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Analyzing the energy performance of a building and retrofit it into a net energy efficiency building in a warm humid climate

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ABSTRACT

The economic development of a country is closely linked to its energy consumption. Currently India is ranked 6th in total energy consumption it still need more energy to keep the pace in control with its future development. In present changes have made to make building more energy efficient keeping the usage of buildings energy consumption in mind. The main objective of this thesis is to obtain clear understanding of the usage of building energy consumption and To study the economic benefits and advantages of a NZE office building in hot and Humid climate and reduce the carbon footprint in future where the energy demands is increasing day by day and to achieve it in a low cost. It is done through evaluating the building performance and energy usage (EUI) by modelling and stimulation by analysing energy use index, various optimistic design solution and life cycle cost. The study also deals with finding solutions that reflect current trends achieved towards making building more intelligent, self-sustained and more sustainable.

Keywords: *building performance, sustainability, humid climate*

1. INTRODUCTION

"Energy saved is energy created".

Energy performance and energy efficiency have become the growing concern of the economic activity in today's world to achieve sustainability. Sustainability, of which energy plays a major role, encompasses all facets of economic activity such as Agriculture, Manufacturing, Services and Infrastructure including commercial buildings. Sustainability in developing nations poses specific challenges as the country has to cope up with diagonally opposite phenomena in terms of current GDP and Sustainability. Infrastructure including Commercial and IT buildings is a major stream of economic activities. Energy in these sectors is, of course, a factor to be reckoned with. This research work addresses the need of energy efficiency in commercial buildings in the developing nation's context.

2. AIM

The aim of this thesis is to identify the most adequate design solutions for improving energy efficiency of the existing office building with NZEB strategies in warm and humid climate, considering the influence of the local climate, the endogenous energy resources and the local economic conditions.

3. OBJECTIVES

To study the important criteria for achieving net zero energy building.

•Conducting a comprehensive literature review of current and past studies on the building sustainability and net energy fields.

•To study the impact of building design, components and operational parameters on the overall building energy use.

•To study how the NEEB strategies help in improving the energy efficiency of the existing building through various example.

•Perform and analysis of building simulations to evaluate the effectiveness of various designs and operation strategies for each case study building and identify the most effective ways of achieving net energy in a building.

4. LIMITATIONS

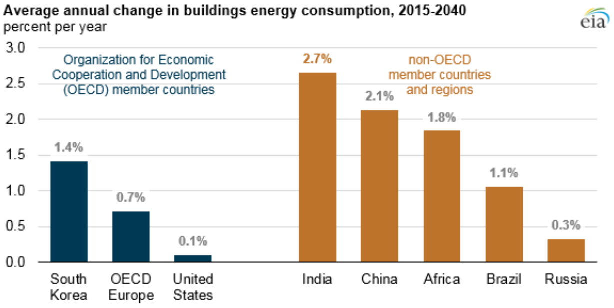
Obtaining net energy efficiency building requires a good design, construction process and operation stages, but due to time limitation only design process will be considered and the study is about to improve the energy efficiency of an existing office building by analysing requirements and application of net energy strategies

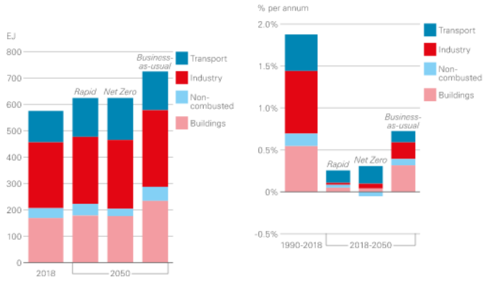
5. LITERATURE STUDY

5.1 Energy modern evolution

Driven by the extensive use of fossil energy, energy buildings are being regarded as the prime solution to zero fossil energy consumption and as a promoter of renewable energy harvesting to cut down on the green-house gas emissions

The development of modem energy buildings became possible not only through the progress made in new construction technologies and techniques, but it has also been significantly unproved by academic research on traditional and experimental buildings, which collected precise energy performance data Today's advanced computer models can show the efficacy of engineering design decisions.





Energy use can be measured in different ways (relating to cost, energy, or carbon emissions) and, irrespective of the definition used, different views are taken on the relative importance of energy harvest and energy conservation to achieve a net energy balance. Using NEEB design goals takes us out of designing low-energy buildings with a percent energy savings goal and into the realm of a sustainable energy endpoint The goals that are set and how those goals are defined are critical to the design process The definition of the goal will influence designers who strive to meet it (Deru and Tortellini 2004). Because design goals are so important to achieving high- performance buildings, the way a NEEB goal is defined is crucial to understanding the combination of applicable efficiency measures and renewable energy supply options.

5.2 Supply-side technologies on and off site

Various supply-side renewable energy technologies are available for ZEBs. Typical examples of technologies available today include PV, solar hot water, wind, hydroelectric, and bio-fuels these renewable sources are favorable over conventional energy sources such as coal and natural gas.

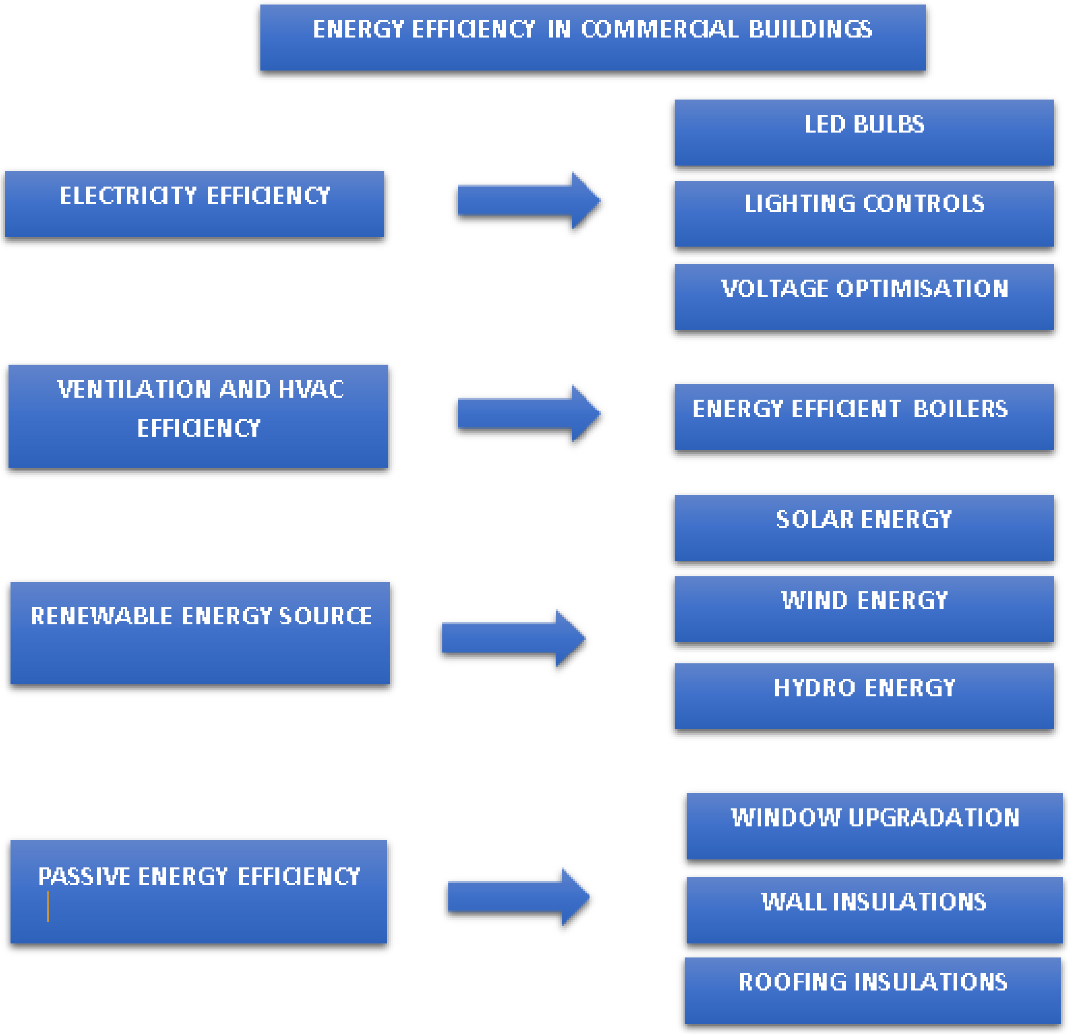
.The principles that have been applied to develop this ranking are based on technologies that:

- Minimize overall environmental impact by encouraging energy-efficient building designs and reducing transportation and conversion losses
- Will be available over the lifetime of the building

Option Number	ZEB Supply-Side Options	Examples
1.	Reduce site energy use through low-energy building technologies	Day-lighting, high-efficiency HVAC equipment , natural ventilation, evaporative cooling, etc.
On-Site Supply Options		
2.	Use renewable energy sources available within the building's footprint	PV, solar hot water, and wind located on the building.
3.	Use renewable energy sources available at the site	PV, solar hot water, low-impact hydro, and wind located on-site, but not on the building.
Off-Site Supply Options		
4.	Use renewable energy sources available off site to generate energy on site	Bio mass, wood pellets, ethanol, or bio diesel that can be imported from off site, or waste streams from on-site processes that can be used on-site to generate electricity and heat.
5.	Purchase off-site renewable energy sources	Utility-based wind, PY, emissions credits, or other "green " purchasing options. Hydroelectric is sometimes considered.

5.3 Energy efficiency in commercial buildings

It is important to note that buildings are responsible for 43% of current energy usage. The Building Energy Efficiency Survey 2016 reported that 67% of energy consumption in commercial buildings was used to provide building services including lighting, heating, ventilation, cooling, and hot water. Therefore, making these factors more energy efficient could potentially produce massive energy saving gains.



5.4 Net study comparison

No	Aspects	Alliance centre	The Byron g. Rogers federal office building, Denver, co	The Aventine
1.	Location	Denver, CO	Denver, CO	La Jolla, CA
2.	Building Type	Medium Office	. office building	large Office
3.	Owner Type	Owner Occupied Non-Profit + 50% tenants	Federal agency tenants	Private Investor Tenant Occupied
4.	Renewal Description	Historic Renovation	aggressive Renovation	Renovation
5.	Energy Star Score	100	90	85
6.	Climate zone(s)	(Warm-Marine), (3600 ≥ HDD65 °F)	(Warm-Marine), (3600 ≥ HDD65 °F)	(Mixed-Humid), (3600 < HDD65 °F1 ≤ 5400
7.	Building Envelope	1.Mylar film 2.Occupancy sensors 3.High-Efficiency glazing 4.Translucent Wall Panels 5.Increased insulation	1. Wall insulation 2. Roof insulation 3. Floor insulation 4. New window/ door	1. EPA cool roof
8.	Lighting and Electrical systems	1. T8 fixtures with dimmable ballasts 2. Super-efficient ballasts	1. Efficiency lighting/control	1. Lighting retrofit 2. Automated lighting controls 3. Daylighting: 50% daylighting views
9.	HVAC	1.Direct Digital HVAC Control system	1. New heat –cooling supplier/distribution system	1. Replaced chiller compressors 2. Automated chiller controls
10.	Renewable energy systems	1. Photocells for daylight harvesting (fifth floor only) 2. Photovoltaics 3. Un-refrigerated water	1. Solar thermal system	1. Solar thermal system

		fountains		
11	Total% energy saving after DER	45%	51%	35%
12	Total% energy savings after solar production	75%	72%	55%

6. INFERENCES

To achieve 50% heating energy savings, the majority of case studies had to carry out refurbishment of major parts of the building´s thermal envelope. DER measure bundle: To cut back heating energy up to 80 to 90%, use a holistic concept of combined building´s thermal envelope, HVAC renovation, and a change of supply solutions. Energy should also be reduced by means of demand side measures. Energy exchange between buildings with different user/load profiles offer a potential for further energy reduction.

The indoor air quality increased significantly: buildings with ventilation systems, which are still not very common in most of European cz. 4 and 5 countries, achieve a more stable humidity and a better fresh air quality with less ventilation heating losses than do buildings with window-based ventilation. The implementation of building automation systems allows indoor temperature to be controlled more accurately; this improves indoor climate and energy efficiency. Combining a DER with a major renovation allows energetic refurbishment to be combined with a new layout of the occupied space; this helps project designers to consider indoor climate, daylight usage, etc.

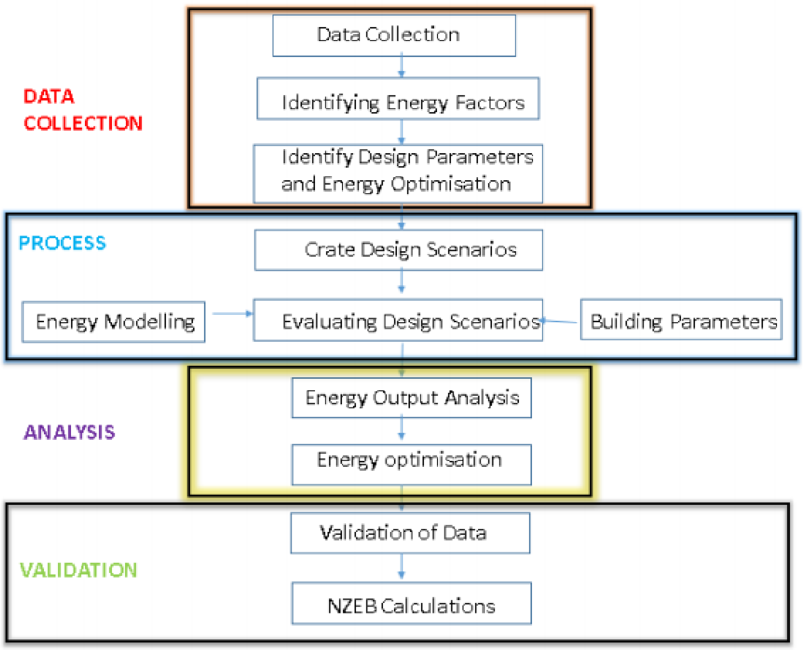
The savings resulting from selecting the bundle of energy saving technologies should be calculated in energy and financial terms. As the individual measures influence each other, a separate calculation must be performed for each individual bundle investigated.

Following points are inferred from the journal reviews. Identified few elements which can be used for final output implementation.

- While building rector field, negotiate or avoid implementing Techniques and Resources which are applicable for short term benefits. Reason is that the Benefit loss ratio can be calculated using the pay back analysis period. So it is important to avoid short term benefits.
- During Retrofitting, common points like renewable resources, electrical efficiency, and HVAC efficiency are getting considered. But, it is required to consider the passive energy efficiencies like windows upgradation, exceeded paintings, wall thickness, insulation panels, roofing panels.
- Cost benefit analysis needs to be done along with payback analysis implement stats. It helps us to evaluate the benefits of the implementation technology which we have chosen for our implementation.
- While doing retrofitting of an office building, along with design consideration, we also need to consider following things like,
    - Type of material which is getting implement
    - Improving building envelope
    - Retrofitting the lighting system
    - Minimizing occupancy loads

This helps us to get more energy efficiency at low cost.

7. METHODOLOGY

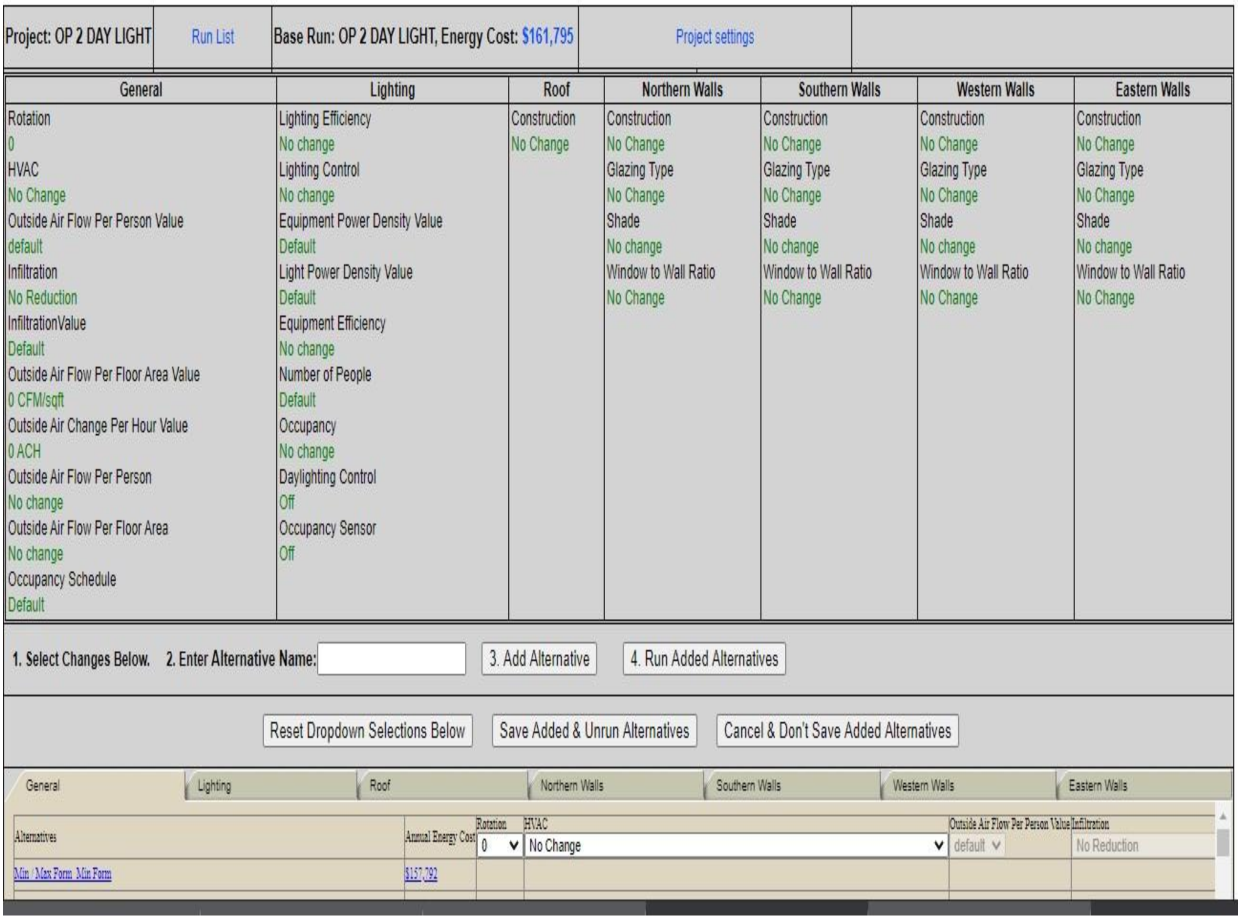


8. LIVE CASE STUDY

This building is known as Raman yam Lord's Building or Virtusa building. The function of the building is official usage. For 1000sqft 2 -Two Wheeler Parking, 1-Car Parking for 17,000 sq.ft has been allocated for Parking zone.

BUILDING NAME	RAMANIYAM LORDS
Typology	Office
Locality	Guindy
Year built	2006
Storey	6
Typical floor area	17000sq.ft
Total area	102000sq.ft
Parking ratio	1:1000

9. RESULTS OF REVIT ENERGY ANALYSIS



Selected parameters need to be simulated, those parameters were listed below.

BASECASE	SCENARIO 1	SCENARIO 2	SCENARIO 3	SCENARIO 4	SCENARIO 5
Exterior wall	250mm Cavity Brick Wall U value: 0.24	250mm Cavity Brick Wall U-value: 0.24	10mm thk. Concrete board + U-Value = 0.14	10mm thk. Concrete board + U-Value = 0.14	Steel Frame U value-0.124
Exterior wall insulation	Glass Wool stuffing 0.25 150	Expanded Polystyrene (EPS) 0.30 100	25mm XPS insulation + 460mm airgap + 4mm ACP Cladding	25mm XPS insulation + 460mm airgap + 4mm ACP Cladding	Air (Still) 0.20 30
Interior wall insulation	Rigid insulation: polystyrene boards	Rigid insulation: rafter vents	Foam insulation	Stone wool insulation	Blow-in insulation, using cellulose fibre
Roof and insulation	150mm R.C.C slab + 75mm XPS Insulation + 100mm screed + 25mm PCC Uvalue= 0.05 Btu/hr.ft2 0F	150mm R.C.C slab + 75mm XPS Insulation + 100mm screed + 25mm PCC Uvalue= 0.05 Btu/hr.ft2 0F	150mm R.C.C slab + 75mm XPS Insulation + 100mm screed + 25mm PCC Uvalue= 0.05 Btu/hr.ft2 0F	150mm R.C.C slab + 75mm XPS Insulation + 100mm screed + 25mm PCC Uvalue= 0.05 Btu/hr.ft2 0F	insulation entirely above deck U value0.063 Btu/hr.ft2 0F
Floor insulation	Insulation boards – EPS sheets 3.15 inches.	Polyurethane spray	Insulating screed	Insulation boards – EPS sheets 3.15 inches.	Polyurethane spray
Window to Wall Ratio	35%	35%	30%	30%	30%
Window and	Fiberglass	Aluminium	Combination	Composite	Fiberglass

door frame retrofit	frames With foam insulation.	frames includes thermal breaks	frames	frames	frames With foam insulation.
Glazing materials	Double Glazing U Value: 0.32	DGU U Value: 0.32 Btu/hr.ft2 0F SC : 0.62	Absorbing Glass 0.20	Double polycarbonate with air space0.32	Corrugated fibre glass0.25
Shading devices	6 Inches Recessed	6 Inches Recessed	Deep Recessed	Deep Recessed	None
Timer switches	To be provided	To be provided	To be provided	To be provided	To be provided
Lighting fixtures	Replacing inefficient lighting fixtures with energy efficient LED	Replacing inefficient lighting fixtures with energy efficient LED	Replacing inefficient lighting fixtures with energy efficient LED	Replacing inefficient lighting fixtures with energy efficient LED	Replacing inefficient lighting fixtures with energy efficient LED
Occupancy sensors	CO sensors in parking microwave sensors in offices	CO sensors in parking microwave sensors in offices	CO sensors in parking microwave sensors in offices	CO sensors in parking ultrasonic sensors in offices	None ultrasonic sensors in offices
Plant system manager on hvac plant	To be provided	To be provided	none	To be provided	none
Hvac type	Variable Air Volume	Variable Air Volume	Variable Air Volume	Variable Air Volume	Constant air volume
Fan control in a.h.u.'s	Variable speed	Variable speed	Variable speed	Variable speed	constant speed
Chillers	10X800 TR Water-cooled Chillers COP – 5.5	20X400 TR water-cooled Chillers COP – 5.5	8X900 TR Water Cooled Chillers COP - 6.1	8X1000 TR Water Cooled Chillers COP - 6.1	10X800 TR Water Cooled Chillers COP - 6.1

Result of the simulation and the comparison is listed and therefore scenario 2 is best suitable and it saves energy up to 23%

Input parameter's	**Scenario1**	**Scenario2**	**Scenario3**	**Scenario4**	**Scenario5**	**Scenario6**
Interior lights	8117	**6890**	7007	6890	7007	8117
% decrease	0	**17.11**	15.11	17.11	15.11	0
equipment	10322	**10322**	10322	10322	10322	10322
Space cooling	34467	**19569**	43245	24567	28457	27563
% decrease	-19.23	**23.67**	-47.56	8.09	0	0
Heat rejection	572	**246**	386	254	277	271
% decrease	-102.4	**9.1**	-36.54	7.8	0	0
Pumps and aux	3043	**2256**	1789	1923	2345	2471
% decrease	-23.53	**9.89**	23.55	19.67	0	0
fans	16161	**5071**	5096	4967	5096	5096
% decrease	-217.4	**0.78**	0	4.54	0	0
elevators	2650	**1500**	2650	1500	2650	2650
% decrease	0	**43.4**	0	43.4	0	0
Exterior lights	153	**153**	153	153	153	153
total	75567	**45890**	69678	49876	55678	56754
savings	-29.78	**23.43**	-22.43	10.67	3.78	2.67

For the above scenario, it is observed that the effective energy requirement for the optimized design as well as the cost of operations per unit is 23.43% lower than the ASHRAE baseline design.

This means a single campus can be optimized with higher energy efficiency compared to a multi campus. Few comparative cases were considered for captive usage wherein the optimized energy efficient design could be made up to 23% as per ASHRAE standards as one of the cases is highlighted in the literature study.

In this study, it can be seen that the design case simulation only fulfils the required criteria on LEED credit (above 10% over baseline). The energy consumption showed a 23.43% savings over the baseline figures for Scenario 2

While comparing all other scenarios the scenario number 2 provides energy savings up to 23%.

