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MOVING AHEAD TOWARDS NET POSITIVE ENERGY FROM NET ZERO ENERGY ARCHITECTURE

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Abstract: **Are we doing construction or destruction? This becomes a need to study the impacts of construction on environment and there is need to check the total impact one had made on the environment till today. This paper discusses about the pollution caused by buildings and need to minimise those impacts resulted into the emergence of the concept of NZEA (Net Zero Energy Architecture). Nowadays there is a need of adding to the environment rather than taking from environment. This is known as NPEA (Net Positive Energy Architecture) with the involvement of productive techniques in building industry.**

Keywords: **NZEA (Net Zero Energy Architecture), NPEA (Net Positive Energy Architecture), Productive techniques, Environment.**

I. INTRODUCTION

With the rising public and political awareness, regarding tremendous climatic change and environmental degradation is translating one's attention towards environmental up gradation which is far above the stability. The building construction industry needs to be upgraded with higher environmental efficient performances. More over this development follows the strategies where one has to reach after going through different stages.

A. ENERGY SCENARIO OF BUILDING CONSTRUCTION INDUSTRY:

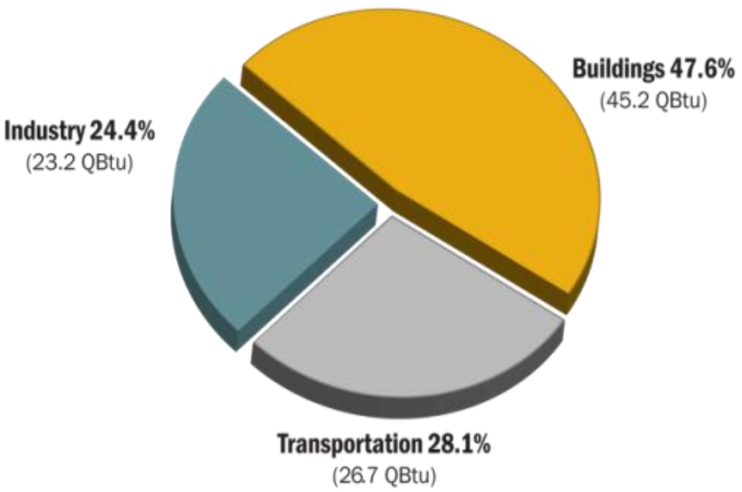

Figure 1: ENERGY CONSUMPTION SURVEY

Source: (U.S. Energy Consumption Survey, 2017)

Figure 1 shows according to U.S. energy information administration building industry dissipates of the total energy produced in the world and adding to the greenhouse gasses emissions.

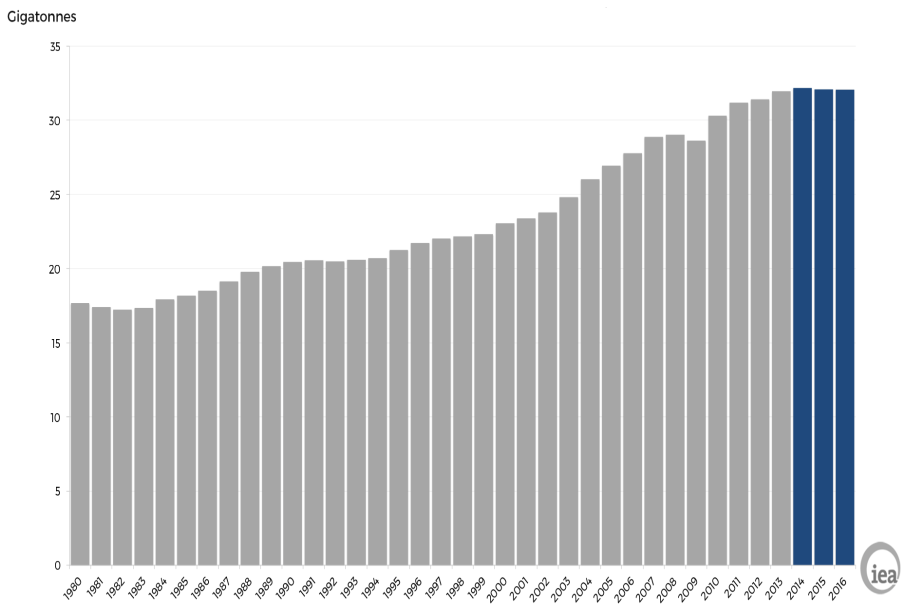

Figure 2: GLOBAL CARBON DIOXIDE EMISSIONS, 1980 - 2016

Source: (CO2 Emissions Survey, 2017)

Figure 2 shows that the large scale increase in the carbon dioxide emission till date due to building construction industry has added a lot in the global warming.

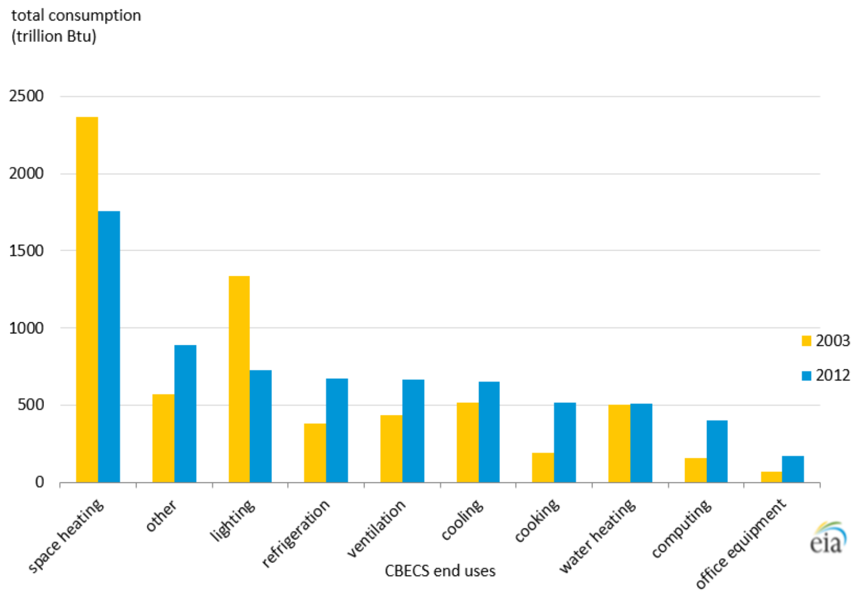

Figure 3: 2012 COMMERCIAL BUILDING ENERGY CONSUMPTION SURVEY

Source: (Energy Consumption Analysis, 2017)

Figure 3 The major amount of energy consumed by the building is due to space heating or HVAC systems and second major is the lighting. This has necessitated the architects, designers, engineers, developers and concerned authorities to wake up from deep slumber and start thinking towards sustainability which resulted into net zero energy architecture which means no negative impact on environment.

B. NZEA (NET ZERO ENERGY ARCHITECTURE):

Net zero energy architecture means producing the amount of energy required or to be consumed by the building through various techniques such as use of renewable energy, use of 3 R's i.e. reduce, recycle, reuse, various passive and active techniques of construction. But this doesn't seem to be sufficient to sustain environment. Now the time has come to think Productive which raised the concept of productive architecture.

C. PRODUCTIVE ARCHITECTURE:

Productive architecture means producing more than required and produces positive benefits on every level – human, environmental and economic.

In **human** terms - promote health, happiness and inspiration.

In **environmental** terms - producing surplus of renewable energy, using no ground water and generating no waste.

In **economic** terms - creating real value.

This promotes the concept of adding rather than taking from to the environment which further highlighted the concept of **NPEA** (net positive energy architecture) resulting in the construction of **NPEB** (net positive energy buildings) and **NPL** (net positive landscape)

D. NET POSITIVE ENERGY ARCHITECTURE:

"Producing more energy than is needed by a building or system, and exporting this to other systems i.e. energy storage management and feeding extra energy produced to the grid."(Koutroulis) In this concept, a building with self heeling, self organizing and self sufficient can act as a catalyst for positive change within the place it is situated focused on enhancing life in all its manifestations- human and ecological system through an enduring responsibility of stewardship. These buildings promise to add value and a designed to generate more than they need, not simply generating more energy but also identifies the purpose and designing how the excess resources will be deployed. "The physical development which is archived through NPEB is improved life cycle over predevelopment conditions by increasing economic, social and ecological capital. This not only generates clean energy, air and water but would also leave ecology better than before." (Birkeland)

E. NET POSITIVE ENERGY BUILDINGS:

Net positive energy building is one that produces more energy generated through non polluting renewable sources than it uses over a declared period of time e.g. over a year and adds much more to the system and make it more resilient to future stresses such as climate change, increasing individualisation and the observed change in the type of end users wishes and demand.

II. SHIFTING FROM NET ZERO TO NET POSITIVE ENERGY BUILDINGS

Net zero energy projects claim the use a variety of different approaches- on site and off site renewable energy technologies, purchases green energy credits. Continuous efforts have been made to formulate the more clarity of the concept of net zero energy buildings resulted in the emerging notion of net positive energy buildings and has introduced the new theories and new design considerations which emphasises on the maximisation of energy performance of a building and adding values to the system and environment and is a shift from net zero energy.

III. CHANGING EXPECTATIONS

A. LIFE CYCLE ASSESSMENT:

It is method of analysing and improving environmental impacts of the processes of the system. Optimum use of renewable resources material, energy reduces the environmental emissions and provides better life cycle. The concept of net positive energy has actually improvised the life cycle and has uplifted the system of cradle to grave to cradle to cradle.

B. NEB (NET EXPECTATION BENEFIT):

NEB is understood as the generation consumption difference between the importing and exporting buildings weighted appropriately by the price the energy is purchased or sold and represents anticipated monetary gain from the exchange. This emphasizes on minimizing operational cost or maximizing the return on the energy efficiency measures investment. Maximization of net energy produced is considered as the most environmental friendly approach as it maximizes produced from the building.

C. INDUSTRIAL ECOLOGY:

A system or a means by which humanity can deliberately and rationally approach and maintain a desirable carrying capacity, given continued economic, cultural and technological approach. With this one can seek optimum cycles and processes of using materials and energy resources, satisfying environmental constraints, financial and others desires as well. Reduction in technology use- results in reduction of resources used and waste emissions.

D. DESIGN FOR THE ENVIRONMENT:

Design is the act of creating a product or process to provide a service, to satisfy the needs various factors considered while designing includes the ability to meet purpose, safety, economics, user satisfaction, efficiency, life time of design and product, environmental impacts. With net positive approach of designing, the impacts on the environment are set to least and maximises the ecological growth, the means of energy optimisation, resource optimisation and design optimisation.

IV. ADVANCED BUILDING WITH POSITIVE OUTPUT

A. ROCHESTER INSTITUTE OF TECHNOLOGY, NEW YORK CAMPUS:

ARCHITECT: SWBR ARCHITECTS

Figure 4: ROCHESTER INSTITUTE OF TECHNOLOGY, NEW YORK

Source: (Hu, 2016)

The design of campus has received the credit for **"Innovation in Design",** a category for exemplary performance that spans beyond the **defined LEED Rating System** through advanced features that included the wide range of sustainable design strategies involving management of site, preferred use of **recycled and renewable materials**, measures for **indoor air quality**, improved **design for energy and water efficiency**.

Figure 5: ENERGY EFFICIENCY FEATURES OF RIT, NY

Source: (Advanced Energy Efficiency Strategies, 2017)

KEY FEATURES THAT REDUCE ENERGY REQUIREMENTS:

- 400 kW phosphoric acid fuel cell
- 40 kW photovoltaic array
- Vertical-axis wind turbines with a combined capacity of 3 kW
- Lithium-ion battery storage system
- Eight geothermal wells
- Exhaust air energy recovery (ERV-1)
- Control efficiency through the building automation system (BAS)
- Improved levels of building envelope insulation over the prescriptive requirements of ASHRAE Standard 90.1-2007
- “Chilled Beam” room heating and cooling units
- High-performance window glazing
- Highly-efficient lighting and controls with lighting power
- Day lighting

The key features of project comprises of various energy conservation features including high **R-factor insulating roof** and **wall panels**, **“chilled beam”** room heating and cooling for **temperature control**. the **Micro - Grid** computer system in the building helps in the real - world testing for **electrical supply and demand management**. Appropriate 1500 sensors were installed for real time performance of the building.

V. MATERIALS AND RESOURCES USED

RECYCLED CONTENT:

While selecting the materials, preference was given to those materials which had the huge amount of **recycled content**. This reduced the 20**.77% of total material cost** of the project. Thus results in increase in the demand of materials with high recycled content as it **reduces the cost** as well as the **impacts** caused from the **extraction** and **processing** of the virgin materials.

REGIONAL MATERIALS:

While material selection of the project, materials which are **harvested and manufactured** within **500 miles** of the site were preferred, steel studs and concrete, as it helps in promoting the local materials and resources of that region and reduces the environmental impacts being caused through the **transportation**.

CONSTRUCTION WASTE MANAGEMENT:

Initially when the project was planned, it was targeted to divert at least 50% of waste from landfill. Individual bins were set - up on site to segregate different wastes: concrete and masonry, metal, wood, cardboard, mixed debris.

Concrete waste was sent to The Dolomite Group of Rochester, New York, that recycles for reuse as sub base in other projects.

Metal waste was sent to Genesee, Rochester, New York, as they shred and separates ferrous and non-ferrous products and forward it to recycle into new metal products.

Wood waste was sent to Terry Tree Service, LLC, they mulches and recycles it for landscaping and products.

Cardboard waste was sent to JC Fibres of North America based in Rochester, New York, works paper and cardboard recovery.

The mixed debris was carted away as waste. at the end 60% of construction waste of the project was recycled.

ADVANCED TECHNOLOGIES:

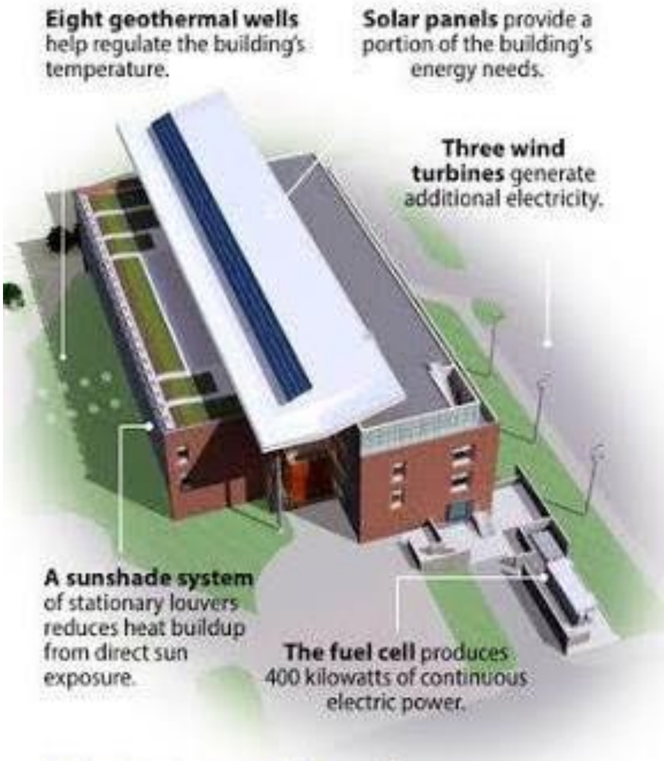

Figure 6: ADVANCED ENERGY EFFICIENT TECHNOLOGIES

Source: (Advanced Energy Efficiency Strategies, 2017)

PHOTOVOLTAIC ARRAYS:

Figure 7: PHOTOVOLTAIC ARRAYS

Source: (Advanced Energy Efficiency Strategies, 2017)

3 photovoltaic arrays: **2- 20 kW** PV arrays are installed on main roof, **1- 5 kW** experimental PV array was installed on lower level green roof which are capable of producing 40 kW. On an average sunny day expected to reach **35 - 40 kW**. The peak output between **9 am to 5 pm**, is capable of matching the **entire lighting load** of the building.

VERTICAL AXIS WIND TURBINES:

Figure 8: VERTICAL AXIS WIND TURBINES

Source: (Advanced Energy Efficiency Strategies, 2017)

3 - 1kW vertical axis wind turbines on the north of the building were primarily installed for academic study are able to produce **3 kW** at high wind speed.

LITHIUM-ION BATTERY STORAGE :

56 kWh lithium - ion battery storage in the **micro - grid** of the building on the first floor. These batteries are charged by wind and solar inputs. They are able to **store electricity** and can **discharge** it to **supply** other buildings of the campus and **reduce** the total electricity delivered to the campus from **external sources**.

ALTERNATIVE ENERGY RESOURCE: FUEL CELL

Fuel cells are installed on east of the basement of the building which uses **natural gas** as its input fuel and convert it into **electric energy** with **no combustion** of fuel. This is capable of producing **400 kW** with average **90% efficiency**. This is capable of meeting entire building **electricity demand** and **excess** is transferred to the **main campus grid** which makes it **NET PRODUCTIVE**. **Heat generated** as by - product is transferred to **geo - thermal pit** which is capable of producing **energy** and **heat 4 storey high hall**.

LEED-PLATINUM CERTIFIED, FEBRUARY 2014

CONTRIBUTIONS TO ENERGY SAVINGS

Envelope Performance:	15%
Systems Performance:	31%
Exterior Fuel Cell:	11%
DESIGN ENERGY SAVINGS BEYOND ASHRAE 90.1:	56.5%

LEED 2009 EAc1 offers a maximum of 19 points at 48% savings. GIS earned exemplary performance in this category.

REDUCTION IN ANNUAL CARBON FOOTPRINT: (AIA 2030 GOAL OF 60%)	61%
PERCENT ONSITE RENEWABLE ENERGY:	5.1%
PERCENT RENEWABLE ENERGY CERTIFICATES:	100%
ANNUAL WATER SAVINGS:	75%
RECYCLED + REGIONAL MATERIALS (EACH):	25%
FOREST STEWARDSHIP COUNCIL CERTIFIED WOOD:	88%
RECYCLED CONSTRUCTION WASTE:	80%
OCCUPANTS WITH QUALITY VIEWS TO THE EXTERIOR:	90%

Figure 9: LEED CERTIFICATE

Source: (Achievements, 2017)

B. 'HYPERIONS' – An Eco-friendly Vertical Village in Delhi:

Figure 10: HYPERIONS By Vincent Callebaut Architects

Source: (HYPERIONS, 2017)

LOCATION: Jaypee Greens Sports City in New Delhi, India

ARCHITECT: Vincent Callebaut Architecture, Paris

The idea of **urban farming utopia** was introduced by Callebaut Architecture, Paris in collaboration with Indian agro ecologist with self sustaining features that not only grows organic food, but also produces **more energy than it consumes**.

DESIGN CONCEPT:

The fusion **"forest + agriculture + urban fabric"** that brings together the best of both of **city** and **countryside**. The basic concept and aim behind designing is to reconcile **urban ecological restoration** and **small scale farming** with **environment protection** and **biodiversity**.

MATERIALS:

This comprises of **six - 36 storied** connected towers to be built from **cross - laminated timber**, will provide best **environmental footprint** during its **life cycle** through transportation, processing, implementation, maintenance and reuse. All the wood is to be imported from Delhi forest and will make sure to renew what they will collect for appropriate cutting cycle and regenerating capacity. "the tall building structures should be designed with wood as it reduces **carbon dioxide emissions**." (Amlankusum)

The use **steel and concrete** for the **sub - structure** for the earthquake resistant foundations, parking areas, and **super - structure** of **solid wood** columns, beams and walls reinforced with steel blades.

The **skeleton** will be made with **25% inert materials** and **75% bio sourced materials**. The mix is preferred as it is well reputed for its strong **mechanical resistance** in events such as earthquake, fire, thermal performance.

Figure 11: Use of Wood Timbers

Source: (HYPERIONS, 2017)

TECHNIQUES:

This is to be designed for hot and humid climate, architects put a natural climate control system. They are using **wind chimneys** which will stable the internal temperature of the building to **18 deg. C.** earth's thermal inertia. This will **naturally cool or heat** in contact with earth without the use of **single kW of electricity**.

One facade of the building is **solar facade** and other has **hydroponic balconies** (Figure 12) which helps in the **solar heat gain** and maintains internal **thermal comfort**.

Figure 3: Hydroponic Balconies and Solar Facade

Source: (HYPERIONS, 2017)

VI. ANALYSIS

A. ENVIRONMENTAL PRODUCTIVITY:

It can be improvised if one stop ignoring what is available and can be achieved with **maximize** use of what is available ether it's a **resource** or its **waste** for e.g. Rochester **Institute of Technology, New York**. Adoption of the new concepts such as **vertical forests** are able to provide improved **air quality**, **thermal comfort** in the **high rise structures** in the mega cities. Adopting the new concepts such as **Urban Farming Utopia** for the mega cities which is one of the fine model of **urban farming technique** which is not only sustainable but also **productive** in almost every sense.

The emergence of **productive landscape techniques (Net Productive Landscape)** is an initiative for adding to the environment for e.g. Planting the trees in a building or in surroundings which produce more oxygen than required by the occupants, trees which **absorb maximum amount of carbon emissions** produced by the building and its surroundings.

B. SOCIAL PRODUCTIVITY:

The emergence of net productive architecture is helping in **reconnecting** the **society** through its advanced techniques of improved productivity and is promoting **cultural sustainability** by enhancing **communal relations**, **promoting neighbourhood** in a new manner. The ideas like **Urban Farming Utopia** provides the new vision for better upliftment of the society as they provided the new vision for **live, work and play**.

C. ECONOMIC PRODUCTIVITY:

Producing more than required is always beneficial for e.g. The buildings which produce **more energy** than required stores that **extra energy** and can **give** it to **power grid** is one of the way to **earn** from the extra produced and **pay back** method for the **initial investment** made for set up. **Managing what is produced (even waste)** can let us earn e.g. In **Rochester Institute of Technology, New York**.

ANALYSIS:

Various projects and models have been presented for net zero energy but if the resources available are used efficiently can easily be shifted from **"net zero to net positive energy"**. This could be achieved when one will utilise the resources available to its full potential for e.g. optimum utilisation of renewable energy available on site for increase in the share of energy supply to the main supply grid, thus reducing the environmental impacts caused during energy production through non renewable resources. The surplus energy produced can be sold to the main supply grid and can earn. Then investment should be made for making such models on ground as **NPEB** are very few in number. This will help in giving back to the environment, by reducing rather than controlling the impacts caused due to building construction industry till date, promoting better social, physical, environmental, economic sustainability in positive sense. Through this **sale/purchase** model of surplus energy produced, **new building energy policies** can be made to achieve the goal of **producing more** rather than **consuming**.

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