero Energy movement started in India with the launch of Net Zero Energy Building Rating system in 2018.IGBC's Advancing Net Zero is also aligned with World GBC.

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BENEFITS

IGBC Net Zero Energy Buildings rating system enables reduction in energy consumption and use of appropriate renewable energy sources to meet the energy requirement. The benefits of adopting Net Zero Energy concept in a building are as below:

- Improvement in energy efficiency and hence reduction in annual energy consumption to the tune of about 25 -30% with respect to national baseline.
- Overall reduction in energy cost of at least about 30%.
- Reliable source of power supply if combined with energy storage devices.

IGBC NET ZERO ENERGY RATING

IGBC Net Zero Energy Buildings Rating System is a voluntary and consensus-based programme. The objective of IGBC Net Zero Energy Buildings Rating System is to facilitate a holistic approach to make energy efficient buildings and fully powered by renewable energy sources. The rating system evaluates buildings on a performance-based approach. The rating system has evolved to be comprehensive and at the same time user-friendly. The programme is fundamentally designed to reduce the energy needs of a building and national priorities.

To achieve the IGBC Net Zero Energy Buildings rating, the project must be able to demonstrate that net annual energy consumption is zero i.e. meeting all energy demand through renewable energy.

The project can also apply for IGBC Near Net Zero Energy certification if it complies with all mandatory requirements and is able to demonstrate that 75% of the total energy use is offset by renewable energy in a year.

To demonstrate energy efficiency, the Energy Performance Index (EPI) ratio is calculated against ECBC 2017 and based on the EPI ratio credit points are awarded.

STRATEGIES FOR ACHIEVING NET ZERO ENERGY STATUS

Energy efficiency has paramount importance for achieving Net Zero Energy performance. CII-GBC building has been designed with energy efficient measures and has demonstrated more than 20% energy savings over the baseline defined in ECBC 2017 (latest Energy Conservation Building Code).

Retrofitting strategy developed to further reduce energy demand and to increase use of renewable energy, following measures able suggested for implementation:

- Retrofitting of lighting(interior and exterior) system
- Replacement of air-conditioning system (chiller plant)
- Commissioning of advanced BMS system for optimised building performance
- Increased capacity of on-site Renewable Energy generation

Energy end-use summary and load profile recorded, and deep analysis performed to understand hourly energy use. The peak load is 100 kW. Maximum demand occurs during the daytime, cooling system (chiller and Air Handling Unit) are main energy guzzlers.

RETROFITTING OF LIGHTING AND COOLING SYSTEM

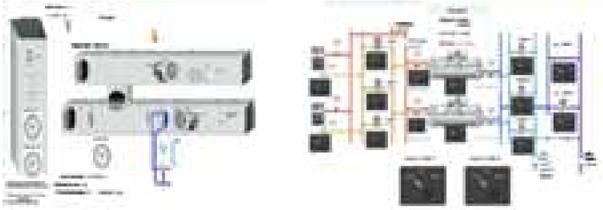
Completely automated CFL based (with dimming control, integrated with daylight and occupancy sensor)lighting fixtures installed in 2003.Globally, lighting has found complete transformation owing to the introduction of LED based lighting system which in fact reduced lighting load in buildings drastically. The lighting system was retrofitted in 2018 and it cut down the load from 16.5 kW to 3.5 kW. LPD (Lighting Power Density) is less than 0.4 W/sq.ft). The reduction in light power density has contributed to reduction in cooling load of about 4%.

The whole chiller plant retrofitted including chillers, pumps and cooling tower with the most advanced and energy efficient system. The system is integrated with the wind towers (passive cooling system) that consciously supply pre-cooled fresh air. Two water-cooled screw chillers (2x49TR, COP of chiller is 4.85, iKW/TR is 0.725 at 100% loading). Since, most of the time, building operates at part load hence chillers selected giving more emphasis on part load performance (IPLV is 6.58 and ikW/TR at part load is 0.534). High efficiency pumps (IE4 motor) are installed for chillers and cooling towers, integrated with VFD to optimize the performance.

Before retrofitting After Retrofitting

COMMISSIONING OF ADVANCED BMS SYSTEM

A sophisticated Building Management System (BMS) system was commissioned to optimize energy performance. It is estimated that an integrated BMS system can save 8-10% energy in commercial buildings. Chiller plant, AHUs and indoor & outdoor environmental variables are continuous being monitored, Then, the recorded data are used to analyse the performance.



INCREASED ON-SITE RENEWABLE ENERGY GENERATION

Since inception, 2003, CII-GBC has been promoting the use of renewable energy sources. Earlier, the SPV capacity was 24 kWp that off-set grid energy use by 21%.For a Net Zero Energy Building, it is mandatory to off-set 100% grid energy use by renewable energy. Hence, it was decided to opt for new technology that can enhance RE generation from the roof-top(1175 sq.m). Initially, a site assessment was carried out and potential RE technologies are studied. Bifacial Solar PV technology adopted which had promising efficiency (high electricity generation).

Bifacial solar PV is a transparent and frameless module unlike regular solar modules that come with a singular face for absorption of light. Bifacial solar modules are equipped to allow passage of light from both the sides of solar cell and generate electricity from both sides (front and rear face of the module).

This helps in increasing the efficiency per cell, resulting in an increase in the total energy generation. In fact, to increase the yield on the backside, roof surfaces are coated with high SRI (more than 95) paint that reflects the radiation on back side of the module. The SPV system installed at 1.5 m height from the roof, so that diffused radiation will fall on back side of the SPV modules. Total 130 kWp (efficiency of module is 22.3% which is higher than the conventional module-18.6%) capacity of onsite bifacial SPV installed(over roof-top and wind towers) and 8 kWp of old SPV system commissioned (on utility rom). The total SPV system capacity is 138 kWp.]

Grid connected net metering installed in July 2019 and since then the building only uses RE to fulfil energy usage and excess energy is fed to the grid. On an occasion, when RE generation is insufficient to meet the demand, power is drawn from the grid.

NET ZERO BUILDINGS IN INDIA

IGBC is actively collaborating with a portfolio of over 100 projects within the Net Zero Energy rating system. Currently, more than 50 projects are registered with IGBC, and 17 projects have already achieved Net Zero Energy certification. The certified projects include:

1. Plant - 13 G&B, Mumbai
2. Globicon Terminal, Mumbai
3. Capagemini EPIP, Bengaluru
4. ICICI RSETI
5. GBC Hyderabad
6. Shairu Gems, Surat
7. Bhawar House, Chennai
8. MLDL Kanakpura, Bengaluru
9. HURC, Bengaluru
10. One Place Lodha
11. DRI Office, Manesar
12. HPCL Green R&D Centre Building 9 - Admin
13. ITPC Radial Road, Chennai
14. Badriya Juma Masjid
15. Club Mahindra, Madikeri

16. Vaibhav Global Limited, Jaipur

17. MLDL Province, Kandivali

CONCLUSION

Net Zero Energy Buildings offer significant opportunities for reducing the operational cost apart from reducing the GHG emissions. This makes business sense in all typology of buildings; more so in case of commercial buildings. Improving the energy efficiency and increasing the utilization of renewable energy sources are key aspects of achieving Net Zero energy status in a building. The building projects are facing challenges in increasing the utilization of renewable energy sources because of the policies and regulations at the state level. There is a need for enabling policies and regulations for wider adoption of Net Zero energy concepts in buildings.

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MAXIMIZING ENERGY EFFICIENCY IN SMART HOMES THROUGH PREDICTIVE ANALYTICS IN SMART GRIDS

Sameer Jain*

Abstract

Smart homes have become an increasingly popular concept in recent years, and with the rise of smart grid technology, there is great potential to maximize energy efficiency in these homes. Predictive analytics can play a significant role in achieving this goal by providing insights into energy consumption patterns and enabling proactive management of energy use. In this paper, we focused on predicting energy consumption in smart homes using smart meter data, and used RStudio tool for data pre-processing, exploration, machine learning implementation, and visualization. We used a Kaggle dataset and time-series analysis to identify trends and patterns in energy consumption, and tested with time series algorithms such as ARIMA for energy consumption prediction. Our results showed that the ARIMA algorithm achieved the best suitable performance in terms of Mean Absolute Percentage Error (MAPE) at 72%.

INTRODUCTION

Smart homes are becoming increasingly popular due to the convenience and automation they offer. The integration of smart grid technology in these homes presents a great opportunity to maximize energy efficiency and reduce energy consumption. Predictive analytics is a promising approach to achieving this goal by enabling proactive management of energy use and providing insights into energy consumption patterns. Smart homes are equipped with a range of devices and appliances that consume energy. Predictive analytics can be used to forecast energy consumption based on historical data and identify patterns and trends in energy use. Several studies have been conducted on the use of predictive analytics for energy consumption prediction in smart homes.

In a study by A. Belkadi and M. A. Benghanem (2017), machine learning algorithms were used to predict energy consumption in smart homes. The authors used data from smart meters and applied different algorithms such as k-NN, Decision Tree, Random Forest, and SVM. The results showed that the Random Forest algorithm performed the best in terms of accuracy.

One study by Liu et al. (2021) used machine learning techniques to predict electricity consumption in smart homes. The authors used data from smart meters, weather forecasts, and calendar events to train machine learning models. They found that machine learning algorithms could accurately predict electricity consumption in smart homes, with support vector regression achieving the best performance. The authors concluded that their approach could help homeowners reduce electricity costs and achieve energy-efficient smart homes.

Another study by Li et al. (2020) investigated the use of deep learning techniques for energy management in smart homes. The authors used a convolutional neural network to predict energy consumption patterns in smart homes. The authors found that the deep learning model achieved higher accuracy in predicting energy consumption compared to traditional statistical models. The authors suggested that deep learning models could be used for accurate energy forecasting and optimization in smart homes.

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Similarly, a study by Zhang et al. (2020) explored the use of machine learning algorithms for predicting energy consumption in smart homes. The authors used data from smart meters and weather forecasts to train machine learning models. They found that machine learning algorithms could accurately predict energy consumption, with random forest achieving the best performance. The authors suggested that their approach could help homeowners achieve energy-efficient smart homes and reduce electricity costs.

Another study by Hu et al. (2019) proposed a novel framework for energy management in smart homes. The authors used a deep reinforcement learning algorithm to optimize energy consumption in smart homes. They found that their approach could achieve energy savings of up to 30%. The authors suggested that their framework could be used for energy-efficient smart homes and to reduce the carbon footprint of households.

Bashir, Azam, Khan, and Gulzar (2020) conducted a case study in Pakistan to forecast residential electricity demand using time series models. They used data from the Pakistan Energy Yearbook and applied three models: Autoregressive Integrated Moving Average (ARIMA), Seasonal Autoregressive Integrated Moving Average (SARIMA), and Vector Autoregression (VAR). The authors found that SARIMA out performed the other models with a mean absolute percentage error (MAPE) of 5.51%. They also found that the electricity consumption increased over time due to population growth, urbanization, and increasing household incomes. The authors suggested that policymakers should focus on developing sustainable energy policies to meet the growing demand for electricity in the residential sector.

Hajji, Aziz, Taheri, and Javidan (2021) proposed an improved ARIMA-based model for residential energy consumption forecasting in smart homes. The authors used data from a smart home in Morocco and applied an ARIMA model with two additional features: temperature and day type. The authors found that the proposed model outperformed the traditional ARIMA model with a mean absolute percentage error (MAPE) of 7.2% compared to 8.7%. They also found that temperature had a significant impact on energy consumption, with an increase in temperature leading to an increase in energy consumption. The authors suggested that the proposed model could be used to optimize energy consumption in smart homes and reduce energy waste.

Ou and Ng (2019) conducted a comparative study of time series methods for short-term residential electricity consumption forecasting. They used data from 30 households in Hong Kong and tested three methods: Autoregressive Integrated Moving Average (ARIMA), Seasonal Autoregressive Integrated Moving Average (SARIMA), and Exponential Smoothing State Space Model (ETS). The authors found that the ETS model outperformed the other models with a mean absolute percentage error (MAPE) of 5.8% compared to 6.4% for SARIMA and 7.8% for ARIMA. They also found that the ETS model was more robust to outliers and sudden changes in electricity consumption patterns. The authors suggested that the ETS model could be used to optimize energy consumption in smart homes and support energy management decisions.

RESEARCH METHODOLOGY

The methodology used in the article involves several steps, following the Cross-Industry Standard Process for Data Mining (CRISP-DM) framework. CRISP-DM is a widely used methodology for data mining and machine learning projects, which consists of six phases: Business Understanding, Data Understanding, Data Preparation, Modeling, Evaluation, and Deployment.

- Business Understanding: This phase involved understanding the business problem, which was to predict energy consumption in smart homes using smart meter data. The goal was to maximize energy efficiency in smart homes and enable proactive management of energy use.
- Data Understanding: This phase involved acquiring and exploring the dataset from Kaggle,

which contained smart meter data from a smart home. Time-series analysis was used to identify trends and patterns in energy consumption.

- Data Preparation: This phase involved cleaning and pre-processing the data to make it suitable for modeling. RStudio tool was used for data pre-processing, exploration, machine learning implementation, and visualization.
- Modeling: This phase involved developing and testing different algorithms such as Linear Regression, HoltWinters, and ARIMA for energy consumption prediction. The performance of each algorithm was evaluated using metrics such as Mean Absolute Percentage Error (MAPE).
- Evaluation: This phase involved evaluating the performance of the models and selecting the best-performing algorithm, which was the HoltWinters algorithm with an MAPE value.
- Deployment: This phase involved deploying the selected algorithm for energy consumption prediction in smart homes and enabling proactive management of energy use.

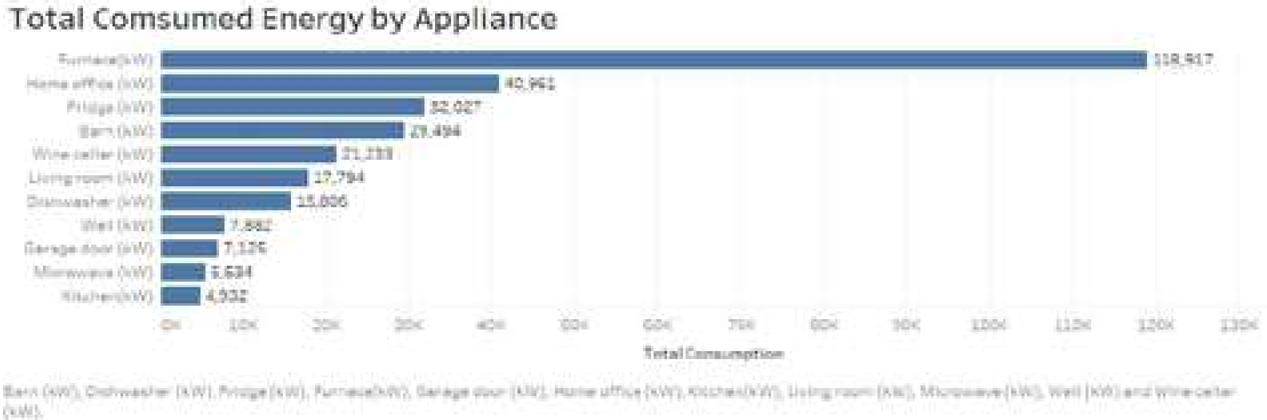
Step 1: Obtain the dataset and load the data using 'R' tool.

Step 2: Explore, clean and pre-process the data.

Attributes Name and their Description

Sr. No	Attributes	Description of the attributes
1	Time	Time at which the energy consumption and generation data was recorded
2	use[kW]	Total energy consumption in kW
3	gen[kW]	Total energy generated by means of solar or other power generation resources in kW
4	House overall[kW]	Overall house energy consumption in kW
5	Dishwasher[kW]	Energy consumed by specific appliance in kW
6	Furnace 1[kW]	Energy consumed by specific appliance in kW
7	Furnace 2[kW]	Energy consumed by specific appliance in kW
8	Home office[kW]	Energy consumed by specific appliance in kW
9	Fridge[kW]	Energy consumed by specific appliance in kW
10	Wine cellar[kW]	Energy consumed by specific appliance in kW
11	Garage door[kW]	Energy consumed by specific appliance in kW
12	Kitchen 12[kW]	Energy consumption on kitchen 1
13	Kitchen 14[kW]	Energy consumption on kitchen 2
14	Kitchen 38[kW]	Energy consumption on kitchen 1
15	Barn[kW]	Energy consumed by specific appliance in kW
16	Well[kW]	Energy consumed by specific appliance in kW
17	Microwave[kW]	Energy consumed by specific appliance in kW
18	Living room[kW]	Energy consumed by specific appliance in kW
19	Solar[kW]	Solar power generation
20	Temperature	Physical quantity expressing hot and cold
21	Humidity	Concentration of water vapor present in air
22	Visibility	Meteorological optical range which is defined as the length of atmosphere over which a beam oflight travels before its luminous flux is reduced to 5% of its original value
23	Apparent Temperature	Temperature equivalent perceived by humans, caused by the combined effects of air temperature, relative humidity and wind speed
24	Pressure	Falling air pressure indicates that bad weather is coming, while rising air pressure indicates good weather
25	Windspeed	Fundamentals atmospheric quantity caused by air moving from high to low pressure, usually due to changes in temperature
26	cloudCover	Fraction of the sky obscured by clouds when observed from a particular location
27	wind bearing	In metrology, an azimuth of 000° is used only when no wind is blowing, while 360° means the wind is from the North. True Wind Direction True North is represented on a globe as the North Pole. All directions relative to True North may be called "true bearings."
28	precipIntensity	Measure of the amount of rain that falls over time
29	dewpoint	The atmosphere temperature (varying according to pressure and humidity) below which waterdroplets begin to condense and dew can form
30	precipProbability	Measure of the probability that at least some minimum quantity of precipitation will occur within a specified forecast period and location

Step 3: Exploratory Data Analysis

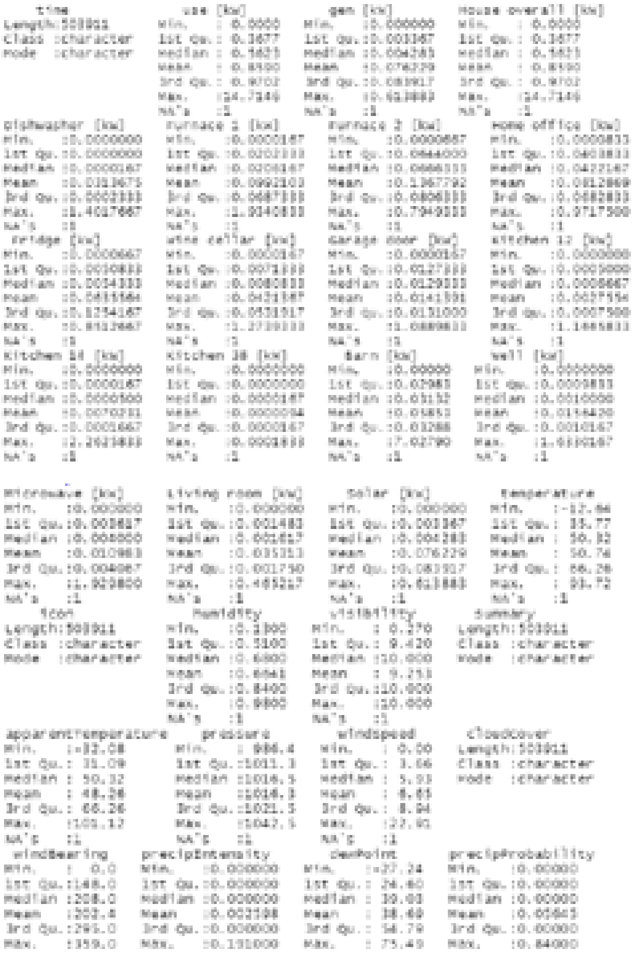


Step 4: Measures the dimensions of the dataset

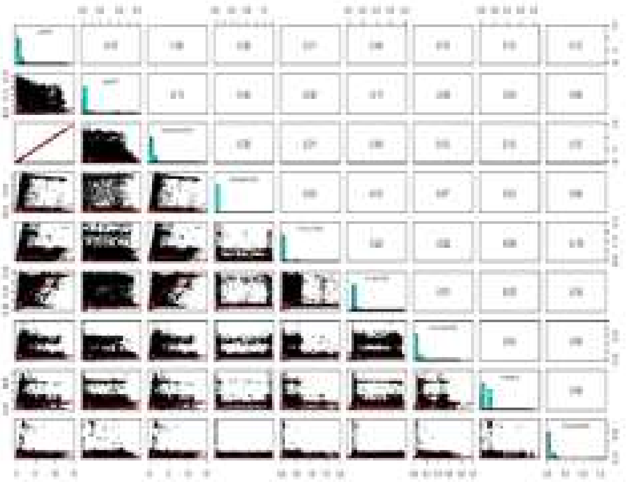
There are 503911 data records and 32 attributes in the given dataset.

Step 5: Dataset Summary as shown below:

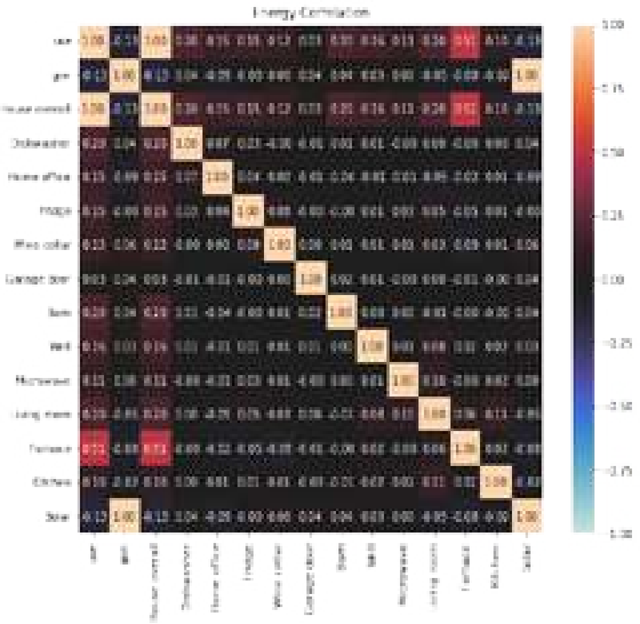
Examine the summary statistics of the dataset



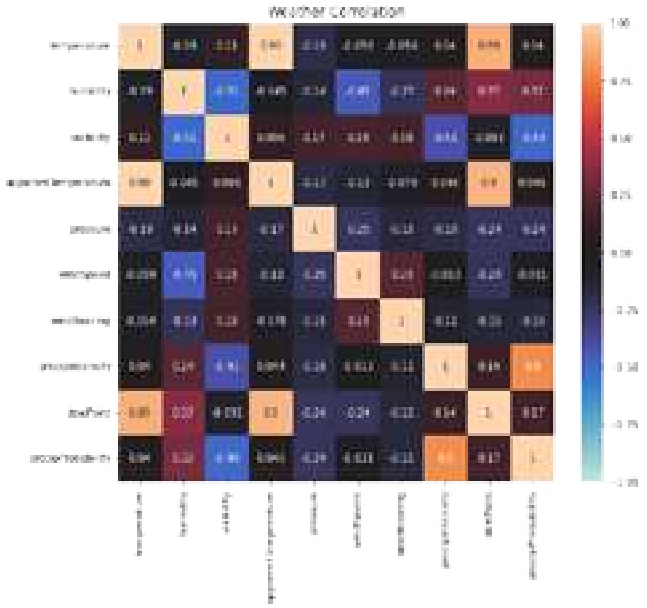
Step 6: Analyze the correlation of attributes



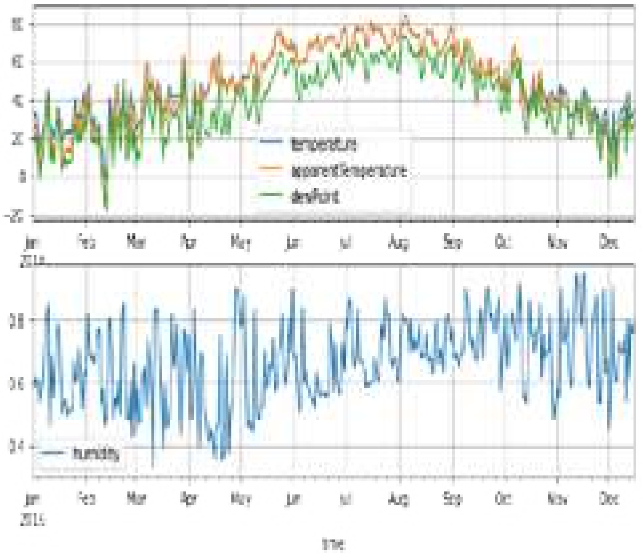
Energy Correlation



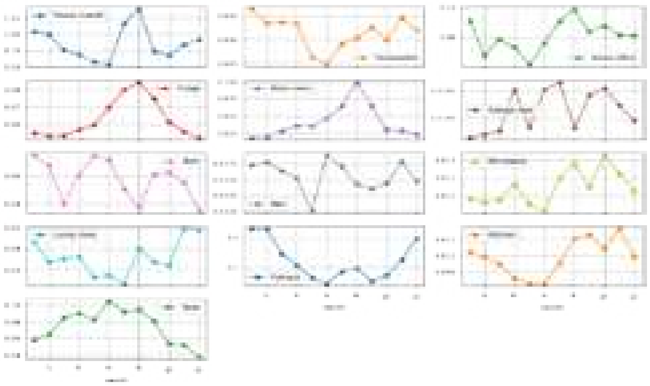
Weather Correlation



Step 7: Weather Data time series



Step 8: Average Energy Consumption of all appliances Per Month

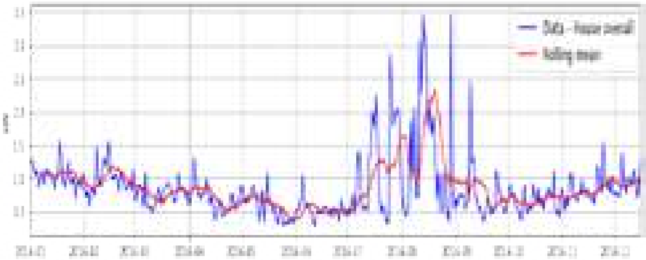


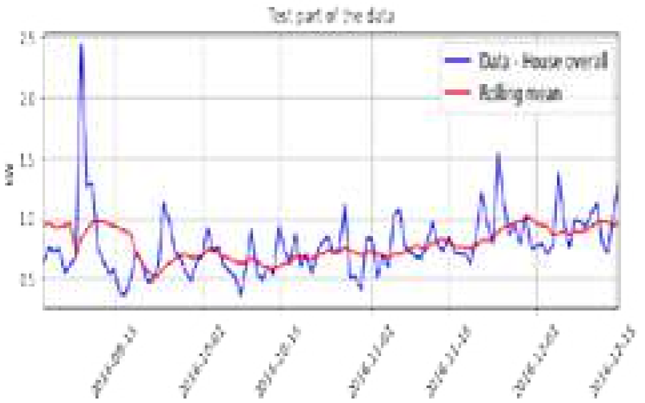
After analysing the energy consumption for each home appliance, we discovered that the Furnace appliance is consuming the highest amount of energy in comparison to the other appliances. Our analysis also revealed that the highest energy consumption occurred on January 1st, 2016. We suspect that this may have been due to the holiday weekend, as people tend to celebrate with family and friends during this time. The energy consumption remained unstable from January 2nd, 2016 until January 7th, 2016, where it finally dropped.

We further investigated the energy consumption per hour during the week and found that Friday has the greatest spread of energy consumption compared to the other weekdays. Additionally, we analysed the total energy consumption per hour of the day and determined that energy consumption is lower during the midday and higher at night.

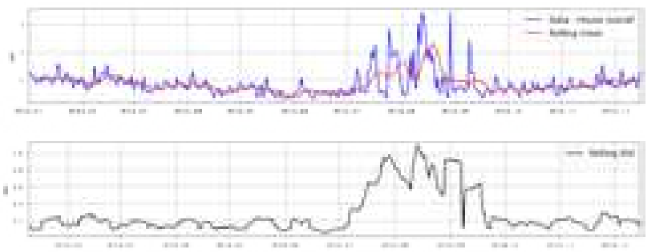
To enhance our analysis, we suggest including "Holidays" as a new feature in the dataset. This will enable us to compare and analyse peak energy consumption times between holidays and working days, providing further insights into energy usage patterns.

Step 9: Baseline Model

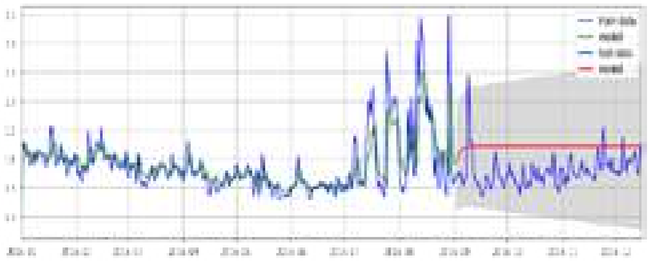




Step 9: ARIMA Model



Step 10: Predication Model



MSE: 0.259RMSE: 0.509MAE: 0.463MAPE: 0.722MASE: 1.886

R^2 score: -2.381

To identify trends in our data and predict energy consumption, we utilized time series analysis. Our analysis revealed that energy consumption did not have any major peaks, but instead increased steadily from the beginning of 2016 until mid-2016, before gradually dropping.

To further refine our predictions, we employed time-series algorithms such as ARIMA. We created a plot of the ARIMA time series algorithm using testing data, and evaluated the model's performance using the Mean Absolute Percentage Error (MAPE). Our analysis showed that the ARIMA method was the most suitable algorithm, as evidenced by a MAPE of 72%

CONCLUSION

In conclusion, smart homes have the potential to maximize energy efficiency through proactive management of energy use. Predictive analytics can play a significant role in achieving this goal by providing insights into energy consumption patterns. In this paper, we focused on predicting energy consumption in smart homes using smart meter data and utilized RStudio for data pre-processing, exploration, machine learning implementation, and visualization. Our analysis using a Kaggle dataset and time-series analysis identified steady energy consumption patterns in smart homes, with no major peaks. The ARIMA algorithm was determined to be the most suitable algorithm for predicting energy consumption, achieving a MAPE of 72%. These findings demonstrate the potential for predictive analytics to enable proactive energy management in smart homes, leading to improved energy efficiency and cost savings for homeowners.

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NET ZERO 2070 AND BUILT ENVIRONMENT
"ENERGY SAVED IS ENERGY GENERATED"

D. S. SACHDEV* AND J. K. CHAUDHARY**

Abstract

The concept of Net Zero built environment has been gaining momentum globally in recent years, as countries strive to reduce their carbon footprint and combat climate change. India, being one of the fastest-growing economies is no exception to this trend. The Indian government has set an ambitious target of achieving Net Zero emissions by 2070, which requires significant efforts in the building sector. However, there are several challenges and pitfalls that need to be overcome to achieve this goal. This paper highlights some of the major challenges in the implementation of Net Zero built environment in India and makes suggestions to overcome the same by sincere and honest participation by all stakeholders in the country.

INTRODUCTION

To understand the concept of Net Zero Built Environment in our Country, we may have to know our earth globally. As we know, the surface area of earth is 510.10 million sq. km and out of this 71% is water and 29% is earth i.e.148.3 million sq. km. Further 20% of earth's terrestrial land surface is either classified as built up urban area or Crop land . This is bound to increase with ever growing population. Though India is seventh largest Country in the world, its earth area is only 3.29 million sq.km which is only around 2.4% of whole land on the earth. Out of 3.29 million sq. km only 1 lakh sq. km is covered with buildings which is hardly 3% of total earth area in India. Now Looking at capital of India, Delhi has an area of 1483 sq.km out of which 80% area i.e. 1100 sq.km is classified as urban and more than 50% of this i.e. 550 sq.km is covered by Urban slums devoid of basic amenities. Further 40% of Urban area caters for civic infrastructure that includes Roads, Railways, Metro, Airports, Ports, waterways, Hospitals, educational institutions, entertainment, sports, Parks and commercial buildings with services such as electricity, water supply, sewerage systems and waste management systems. Almost similar is the condition in almost all metropolitan cities and more so in grade 2 onward cities.

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GOVERNMENT INITIATIVE

Government of India had launched Pradhan Mantri Sahaj BijliHar Ghar Yojana in October, 2017 with the objective to provide electricity to all unelectrified households in rural areas and all poor households in urban areas (Urban slums). With this scheme 28.6 million new consumers were added. Now, if these new electricity demands are not met from renewable energy sources, India will be adding significantly to the problems of global warming and climate change. This prompted the Union government to launch a massive push for tapping renewable energy resources, opening a huge market for the green energy sector as this was the need of the hour at that point of time.

GOVERNMENT TARGETS

Way back in 2015, the country had already set a target of having an installed capacity of 175,000 megawatts (MW) from renewable energy resources by 2022 comprising of 100,000 MW from solar, 60,000 MW from wind, 10,000 MW from bio power and 5,000 MW from small hydro projects.

This was a massive target, given that at the end of March 2015, India's installed capacity of renewable energy stood at only 39,550 MW. This was 14.55% of India's total power generation capacity of 271,720 MW. The new target meant the renewable energy capacity had to increase over four times in seven years.

The most striking aspect of India's roadmap to energy transition was the thrust on solar power. In March 2015, the country's installed renewable energy capacity stood at 39,550 MW of which 23,354 MW came from wind power, 8,397 MW from bio power, 4,055 MW from small hydro projects and only 3,744 MW from solar. This meant the solar capacity had to increase by 26 times.

Since March, 2015, the renewable energy share in India's total power generation mix had gone up from 14.55% to above 28%–standing at 114,064 MW as against a target of 175,000 MW in July 2022 which means, the country could achieve only two-thirds of its 2022 target with five months to go.

While the country has met its target for bio power and small hydro projects on which little thrust was given, Solar and Wind, the two pillars of energy transition mission, lagged behind the Target with the installed capacity for Solar power stood at 57,706 MW and that of Wind power at 40,788 MW as against 100,000MW and 60,000 MW respectively.

THE SHORTFALL

As per the latest data available in March, 2023, as against the target of 175,000 MW by end of 2022, India had achieved a total of 168960 MW say 169000 MW. With 64000 MW of Solar Power, 42000 MW of wind energy, 52000 MW of hydro power and 11000 MW of bioenergy by end of February,2023.

"Out of 100,000 MW of solar power, 40,000 MW was to come from grid-connected rooftop and 60,000 MW from ground-mounted projects, including 40,000 MW from solar parks. However, going by the latest data placed before the Parliament in July 2022, of the 57,706 MW that came from solar, only 7,000 MW was from grid-connected rooftop projects and another 10,000 MW from solar parks.

From the data shared in the preceding paras it is quite clear that road to Net Zero built Environment is through Solar Power and Wind Energy apart from contributions from Bio Power and Small Hydro Projects.

Also, we notice that there is continuing short fall in achieving the milestones set by the government. This trend points to various challenges being encountered by our country which has now become the most populated country in the world. Therefore, it is most important to know these challenges and identify the pitfalls in the implementation of Net Zero Built Environment so that we develop strategy to overcome the challenge faced therein.

Since we have identified the sources of Renewable Energy i.e. Solar, Wind, Bio power, Small hydro Projects, the constraints therein need to be identified and then solution thought of. Further for achieving Net Zero 2070, it is important to achieve intermediate milestones as well.

MISSION 2030: LAND, FINANCE, ENVIRONMENT

Considering that CEA has estimated India's cumulative installed capacity in 2030 at 817,000 MW, with 50% coming from non-fossil fuel-based energy sources, non-fossil fuel energy installed capacity should reach about 410,000 MW in about seven years.

Of this, about 19,000 MW is expected from nuclear power presently at 8750 MW level and 61,000 MW from large hydel projects totalling to 80,000 MW. Therefore, the installed capacity for solar, wind, bio and small hydel projects should reach about 330,000 MW. Since there is little thrust on bio power and small hydro, the solar capacity will have to reach around 200,000 MW and the wind capacity around 100,000 MW for India to achieve the target.

To fulfil this mission, it is most essential to start work at Micro level towards creation of a net-zero built environment pan India with stringent targets even though we are facing several Challenges. In so far as Engineers and Architects are concerned, these include the Lack of awareness and knowledge, Availability of Land, High initial costs, Lack of will in Stakeholders, Lack of policy support, Lack of skilled workforce, and Lack of monitoring and evaluation. These are discussed below:

Lack of awareness and knowledge

One of the major challenges in implementing Net Zero built environment in India is the lack of awareness and knowledge among stakeholders. Many architects, builders, and developers in India are not familiar with the concept of Net Zero buildings and their design and construction requirements. This leads to a lack of interest and investment in this sector.

To illustrate this, few examples are discussed below:

Example 1:

- A multi-storeyed Residential 10 storied Block, 12 flats Each floor, Total 120 flats with a terrace area of about 2000 sq meter with Roof top Solar Panel System will generate about 125 KW of power @ 1 KW per 15 sq meter of solar panel. More than 1 KW per flat which is more than the lighting requirement of each flat.
- Investment @ Rs 60,000 per KW: 90 Lakhs, Rs 75, 000 per flat.
- Power Generation in units per year: 125x10hrs/dayx250 daysx90%=2,80,000 units.
- Revenue earned per year @Rs 9 per unit: Rs 25,20,000.
- Investment payback period: Less than 4 years.
- Solar Panels have useful life of about 30 years.
- They are practically maintenance free, having no rotating parts.
- Require only weekly cleaning and protection from damages.
- After that revenue earned each year is about 25 lakhs which amounts to about 7.5 crores in 30 years, not taking into account the increase in electricity rates.
- Investment of 90 Lakhs gives a return of 7.5 crores.

Note:

i. The Solar Canopy will be about 6 meter above the Roof terrace and will be architecturally and structurally integrated to the building to give a pleasing appearance. No Terrace area will be lost.

ii. In fact, with the canopy overhead, it will give a shading to the building to reduce heat ingress to the building. The terrace space can be used for social functions and also for terrace garden purpose.

iii. The solar canopy also can overhang the terrace boundaries by about 2 meters on each side to provide solar shading for the building and also to increase the solar panel area.

iv. Further the structure will be designed to withstand a wind load of 160 KM/ hour.

Summary:

- Without any additional area requirement, Every Multi-storeyed building can have an integrated solar canopy.
- The investment will be paid back in less than 4 years.
- Provision of solar canopy will meet about 20 % of energy requirement of a building without requirement of additional area.
- With provision of solar panels in other areas like gardens, parking, hopping areas etc easily another 20 % of power requirement can be generated making a total of more than 40%.
- Provision of solar panels by Builders is mostly missing for want of awareness, to the disadvantage of the users. Even it goes unnoticed that huge revenue can be generated out of solar panels.

Example 2: Solar Panels in Large Campus

- A Typical IIT/ AIIMs/NIT/University campus consists of about 200 to 500 acres of area
- Maximum Electricity demand of each campus is about say 5 MVA.
- Annual Electricity charges @ Rs 10 per unit, 50% average loading, 12 hours a day, 250 days a year: 6 Crores a year.
- Out of the campus of about 300 acres, if an area of about 16 acres is earmarked for solar panel, it can generate about 5 MVA.
- Investment of 5 MVA Solar Panel: @ 6 crores/ MVA: 30 crores.
- Investment paid back in 5 years.
- After 5 years, the solar Panel will give an annual revenue of about 6crores.
- After 5 years, No Electric bill to pay for.
- Revenue of more than 200 crores in 30 years.
- If invest in more land, Revenue will increase.
- Areas under Solar Panels can be used for Parking, Indoor Gardens etc.
- Consider the huge advantages goes unnoticed for want of awareness

Thus, the success of Net Zero built environment in India also depends on public awareness and support. The general public in India is not fully aware of the benefits of Net Zero buildings and the impact of climate change. This lack of awareness and support can lead to a lack of demand for Net Zero buildings and hinder their adoption in the market. In India, so far no Net Zero Residential complex has been developed. Only recently Mahindra Life Space Developers Ltd., a realty arm of Mahindra Group has announced a 500 Crore Net Zero Housing Project in Bengaluru. CPWD had taken lead to construct its first Net Zero building known as Indira Paryavaran Bhawan in Jorbagh, New Delhi.

Availability of Land

As seen in the above examples, we require huge tracts of land–about 1 million acres i.e. 4000 Sq. km for the solar and wind power potential to go beyond 300,000 MW in 2030 from the present 98,000 MW. It takes around 5 acres of land per megawatt of ground-mounted solar power projects and around 4 acre per megawatt of wind energy. At present, 88% of India's solar power installed capacity comes from ground-mounted projects.

Cochin international Airport in India is the world's first fully solar powered Airport. 45 acres of land out of total area of 1300 acres has been used to produce around 10 MW power to run the Airport Services and nearly 10,000panels will be added to generate another 2.40 MW power. So Land is one of the critical requirement for various infrastructure projects in the land starved cities where size of projects may be much bigger.

Further in regard to Urban slums which are spread over almost 50% of total urban area of cities, we need space for both Roof top Solar Power and ground mounted Solar Parks. The Development in the slums is structurally unsafe and prone to Fire Hazards. To carve out land on ground, we need to go in for in-situ redevelopment of Urban slum Clusters by way of High-rise buildings to release land on ground.

Now out of remaining 50% urban area, 40% caters for civic infrastructure and remaining 10% was developed as per old building bylaws. But out of greed for more, the bylaws were revised to cater for higher FAR in such areas without bothering to upgrade the civic services resulting in increased demand of Energy. The Civic infrastructure also consumes sizable amount of energy for its construction, operation and maintenance involving right from mining of natural materials, manufacture of construction materials, their transportation to sites, processing, and their fixing and installation and finally operation and maintenance. Each activity involves consumption of Energy and this requires generation of Energy be it through renewable or non-renewable source.

India based its estimated solar energy potential largely on the availability of wasteland. Entrepreneurs, however, have been reluctant in choosing wasteland, because they are usually remotely located and lack infrastructure, ultimately leading to cost escalation. Rajasthan and Gujarat implemented large-scale projects in the past few years, because there were no land-related protests. But recent trends indicate that a section of landowner and cultivators are raising objections to large solar projects for the fear of adverse impact these projects might have on their livelihoods and environment.

After issues of adverse environmental impacts of large solar projects by way of improper disposal of chemicals used during manufacturing and disposal of PV cells at the end of their useful life emerged in recent years, the Environmentalists have also started demanding environment impact assessment before such projects are implemented.

As far as wind energy is concerned, Class I sites–of high wind speed value–are getting exhausted in states with wind power potential. Class II sites will require taller windmills, needing higher initial investment.

High cost of implementation

The implementation of Net Zero built environment requires significant investment in terms of technology, materials, and design. This cost can be a major deterrent for developers and builders in India, especially in the affordable housing segment, where cost is a critical factor.

Lack of Will of the Stake holders

This is a major deterrent to develop Net Zero built environment be it public sector or Private resulting in lack of demand for the Skilled Professionals in this endeavour.

Regulatory challenges

The regulatory framework in India is complex and often not conducive to the implementation of Net Zero built environment. There are no clear guidelines or incentives for builders and developers to adopt Net Zero building practices. The lack of a supportive regulatory environment can act as a major barrier to the growth of Net Zero buildings in India.

Limited availability of skilled professionals

The design and construction of Net Zero buildings require specialized skills and knowledge. However, there is a limited pool of skilled professionals in India who are equipped to handle these requirements. This shortage of skilled professionals can lead to delays in project completion and compromise on the quality of construction. It is ,therefore, important to create knowledge sharing Platforms to create large pool of such Professionals.

Lack of Skilled Workers

What is the scenario on the ground? We say, Energy saved is Energy generated. Are we ensuring it? Answer is big NO. because we do not have a pool of skilled workers to perform various construction Activity and are short of skilled Professionals right from planning to execution and to operation and maintenance barring a small percentage of Building Infrastructure.

Limited availability of renewable energy

The availability of renewable energy in India is limited, which can be a major challenge in achieving Net Zero emissions. While the government has set a target of generating 40% of the country’s electricity from renewable sources by 2030, the current infrastructure and capacity are not adequate to support the demand for renewable energy.

Looking at the above constraints, one thing is very much clear that we need to conserve energy because it goes without saying that “Energy conserved or saved is Energy generated.”

WHY CONSERVE ENERGY?

It is an accepted fact that net zero energy buildings have a smaller environmental footprint than traditional buildings. This is because they rely less on fossil fuels and produce less greenhouse gas emissions resulting in a cleaner environment. This is only one of the parameters towards Green Building which considers all environmental impacts such as use of materials and water pollution etc., whereas the scope of Net zero energy buildings is limited to the energy consumption in a Building and ability to produce an equal amount, or more. IGBC has developed the following guidelines which facilitate the adoption of net zero concepts:

a) IGBC Net Zero Energy Buildings Rating: IGBC-rated Net Zero Energy buildings can support the country in a large way to reduce GHG emissions.

b) IGBC Net Zero Water Rating: This rating also complements the Government's National Water Mission.

c) IGBC Net Zero Waste Rating: The rating is aimed at addressing issues related to waste generation during construction, operation and maintenance of buildings and built-environment.

These guidelines would facilitate organizations to initiate GHG accounting and categorise the emissions under a, b & c above at project level. Based on the emission intensity, appropriate emission reduction measures and abatement strategies can be developed by the organizations to ensure reduction in carbon emissions.

At present, the world over, Countries are focussing on Sustainable development. A universal definition is that Sustainable development is termed as 'Development that meets the need of present without compromising the ability of future generation to meet their own needs. "Sustainability is a broad concept that refers to a building's overall ability to provide a comfortable, healthy, and productive environment over the long term without negatively impacting the environment. Sustainable buildings aren't just about the environment, but take into account all three pillars of sustainability: planet, people, and profit. To meet with this requirement, we need to ensure the following at every stage right from concept to completion, operation & maintenance and waste management both during O & M and at the time of replacement of buildings/ structures at the end of their useful life

Design—Sustainable architecture to consider all parameters for Energy efficiency, water efficiency and construction efficiency. for example, window placement for optimal natural ventilation, Building envelope insulation, MEP Services, selection of materials and method statements thereof for proper installations etc.

Construction—Materials used to be safe for the environment and occupants. construction process should conserve natural resources.

Operation and maintenance—Energy and water to be used efficiently. Cleaning products to be safe for occupants.

Waste Management—Should not affect the environment adversely.

Demolition—Solid waste and disposed materials be handled in an environmentally safe manner.

CONCLUSION

To ensure Net Zero Carbon Built Environment through energy conservation, we must ensure the following:

1. Detailed architectural design
2. Detailed structural design
3. Fabrication drawing with method statement
4. Use of correct T & P for working on materials for proper installation.
5. Environment friendly waste management
6. Post installation up keep & maintenance.

ENERGY EFFICIENCY MEASURES IN BUILDING: A CASE STUDY OF INDIAN RAILWAYS

VEENA SINHA*

Abstract

Indian Railways (IR) is one of the largest transportation organization in the country. It moved 3519 million passengers and 1415.87 million tonnes of freight over its 102831 km of rail network during the year 2021-22. IR infrastructure spread throughout the country include non-rolling stock assets like station buildings, workshops, sheds, train maintenance yards, tracks, land etc. and rolling stock assets like locomotives, coaches and wagons.

Railways is one of the most efficient and eco-friendly mode of transport, yet it lost share in overall transport sector which call for introspection and evaluation. Railways in its attempt to regain its share in overall transport sector is taking up structural changes in the organization and also looking to revamp its technology use, which among other things is based on energy efficiency and fuel switch. Towards energy efficiency measures, IR endeavour is to be the leader by laying foundation to achieve net zero carbon emission by 2030. If we look at the energy usages by IR then 87.79% is towards traction purposes and 12.21% towards non traction purposes in last 10 years. While use of enhanced lighting, increased air conditioning and provision of lift and escalators has been witnessed yet energy use for non-traction purposes is constant, rather declining in last two-three years. This has been possible by periodic monitoring, implementation of transformational measures, issue and implementation of directives on use of equipment, their specification, maintenance periodicity, replacement by energy efficient equipment, training and capacity building in green building technology and rating by the railway engineers.

INTRODUCTION

The building sector is one of the largest energy-consuming sectors followed closely by industry and transport hence, efforts to improve energy efficiency in buildings can result in significant reductions in energy consumption, greenhouse gas emissions, and operational costs. India is third largest contributors to global carbon emissions, producing around 2.6 Giga-tonnes (GT) of CO_2 annually out of 35 GT global emissions. If business continues as usual, India's emissions are projected to rise to 4.48 GT by 2030 [Bureau of Energy Efficiency].

Transport sector, CO_2 emissions account for 17% of India's total emissions. Of this, IR contribute only 3%. The potential for emissions reduction through a model shift from road to rail is considerable, India can avoid 55 mega-tonnes (MT) of emissions from the road sector by 2030. IR has recognized the importance of energy efficiency measures for last many years and has taken various initiatives to reduce its energy consumption and carbon footprint.

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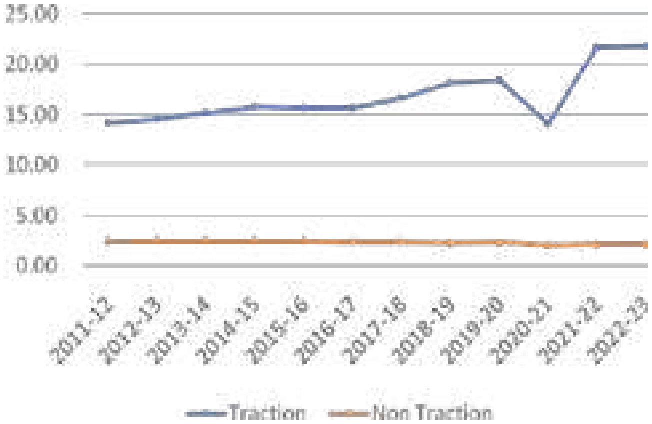

Fig.1: Energy Consumption Pattern of IR (Billion KWh) over Traction and Non-Traction use

[source: IR energy management department]

This paper attempts to track and present how IR could achieve constant non-traction purpose energy use over the years despite increase in electrical loads with suitable case studies of three building/premises. Also, an attempt has been made to come out with some recommendations based on the experiences gained from railway sector for the action that can be initiated for modern sustainable buildings/premises/ urban landscape. Under the Energy Conservation Amendment Act 2022, energy conservation and sustainable building code is also planned to be developed.

It is estimated that activities as highlighted in Fig. 2 related to energy efficiency & conservation would result in savings of 557MT of CO_2 per annum in 2030 (BEE estimation).

Fig. 2: CO_2 Reduction Potential through various programs

LITERATURE REVIEW

For this paper, Energy Audit reports of three buildings such as Rail Bhawan, Jagadhri Workshop, Integral Coach Factory Chennai had been referred. Also reports prepared by IR in association with Confederation of Indian Industries (CII)[3], Shakti Sustainable, USAID, Mission 41000k, recent IR Energy Efficiency Action Plan and Policy[15] are also reviewed. Base data for energy consumptions is taken from railway year book[7].

IR ROADMAP TO BECOME NET ZERO CARBON EMITTER BY 2030

IR has been making significant efforts to reduce its carbon footprint and become a net-zero carbon emitter by 2030. Indian Railway aspires to install 30,000 MW renewable energy by 2029-30 and have commissioned 147 MW of solar plants and about 103 MW of wind power plants so far[1].

Another significant measure taken by IR is to shift from diesel to electric traction, improving energy efficiency for both diesel and electric traction. Presently 80.61% of the broad-gauge network is electrified. With 100% electrification of tracks demand for electricity is expected to increase to about 72 Billion Units (BUs) by 2029-30 from 21 (BUs) in 2019-20[2]. To reduce the cost of procurement of electricity, the Railways is using cost-efficient energy sourcing strategies.

Improving water use efficiency by 20% up to 2030 and implementing the Water Policy 2017 is another crucial step towards effective water management. IR has been planting around 1 crore trees annually since 2017, which will significantly contribute to the target of creating an additional carbon sink.

Railways has been implementing BEE's Shunya and Shunya+ rating, Energy Conservation Building Code (ECBC)[12], and Eco Niwas Samhita for achieving goals of sustainable buildings. To monitor and manage energy consumption across its facilities, IR has developed cloud-based real-time data management system IR NIYANTRAC which includes energy management systems, station lighting, and water management systems[15].

IR promotes use of energy-efficient and star labelled lighting, fans, and air conditioners to reduce energy consumption. It also implements measures to maintain unity power factor through APFCs (Automatic Power factor controllers). Capacity building and awareness campaigns are also a part of the Indian Railways' energy-efficiency action plan. It conducts regular training sessions and awareness campaigns for its employees to enhance their knowledge and skills in energy management.

Energy audit guidelines, manuals and best operating procedures are developed for energy intensive railway operations, including production units, traction substations, workshops, maintenance depots and buildings. The technical specifications of various energy consuming equipment has been finalised for being energy efficient for deployment in relevant projects. The procurement of these energy-efficient equipment to be done on a competitive bidding basis as per public procurement norms, ensuring the performance of installed equipment are as per design specifications.

Incorporating all above measures undertaken in past, IR has come up with Indian Railway Energy Efficiency Action Plan and Policy in 2022[15].

CASE STUDY OF WORKSHOP/ OFFICES/ PREMISES OF IR

Case study of Integral Coach factory (ICF) Chennai

ICF, established in 1995 is spread over an area of 475 acres, ICF has Max Demand (average) of 8500MVA. Annual electrical energy consumption of ICF has gone down from 18 million units (MU) to 13 million units (MU). Energy generated from solar and wind sources also play a significant role in meeting the electrical energy demand.

Energy Performance Index (EPI) for different building in campus ranges from 84 to 285 (KWh/Sqm/ annum) highlighting the effect of energy efficiency measures taken and further required to be taken. Further benchmarking for industrial and commercial installations/ building is required to be laid down separately apart from lighting, Heating Ventilation and Air- Conditioning (HVAC), as there are number of equipment consuming different energy that may require energy efficiency measure planning.

Proposed/implemented measures of energy conservation measures (ECM) has been identified in Energy Audit report prepared in consultations with Railway Engineers and investment of Rs. 244.27 Lakhs is envisaged with payback period of less than a year and annual electrical energy saving of Rs. 28 Lakh (approximately) units.

Case study of Jagadhari (JUDW) Workshop

Jagadhari workshop, established in 1952 is spread over 286 acres. This workshop was awarded Green-Co Platinum rating by CII in 2022. JUDW workshop energy consumption is in range of 4200-4400K units over the years despite significant increase in coach and wagon POH outturn. Solar plant of 1MWp capacity is also installed and substituted 25% of purchased energy from electricity board during 2021-22.

The EPI data 58-69 (KWh/sqm/annum) over the year conforms to the standard norms laid by BEE[4]. Existing measures of energy conservation/ Energy Efficiency in JUDW are: replacement of conventional light to 100% LED, improved power factor above 0.95 through APFCs, provision of solar water heater, rainwater harvesting, water metering.

Further, workshop has planned for provision of VFD based EOT crane, shifting operating lighting load to 70%, parallel operation of transformer for better transformer efficiency, installation of automation system at all five water pumping locations, replacement of inefficient reciprocating air compressors, EOT cranes, oil type welding plants with efficient screw compressors, efficient EOT cranes and with IGBT inverter-based welding plants respectively. Workshop also provided energy meters at 110 locations and covered 25 locations through LAN based energy monitoring system.

Case study of Rail Bhawan

Rail Bhawan is the Headquarter office of IR situated in New Delhi and spreads over an area of 43957m^2. It has an installed solar capacity of 30 KWp which annually generates 45000 KWh of energy.

Table 1: Year wise Energy Performance Index of Rail Bhawan

S. No.	Year	Consumption (KWh)	Area in sq. m	EPI (KWh/sqm/annum)
1	2015-2016	5539000	43957	126.01
2	2016-2017	5756000	43957	130.95
3	2017-2018	5518000	43957	125.53
4	2018-2019	5630000	43957	128.08
5	2019-2020	5632000	43957	128.13
6	2020-2021	3150000	43957	71.66
7	2021-2022	3687000	43957	83.88
8	2022-2023	4149000	43957	94.39

Major contributor to energy consumption is air-conditioning of building space. The EPI data conforms to the standard norms as laid out by BEE[4]. This was possible by replacing window and split air conditioners with Variable refrigerant flow (VRF) fixed type compressor (further planned for VRF inverter type compressors), lamps/Tube lights with LED, Metal halides with LED lights among other measures.

ISSUES IN COOLING SOLUTIONS FOR BUILDING SECTOR

India has one of the lowest access to cooling across the world which is reflected in it's low per-capita level of energy consumption for space cooling at 69KWh as compared to world average of 272KWh[8]. Cooling and air conditioning account for around 10% of global electricity consumption and contribute to about 7% of global GHG emissions[9]. India has witnessed rapid surge in demand for cooling as mean temperature has gone up over the years. Further, demand driver for cooling is population growth, rising income and continued urbanization.

Achieving Net Zero in this sector by optimization of cooling system performance and efficiency is essential as new methodologies and guidance to design, build, operate, and maintain future-proofed buildings will be needed. This includes accounting for elevated air temperature on account of regional air temp, solar radiation, hot process equipment emitting heat by radiation and convection, combustion equipment exhaust stack, stored heat in concrete structures and paving, and air emitted from air-cooled heat exchange[9]. With this potential deficiency in engineered infrastructure due to design criteria reliant on historical weather patterns can be avoided.

RECOMMENDATIONS FOR ENERGY EFFICIENCY IN BUILDING SECTOR

Energy efficiency measures taken by IR is significant and can be applied to other organisations and may help in formulating sustainable building codes. Following are additional recommendations for reducing energy consumption in buildings and bringing down GHG emissions by adopting practices laid down for Green building environment. Some of the recommended measures are yet to be taken up by the rating agencies while rating the building as a sustainable building:

Development of Asset management plan

Organization asset management plan need to be drawn specifying designed material performance, to set operational and maintenance rules and standards specifying wherein when to inspect, repair and renew component/equipment. Further work instructions for operating staffs need to be made available based on laid out standards and rules. Sometimes very energy efficient products are made available in market, for which updation of procurement norms, specifications will be required in real time basis for maximizing the benefits. For monitoring and control purposes use of building management system may also be thought off.

Heating Ventilation and Air-Conditioning

Different way of thinking that goes beyond acting on Energy Efficiency and energy decarbonisation is needed as future climatic design values needs to be incorporated in national and local building code and regulation. Setting rules, specification, test methods and governance procedure is needed. Modeling of city landscape for impact of human produced heat, capacity of building material to absorb, store and emit heat energy in urban landscape (actual temperature and humidity measurement and computer modelling) can provide solution for efficient design.

Refrigerants such as hydro fluorocarbons (HFCs) are particularly potent GHGs with GWPs (Global Warming Potential) that can be thousands of times higher than that of carbon dioxide. Insulated building with lesser GWP refrigerants (134a, 407C, R32 with zero ozone depletion potential) along with HVAC automation and sensor-based management and optimizing cooling system performance and efficiency, developing authoritative standards and engineering design codes, and investing in research and development, we can move towards a future for cooling solutions that is both sustainable and comfortable. For example use of design data like Indian Seasonal Energy Efficiency Ratio apart from other parameters are also need to be taken into account.

CONCLUSION

Energy efficiency measures that had been taken in three buildings (Rail Bhawan, Jagadhari Workshop, Integral Coach Factory) have been presented for showcasing IR commitment to NET ZERO by 2030 for non-traction sector energy use. These include adopting good practices on green building, promotion of energy efficiency as a regular practice, setting up of benchmarks for energy consumption (use), periodic updation of specification (including change), maintenance practices, green certification of railway establishments, use of renewable energy, energy accounting etc. Based on the railway experience, issues that require addressing in the building sector along with possible solutions have been highlighted. To cater to rising temperature in many parts of the country, new building constructions/retrofitment of existing equipments in existing building will require different approach to be sustainable and techno-economically viable in near future.

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ENERGY EFFICIENCY MEASURES IN COMMERCIAL REAL ESTATE

Dr. C. Velan And Deepak Kovendan

INTRODUCTION

Energy use is the single largest operating expense in commercial buildings, representing approximately one-third of typical operating budgets and accounting for almost 20 percent of the annual greenhouse gas emissions. By becoming more energy efficient, commercial real estate (CRE) organizations can reduce operating expenses, increase property asset value, and enhance the comfort of their tenants. They can also demonstrate their commitment to the environment by reducing pollution and the harmful greenhouse gas emissions that contribute to global warming. Making your building more energy efficient also makes your building more valuable. New energy efficient technology can be incorporated into any size of building and can create a huge money-saving upgrade.

Energy use in Commercial Real Estate

By improving energy efficiency, commercial real estate organizations can reduce operation-related expenses, increase property asset valuations and even enhance their tenant's comfort. In doing so, they are also demonstrating a commitment to the environment by doing their bit to reduce pollution and the greenhouse gas emissions that contribute towards global warming. Here are some of the ways that improvements in energy and operational data can enable businesses to increase their commercial building values.

Reducing maintenance and operations costs

A building's equipment performance can be assessed at any time by reviewing energy data, and these insights can provide important information for a facility's teams to use in determining the most efficient approach to maintenance procedures.

From a scalable perspective, by utilizing energy data analysis and thus eliminating the need for manual on-site equipment inspections, companies can reduce the amount of time and money spent on service visits. This also avoids disruptions to operations which further increases productivity.

Reducing equipment-related capital investment

In addition to the impact on maintenance and operations, increased insights into equipment performance can also assist businesses in making more informed decisions when it comes to capital investments.

Individual changes may seem like small-fry savings, but when scaled across an entire portfolio of properties, this extent of visibility could have sizable cumulative effects upon capital investments.

Higher lease rates as well as selling prices.

With investors, customers and even employees showing an increasing expectation towards businesses demonstrating a commitment to energy efficiency, research indicates that tenants are more willing than ever to pay a premium for commercial buildings that go some way towards meeting these demands.

Furthermore, a study into the commercial real estate market found that buildings holding Energy Star, IGBC (Indian Green Building council) and LEED (Leadership in Energy and Environmental Design) certifications were commanding higher leasing rates per square-foot. They were also sold at higher than asking prices compared to the region's average rates.

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Improving tenant retention

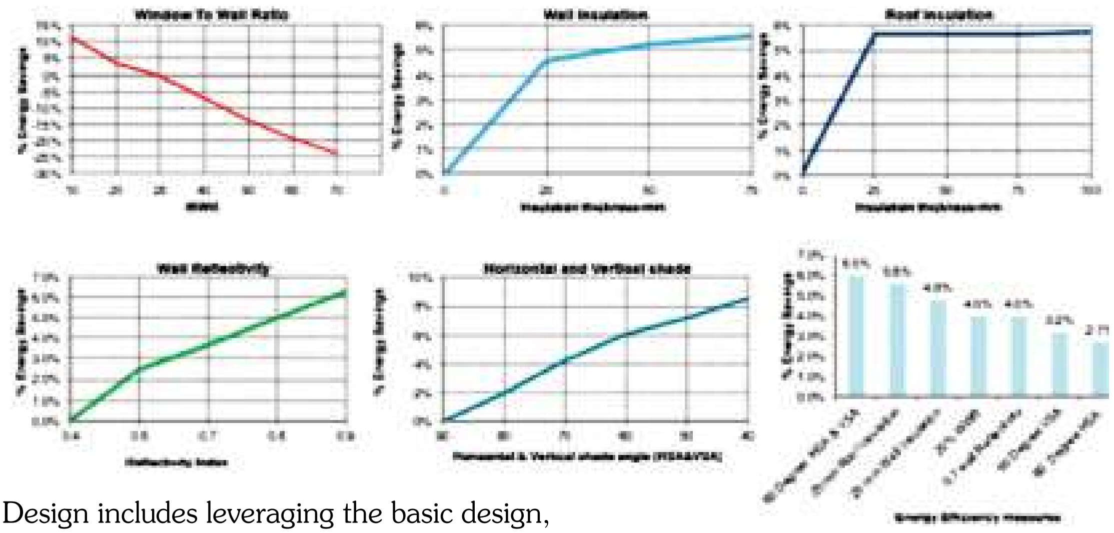
A key component to retaining tenants' long term is the ability to create and maintain a positive overall experience within buildings. Analyzing data by leveraging energy intelligence software allows engineers to identify measures that can be taken to create the greatest impacts upon comfort, and thus improve tenant retention.

Sustainable architecture – Passive vs Active

Sustainable architecture has many different attributes all grouped under two different strategies namely, active and passive.

Passive strategies: These strategies use nature's resources to maintain a comfortable accommodation setting for the users.

With global warming becoming a reality, drastic changes are occurring in temperatures globally. With 90% of modern lifestyle being spent indoors, buildings need to be climate-controlled and energy efficient, without the use of conventional energy sources (electricity) that cause carbon emissions.



Passive Design includes leveraging the basic design, the shape & the form of the building itself, in making that building energy efficient, habitable, and comfortable. Passive design strategies help to maintain thermal comfort in a building without using electricity for heating and cooling, even in the most extreme climate conditions.

- The passive design approaches take advantage of physical energy possibilities as they correlate to the location of the building, the climate of the area and characteristics of building material.
- Improving a building's energy efficiency is the prime aspect of passive design.
- Passive design strategies are the best option to diminish the size of the cooling system by holding the cooled air in the structure.
- Generally, passive design strategies impact the front-end cost of the project. You can support diminishing the cost of active design approaches by degrading heating and cooling quantities.

The following are some of the best passive design strategies.

Building orientation

Form and orientation constitute two of the most important passive design strategies for reducing energy consumption and improving thermal comfort for occupants of a building.

a) It affects the amount of sun falling on surfaces, daylighting, and direction of winds.

b) Properly oriented buildings maximize the amount of solar radiation in winter and minimize the amount in summer.

c) In predominantly hot regions, buildings should be ideally oriented to minimize solar gains, the reverse is applicable for cold regions.

Shading

'External shading devices' are controls that greatly reduce the need for mechanical cooling to maintain thermal comfort inside buildings, by controlling heat gain through openings.

a) Longer sides of a building should be oriented North- South which is preferred to minimize overall solar gain through the envelope.

b) South-facing windows are the easiest to shade. Overhangs on south-oriented windows provide effective shading by blocking summer sun and admitting winter sun.

c) Use fixed horizontal overhangs on south-facing glass.

d) To the greatest extent possible, limit the amount of east and west glass (minimize window area) since they are harder to shade.

e) To enhance natural light utilization, passive design strategies such as light shelves are very useful for deeper and uniform distribution of light

Insulation

a) Thermal insulation in walls and roofs reduces heat transfer between the inside and outside and helps maintain comfortable indoor temperature.

b) It provides a healthier environment, adds sound control, and most important lowers the electricity bills. Insulation helps keep indoor space cooler in summer months and warm during winters.

Daylight

Daylight is the most important factor in making the building energy efficient.

a) The location of the windows in a hot climate is extremely important for receiving proper light without consuming electricity.

b) Buildings that are longer on their east-west axis are better for daylighting and visual comfort.

c) Large buildings can get daylight into more spaces by having central courtyards or atria or having other cut-outs in the building form.

d) Maximize southern exposure and optimize northern exposure.

Ventilation

Fresh air in a building brings health benefits and increased comfort level to its occupants. Fresh air provision is considered as an efficient and a healthy solution as it reduces the need for mechanical means to ventilate a building.

a) For good natural ventilation, building openings should be in opposite pressure zone.

b) The building can be oriented 0° to 30° with respect to the prevailing wind direction / most preferably orientating longer facades of the building towards predominant wind direction.

c) Windows should be staggered rather than aligned.

Passive Cooling Measures:

Wind Tower

a) The hot ambient air enters the tower through its openings.

b) It is cooled when it meets the water mist inside the tower and thus becomes heavier and sinks down.

c) An inlet is provided to the rooms with an outlet on the other side, so that there is a draft of cool air.

Solar Chimney

a) A solar chimney is a modern device that induces natural ventilation by the thermal-buoyancy effect. The structure of the chimney absorbs solar energy during the day, thereby heating the enclosed air within and causing it to rise.

b) Thus, air is drawn from the building into an open near the bottom of the chimney.

c) The air exhausted through the chimney, is replaced by ambient air.

Construction material

a) The embodied energy (carbon) of a building material can be taken as the total primary energy consumed (carbon released over its life cycle). This would normally include (at least) extraction, manufacturing, and transportation.

b) Materials used in conventional building construction constitute lot of embodied energy into the atmosphere. And these materials conduct more heat into the building and increase the cooling energy demand.

The passive design strategies balance the energy and performance of the building by reducing heating and cooling mechanically. By balancing passive design parameters like proper solar orientation, optimal insulation, high-performance windows and doors, an airtight enclosure, and balanced ventilation, Passive projects end up using 20- 40% less energy for heating and cooling than conventional buildings and are proven to be significantly healthier and more comfortable than traditionally built homes.

Active strategies: Active design strategies use purchased energy (including electricity and natural gas) to keep buildings comfortable. These strategies include mechanical system components such as air-conditioning, heat pumps, radiant heating, heat recovery ventilators, and electric lighting.

To put this into context, if a passive design provides ventilation and heating using natural 'non powered' systems, a building using active design will achieve the same end, but must use technologies such as solar panels, heat recovery systems, or the use of renewable energy sources such as wind turbines.

Grid Connected

This helps the building function optimally when the energy generated by the building is less than the required energy.

Net-positive energy cost

PV cells are to be used when the chosen site is suitable for harvesting solar energy. Net-Positive Cost of Energy means that within the period of one year, a project generates enough energy to exceed the cost of energy paid for energy utilized.

High-efficiency HVAC

These strategies need to be personalized to the location and use of the building. It should work with passive strategies to reduce the energy consumed.

HRV/ERV

Heat Recovery Ventilation (HRV) and Energy Recovery Ventilation (ERV) are dedicated ventilation systems that supply continuous fresh air to your home. Fresh outdoor air runs through the HRV/ ERV which pre-conditions the air by transferring the heat (HRV) or heat and humidity (ERV) from stale exhaust air into the fresh outdoor air. This process saves energy in heating and cooling, resulting in lower energy bills and healthier indoor air.

Building automation

Intelligent buildings help reduce manual effort in the process of reducing energy consumed.

Greywater reuse

Greywater is an umbrella term for water used while bathing, showering and hand washing. It could also include water from kitchen sinks and even laundry units. This water can be repurposed to be used for irrigation and toilet flushing.

High-Efficiency Appliances

High-Efficiency Appliances must meet regulated targets for energy consumption. These targets are set lower than typical energy-use for the same appliance. In North America, we use Energy Star as a guide for high energy-efficiency standards for most household appliances.

In-Floor Radiant Heating

In-Floor Radiant Heating uses conduction and convection to exchange heat between a heated fluid running through tubes into the floor and then to the occupied space. Benefits include lower energy consumption compared to forced-air systems, healthier indoor air quality, and a higher level of comfort.

In general, you'll want to optimize your design for passive strategies first. Doing so can often downsize the active systems you'll need to install.

Path to achieve carbon neutrality

The 1st step is to convert all commercial buildings to have green certification under IGBC or LEED minimum platinum level. This will ensure that we meet all the minimum requirements with respect to passive and active design.

The 2nd step is achieving Net Zero in Energy Water and Waste. IGBC accords the Net Zero certification in all 3 categories in 2 stages.

1) During design & construction stage

2) Operation stage

In a programmed approach we can achieve both at design & construction stage and in operations stage. In the subsequent section we explain how we were able to achieve Net Zero design in all 3 stages for our upcoming development in Radial Road Chennai.

International Tech Park Radial Road – a Case study

International Tech Park Chennai, Radial Road (ITPC-Radial Road) is spread over 5.0 million sq ft, with four blocks catering to IT/ITES office space. It offers state-of-the-art infrastructure and Grade A office space with a host of sustainable features.

ITPC-Radial Road is situated in Pallavaram-Thoraipakkam Road (PTR) or 200 Ft Radial Road which connects GST Road and OMR, is primed to become the next IT corridor of Chennai. It is well-connected with all modes of transport including the upcoming metro line.

The site is surrounded by a strong residential catchment with large talent pool in the vicinity.

Envisaged as a Grade A campus and situated at a prime location on Radial Road, 20 minutes from the international airport, the 25.2 -acre site comprises of four towers united by a shaded central plaza that reinstates a "Green Campus" feel through its multiple landscaped nodes channeling user movement. The commercial towers comprise of three basements, ground floor with 10 upper floors and a terrace designed to nurture and promote health activities.

The International Tech Park campus lays a strong emphasis on sustainability and wellness with an IGBC Platinum Pre-certified rating while simultaneously pursuing WELL Gold Certification. As a feather in the cap IGBC has recognized International Tech Park Chennai - Radial Road as the first Net Zero -Design rated business park in India in all 3 categories of Energy, Water and Waste.

The campus is designed around a well landscaped central green lung that is pedestrian friendly. The Master plan of the campus has been organized in two parts: Eastern pedestrian edge and western vehicular edge creating a clear segregation between vehicular and pedestrian movement to the building. The campus is intended to influence human health and well-being by encouraging walking throughout the campus with a continuous covered pedestrian walkway that begins right at the site entrance.

The faзade envelope comprises of high-performance glazing with vertical fins giving the building a timeless and international appeal. The fa3ade is enhanced by variation of aluminum fins wrapping around the edges with a colored palate inspired by the brand colors to augment CapitaLand's brand presence. This tonal variation allows the building to develop a visual hierarchy and rhythm across the fa3ade.

The arrival experience captures spatial proportions through double and triple height

volumes at the entry points on either side of the tower before being drawn into the vortex of a dramatic 10-storey, naturally lit atrium.

The interior spaces provide seamless functional circulation connecting users both horizontally and vertically, by use of landscape pockets as relief zones and vertical landscape which are achieved through hydroponic plantation. It features local species of plants to create a calming experience for occupants while promoting well-being and improving overall Indoor air quality. This inherent connection with light, air, and green blurs the boundaries of indoor and outdoor.

Step -01 Base Building Certification

The International Tech Park campus lays a strong emphasis on sustainability and wellness with an IGBC New Building Platinum Pre-certification.

Step -02 Net Zero certification

IGBC has recognized International Tech Park Chennai - Radial Road as the first Net Zero -Design & construction rated business park in India in all 3 categories of Energy, Water and Waste.

1) Net Zero Energy

Net Zero energy buildings combine energy efficiency (Active & Passive) and renewable energy generation to consume only as much energy as can be produced onsite/offsite through renewable resources over a specified time.

2) Net Zero Water

Net Zero Water Buildings are those that consume minimum raw water & produce alternate water to meet the balance requirement (and) give back such quantities to the original sources for use, so that the net annual water consumption is zero.

3) Net Zero Waste

Net Zero Waste for Buildings & Built Environment is one which eliminates the diversion of waste being sent to landfills, by a multi-pronged approach - nature-centric design, reducing debris during construction, responsibly handling waste during operation, reusing the waste as much as possible and recycling the remaining waste.

CONCLUSION

Achieving carbon neutrality would imply reduction of overall embodied carbon associated with construction of the project, from the developer side we have taken all measures and initiatives towards that, but as an overall industry we are still progressing towards sustainable methods of manufacturing and producing building materials.

Once a sustainable ecosystem is in place for production and manufacturing, we will be able to move completely towards carbon neutrality.

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