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Design and Analysis of Energy-Efficient Residential Building by Using Passive Design Features

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Abstract:-This take a look at aimed at identifying passive design features via full-size literature observe that may be incorporated in residential buildings to lead them to strength green. The have a look at additionally aimed toward identifying changes in the design method which can have an effect on strength performance in residential buildings.It also analysed the prevailing electric strength use for cooling and lighting fixtures regular residential homes of higher centre profits families in Chennai and the possible electricity savings via adopting positive strength efficient functions inside the case have a look at buildingIt also distinguishes the different roles of developers, architects, interior designers, land owners (clients) and residents that can act as a barrier in achieving energy efficiency in residential buildings.

The findings from this study indicate that doubling the thickness of external walls on east and west, use of hollow clay tiles instead of weathering course for roofs and use of appropriate horizontal overhang ratios for all four orientations can reduce the cooling load of the case study building by 64% and hence reduce the total energy use of the building by 26%.In the end it could be concluded that the process of designing strength green residential homes isn't a 'one-man's show'. Architects, developers, interior designers and customers are the opposite actors who can bring a trade in the design exercise.

Keywords: Energy- Efficient; Passive Design Features; Residential Building; Tropical Climate.

I. INTRODUCTION

A. General

Cooling is the switch of power from a area or from the air, to a space, with the intention to reap a decrease temperature than that of the natural surroundings. In recent years, air conditioning systems are used to control the temperature, moisture content, circulation and purity of the air within a space, in order to achieve the desired effects for the occupants. The lack of traditional power sources and escalating electricity prices have brought on the re-examination of the overall layout practices and programs of air con structures and the improvement of new technologies and techniques for achieving consolation conditions in homes by way of herbal method. In recent years, the rapid economic growth in some of the thickly populated nations has stimulated the utilization of sustainable energy sources and energy conservation methodologies considering environmental protection. Globally, buildings are responsible for about forty% of the complete world's annual electricity consumption. Maximum of this energy is for the supply of lighting fixtures, heating, cooling and air-conditioning. The growing degree of damage to the environment has created extra attention on the worldwide stage, which resulted in the concept of inexperienced energy constructing in the infrastructural sector Hence, the major focus of researchers, policy makers, environmentalists and building architects has been on the conservation of energy and its utilization in buildings. It's far further hooked up that opportunity power assets, strategies and systems may be used to fulfil a major portion of the cooling wishes in homes.

This topic, natural and passive cooling, covers all herbal processes and techniques for cooling homes. It's far cooling with none form of electricity enters, aside from renewable power resources. Passive cooling strategies also are carefully connected to the thermal comfort of the occupants. It is also possible to growth the effectiveness of passive cooling with routinely assisted warmness transfer techniques, which decorate the natural cooling methods mentioned by way of [1]. Such packages are called "hybrid "cooling systems. Energy consumption is maintained at very low degrees; however the performance of the systems and their applicability is greatly progressed.

B. Passive Design

Passive layout is layout that takes advantage of the weather to maintain a cosy temperature variety inside the home. Passive layout reduces or gets rid of the want for auxiliary heating or cooling. The importance of passive design cannot be overstated. Being attentive to the ideas of high-quality passive layout appropriate on your weather efficiently 'locks in' thermal comfort, low heating and cooling bills, and reduced greenhouse gasoline emissions for the lifestyles span of your house. Passive layout uses natural resources of heating and cooling, along with the sun and cooling breezes. Its miles accomplished through accurately orientating your constructing on its site and thoroughly designing the building envelope (roof, walls, home windows and flooring of a home). Properly-designed building envelopes minimize undesirable warmness gain and loss. The maximum cost-efficient time to achieve accurate passive layout in a home is whilst initially designing and constructing it. However, tremendous renovations to an existing domestic can also offer a fee effective opportunity to improve thermal comfort even small upgrades can supply significant improvements. If you're buying a brand new home or condominium, verify its possibilities for thermal consolation and/or capacity to be cost correctly upgraded to reflect exact passive layout concepts in its weather. For high-quality outcomes, 'passive' houses want 'active' customers — people with a primary know-how of ways the home works with the each day and seasonal climate, together with while to open or near home windows, and a way to perform adjustable shading. Exact passive layout is important to attaining a life-time of thermal comfort, low power payments and coffee greenhouse fuel emissions.

C. Importance of Building Energy Efficiency

- Buildings are significant users of energy and building energy efficiency is a high priority in many countries.
- Efficient use of energy is important since global energy resources are finite and power generation using fossil fuels (such as coal and oil) has adverse environmental effects.
- The potential for energy savings in the building sector is large.

D. Climate and Site

- Climate has a major effect on building performance and energy consumption. Energy-conscious design requires an understanding of the climate.
- Buildings will respond to the natural climatic environment in two ways:
- Thermal response of the building structure (heat transfer and thermal storage).
- Response of the building systems (such as HVAC and lighting systems).
- To advantage the maximum blessings from the nearby weather, building design have to" match" its particular climate.

E. Software Used in the Project

- *Revit Software*

Autodesk table revit is constructing facts modelling software program software for architects, structural engineers, ME engineering's, designers and contractors superior via the usage of way of autodesk. It allows clients to position out a building and form and its additives in 3-D, annotate the model with 2nd drafting factors, and get proper of access to constructing information from the building version's database. Revit is 4D BIM successful with equipment to plot and tune severa degrees within the constructing's life cycle,from idea to creation and later demolition.

F. AIM

The aim of the project is to develop a energy efficient by using passive design features for residential buildings in Chennai and identify the energy efficiency by using rivet software.Also to study the climatic condition, low cost material, calculation and carbon emission.

G. Objective

- find the energy efficiency between normal building and energy building.
- To find the temperature difference between normal building and energy efficient buiulding after using the passive material in Chennai housing.
- To find the energy efficiency of low cost material with no additional capital interest.
- To determine the annual electrical cost/use and carbon emission.
- To study the climatic condition for west of Chennai

H. Need of the Project

- The constant gap between demand and supply of power in present scenario of housing sector in Chennai city.
- High population growth

II. LITERATURE REVIEW

Sunil Kumar SharmaWith some recent developments, the zero energy building and near zero energy building has gained a worldwide attention and now it is seen as the future building concept. Since such buildings are now the centre of attraction, various advancements in this area are being reported. This paper is an in depth assessment of the literature at the zero (or close to zero) power building (ZEB) envelope components. The paper offers an in depth evaluation of the zero power constructing envelope additives along the possible tendencies inside the future for the advantage of the constructing designers and constructors. It strives to offer the state of the artwork on the numerous building envelope components consisting of insulation substances, destiny insulation materials, partitions, roofs, home windows, doors and glazing from the potentialities of power efficiency. Photovoltaic integration with the building envelope is likewise discussed for on-site energy technology to meet the operational strength demand with a purpose to acquire the goal of zero electricity constructing.

L. De Boecka,b, A. Audenaertc, L. De Mesmaekerd . Selling strength efficiency enhancements of residential buildings is taken into consideration to play an critical function in achieving the Kyoto targets. This is because it allows us to lessen strength consumption without curbing social welfare. It is worth noting that there's an growing quantity of literature on this subject matter that has been published in latest years. This paper therefore gives an up to date evaluation of the literature on improving the power performance of residential homes. The set of substances acquired has been tested in keeping with the subsequent subjects: area of application and design variables, goals and overall performance measures, type of evaluation, solution methodology, software program tools, case have a look at location and type of constructing. Other than tendencies related to the exceptional topics, opportunities for future studies also are presented.

R. Diamond, M. Optiz, T. Hicks, B. Von Neida, and S. Herrera. Lawrence Berkeley National Laboratory: Berkeley, Calif. 2006.

This study by using Diamond et al. Supplied an early analysis of the actual energy overall performance of 21 LEED-certified buildings that had been certified between December 2001 and August 2005. The observe does now not indicate what certification levels had been executed by using person homes.

C. Turner and M. Frankel. New Buildings Institute, White Salmon, Wash. 2008.

R. Diamond, M. Optiz, T. Hicks, B. Von Neida, and S. Herrera. Lawrence Berkeley National Laboratory: Berkeley, Calif. 2006.

III. THEORETICAL FRAMEWORKS

A. Energy Efficient Residential Buildings

Nicely-designed electricity green homes keep the pleasant environment for human habitation while minimizing the price of power. According to the improvement and Land Use policy guide for Australia (2000), the objectives of strength green homes are to enhance the consolation ranges of the occupants and decrease energy use (energy, herbal gas, etc.) for heating, cooling and lighting fixtures. United countries (1991) define energy efficient buildings to have the minimum tiers of power inputs. Janssen (2004) claims that and development in strength efficiency is taken into consideration as any action undertaken by using a manufacturer or consumer of power products, that decreases power use in step with unit of output, without affecting the level of service supplied.

B. Basic Principles in Energy Efficient Building Design

It is evident from the above section that energy efficiency in buildings is vital for many reasons. Having justified the needs for energy efficiency it is now important to focus on the basic principles that can bring about energy efficiency in residential buildings of Chennai. An extensive literature review consisting of different journals, books, researches and related websites was undertaken to establish the basic passive principles for designing energy efficient residential buildings. Underneath is the listing of elements for energy efficient residential homes that has been arrived at from the literature evaluates and is based at the context of Chennai.

- *Making plans factors*
  - Web page evaluation
  - Building shape
  - Building orientation
  - Room orientation
- *Constructing Envelope*
  - External wall
  - Thermal insulation
  - constructing cloth
  - Roof
  - Window − length − Orientation − Shading tool − herbal ventilation − daylight

C. Planning Aspects

a) Site Analysis

Analysis of the building site should be made to determine the following:

- *Wind Breaks*

Wind breaks aren't ideal in tropical climates as they obstruct applicable breezes. As a substitute, it's miles proper to have air motion. But, dense housing trends and proliferation of constructed systems in Chennai do not depart a scope for choosing a portion of the site without windbreaks. Generally, plots are not surrounded by open spaces or green spaces in Chennai.

- *Shade from Existing Buildings and Trees*

Watson and Labs (1983) recommend placing a building in such a way that it gets shading from existing trees and land masses. The building can be sited to the east of such feature to reduce solar gain during afternoons when the sun is low. UNEP (2006) warns that improper planning of the site can result in ‘heat island effect’. Such effects according to UNEP (2006) can be alleviated by reducing the total paved area on the site and shading the paved surfaces.

As already mentioned above, surrounding buildings in Chennai are at very close proximity to plots. Hence, buildings constructed get shade from existing land masses in almost all cases. Buildings, however, do not get shade from surrounding trees due to the absence of green spaces.

The above mentioned criteria do not directly generate reductions in energy use. Instead, they provide air movement for ventilation if windbreaks are absent and help to keep buildings cool through the shade provided by surrounding buildings.

b) Building Form

Gut and Ackerknecht (1993) have suggested forms with large surfaces rather than compact buildings as large surfaces favour ventilation and heat emission at night-time. The building forms should thus be open, outward oriented and built on stilts. Givoni (1998) states that building form largely depends on whether the building is planned to be air-conditioned or if it is intended to rely on natural ventilation. He recommends a compact shape for the building dwelled by people who are determined to use air conditioners and open forms for naturally ventilated buildings. Compactness of the building minimizes the surface area of the building envelope, resulting in a reduction of the heat gain through the envelope.

It might not be possible to design open, outward buildings in constricted sites as of Chennai and where maximum utilization of land for profitability is the main objective. Most residential buildings in Chennai are compact. The compactness of residential buildings is attributed to the fact that land is exploited to its utmost capacity, without leaving any open space. Prior to the establishment of Chennai City Building Construction Act-2008, only 15% of a plot was left vacant as setback space. Now, after the new rules got underway, 32.5% of a plot (smallest size, about 135 square metres) is said to be left open for green space.

c) Building Orientation

Well oriented homes take benefit of solar radiation and winning wind. According to intestine and Ackerknecht (1993), the longer axis of the constructing must lie alongside east-west path for minimum sun warmth benefit through the building envelope. Wong and Li (2007) done area measurements and computational energy simulations to take a look at the effectiveness of passive climate control methods which include constructing orientation in residential homes of Singapore Their results state that the best orientation for a building in Singapore with its tropical climate is for the longer axis of the building to lie along east-west direction. They also conclude that the cooling load for a residential building can be reduced to 8% -11% by following this orientation.

- *Building Orientation*

1. According to gut and ackerknecht (1993), the longer axis of the building runs north-south**.**
2. Facades on the west and east are bigger than the north and south elevations as shown in below figure.
3. The best orientation of the building is the longer axis of the building is it can avoid the solar heat gain.
4. The given building is faced north to south it is the best orientation to reduce solar heat gain it is shown in given below diagram

Fig (1): Building Orientation from North to South.

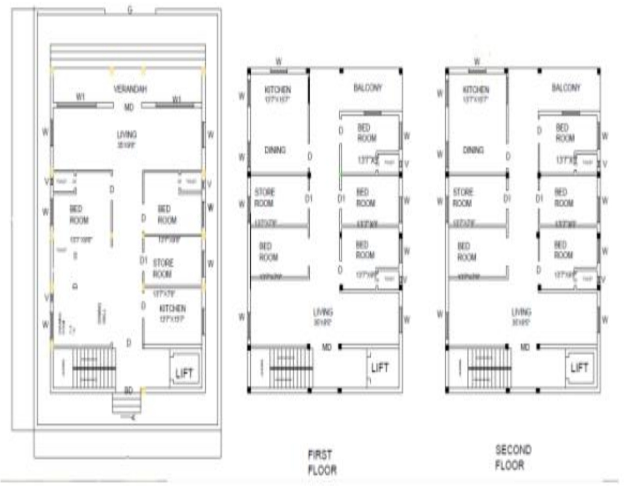

Figure (2): Line Plan of Diagram.

- *Room orientation*

1. Instead of the plan the bed rooms are located on the east side where it is coolest in the evening.
2. Kitchen and store rooms are located on the west side which is not in use for most times of the day.
3. Living room and dining rooms are located on the northern and southern side according to gut and ackerknecht(1993).
4. Instead of plan I given more ventilations and veranda so it reduces the heat.

- *Room Arrangement*

	Living	Dining	Master bedroom	Bed room	kitchen	Store room	
GF	North	Central	East	West	east	East	
	Living	dining	Master bed room	Bed room	Bed room 3	Store room	Kitchen
First floor	South	Central	East	East	East	west	West

Table: 1 Room Arrangement

d) Building Envelops

- *External Wall*

1. All external walls are of 125mm solid brick, thicker construction on east and west external walls.
2. 280mm brick walls including an air cavity of 50mm. It reduces cooling energy 7-10%.
3. Both external and internal walls have a cement plaster over the brick and white color finishes. Saving energy (12%).

D. Windows

1. The rooms on the west have big windows 2m.
2. Natural lighting and ventilation
3. Cross ventilations

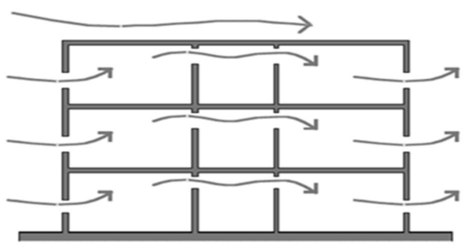

Fig. 3. Concept of Wind Driven Cross Ventilation System.

a) Shading Devices

Horizontal shading devices of lengths 0.3m and 0.9m on both east and west.

b) Glazing

Increasingly used in double and even triple the thermal properties of the glazed surfaces of a building affect the penetration of solar radiation to the interior. The influences of channel width and the dimensions of the inlet and outlet openings affect the convection process, and hence, affect the overall heating performance. Using double glazing could increase the flow rate by 11-17%. On the other hand, insulating the interior surface of the storage wall for summer cooling can avoid excessive overheating due to south facing glazing [18].

Research in the field of glazing system technology received a boost, glazing's, electro chromic, windows, thermo tropic materials, silica aero gels and transparent insulation passing from a single pane to low-remittances window systems, and again to low thermal transmittance, vacuum materials (TIM) [19-21].

Transparent selective films represent an interesting option for the control of solar heat gain, to be used to treat windows or façades, especially in existing buildings, to improve the performance of windows and transparent façades. Transparent selective coatings and films are being synthetic these days by means of all primary glass and glazing groups all around the world. They constitute pretty an advanced technology and are being.

c) Insulation

Belasco et al. [34] investigated the thermal resistance for the warmth drift via a standard wood framed pitched roofing system measured under out of doors situations for warmth waft up. But, with better thermal resistance structures containing bulk insulation inside the timber frame, the measured end result for a regular set up was as low as 50% of the thermal resistance determined thinking about two dimensional thermal bridging the usage of the parallel route method. This result was attributed to three dimensional heat flow and insulation installation defects, resulting from the design and construction method used. Translating these results to a typical house with a 200 m2 floor area, the overall thermal resistance of the roof was at least 23% lower than the overall calculated thermal resistance including two dimensional thermal bridging.

On [35] reported that the heat transmission through the roof could be reduced by providing insulation in the attic under the roof or above the ceiling. A roof sun collector should offer each air flow and cooling inside the attic. Several laboratory sized units of passive roof designs had been built and examined facet-by means of-aspect under outside conditions to reap temperature records of the roof, attic and ceiling in an effort to compare their performances.

d) Shading

Shading denotes the partial or complete obstruction of the sunbeam directed toward a surface by an intervening object or surface. The shadow varies in position and size depending upon the geometric relationship between the sun and the surface concerned.

Shading devices are essentially a second link between day lighting and the thermal performance of perimeter spaces. Thus, an integrated analysis should be carried out in order to take into account the interactions between the different parameters and to attain optimal results. However, with a few exceptions, an integrated façade analysis is not applied at the early design stage, when critical decisions with small economic impact could lead to significant energy savings during the lifetime of the building, and a simultaneous improvement in interior conditions [36]. Li et al. [37] studied the effect of day lighting and energy use in heavily obstructed residential buildings in Honk Kong. They simulated the day lighting performance of high rise buildings by varying five parameters for assessing daylight availability, and they found limits for external obstructions, in order to reach satisfactory internal levels of day lighting. Ho et al. [38] analyzed the daylight illumination of a subtropical classroom, in search of an top of the line geometry for shading gadgets; they also evaluated the lighting power required to enhance the luminance condition inside the school room.

Passive Thermal Design Features

1. Insulation
2. Thermal mass
3. Color of external walls
4. Glazing systems
5. Window size
6. Shading devices

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IV. RESULTS

A. Energy Use Intensity for Normal Building

Electricity EUI:	15 kWh / sf / yr
Fuel EUI:	2 kBtu / sf / yr
Total EUI:	53 kBtu / sf / yr
Location:	Chennai, India
Weather Station:	726145
Outdoor Temperature:	Max: 105°F/Min: 62°F
Floor Area:	5,831 sf
Exterior Wall Area:	5,813 sf
Average Lighting Power:	0.90 W / ft²
People:	22 people
Exterior Window Ratio:	0.11
Electrical Cost:	$0.08 / kWh
Fuel Cost:	$0.78 / Therm

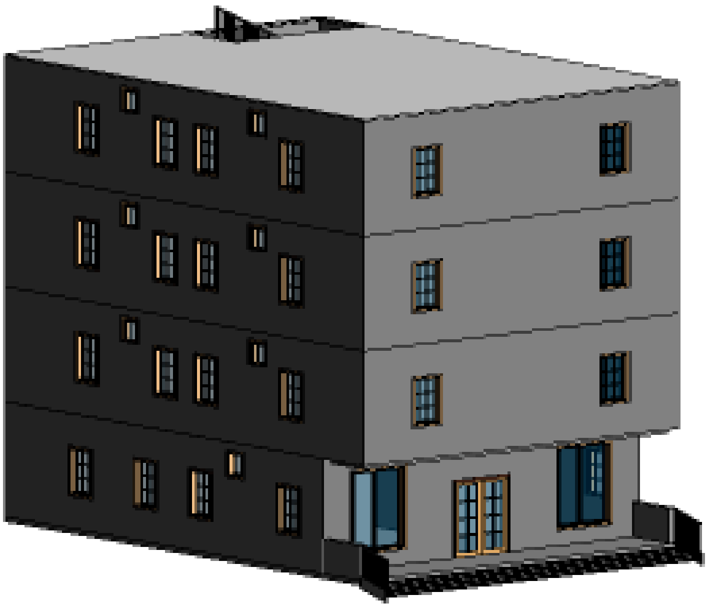

Fig (1) Figure Showing the Geographical Conditions of the Normal Building.

B. Energy Use Intensity For Energy Efficient Building

Electricity EUI:	11 kWh / sf / yr
Fuel EUI:	8 kBtu / sf / yr
Total EUI:	47 kBtu / sf / yr
Location:	Chennai, India
Weather Station:	726146
Outdoor Temperature:	Max: 105°F/Min: 61°F
Floor Area:	5,716 sf
Exterior Wall Area:	4,019 sf
Average Lighting Power:	0.60 W / ft²
People:	14 people
Exterior Window Ratio:	0.13
Electrical Cost:	$0.08 / kWh
Fuel Cost:	$0.78 / Therm

Fig. (2) Figure Showing the Geographical Condition of Energy Efficient Building.

C. Comparing Report of Annual Carbon Emissions

- Normal Building
- Annual carbon emissions

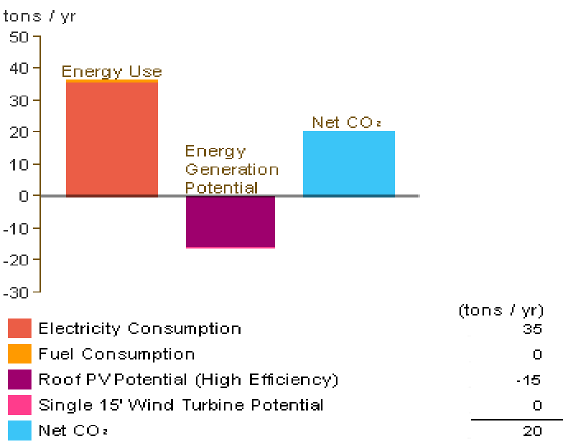

Fig (3) Figure Showing the Annual Car

D. Bon Emissions Of Normal Building

- Energy efficient building
- annual carbon emission

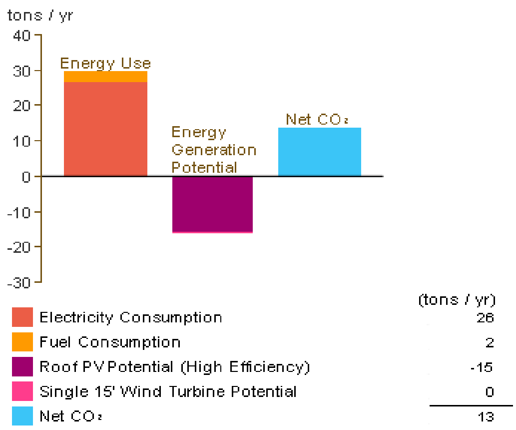

Fig (4) Figure Showing the Annual Carbon Emissions of Energy Efficient Building

E. *Energy Analysis Compare Report of fuel consumption*

- Normal Residential
- Monthly Fuel Consumption

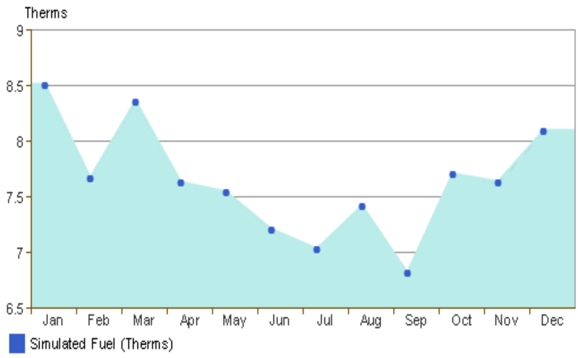

Fig. (5): Figure Showing the Monthly Fuel Consumption of Normal Building

F. *Energy Efficient Residential Building*

- Plan Analysis
- Monthly Fuel Consumption

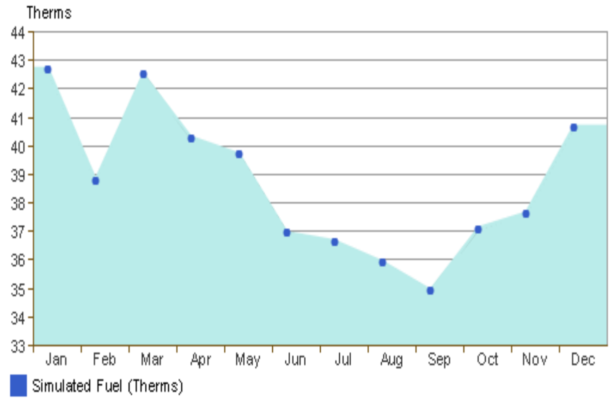

Fig (6): Figure Showing the Monthly Fuel Consumption of Energy Efficient Building

G. *Comparing Life Cycle Energy For Both Buildings*

- Normal Building
- Life Cycle Energy Use Cost

Life Cycle Electricity Use	26,16,477 kwh
Life Cycle Fuel Use	2747 thems
Life Cycle Energy Use	$96008

30 Year Life And 6.1% Discount of Cost

- Energy Efficient Building
- Life Cycle Energy Use Cost

Life Cycle Electricity Use	19,47,453 kwh
Life Cycle Fuel Use	13912 thems
Life Cycle Energy Use	$75681

30 Year Life And 6.1% Discount of Cost

V. CONCLUSION

This study has identified the following energy efficient building features for the project of the Chennai house:

- Doubling the thickness of external walls with 280 mm brick walls including an air cavity of 50 mm on east and west.
- The use of hollow clay tiles (HCT) in place of weathering course for roofs.
- Horizontal overhang ratio of 1.3 for east orientations, 1.2 for west orientations, 1 for north orientations and 1 for south orientations respectively.
- All the features that were analysed in this take a look at for adoption in the case take a look at constructing reduce the energy use for cooling. The observe indicates that it's miles feasible to lessen the cooling load of the apartments studied with the aid of sixty four% and for this reason lessen the entire strength use of the apartments surveyed by 26%. It should also be burdened that the theoretical framework has mentioned many other alternatives that lessen the cooling load and additionally enhance natural ventilation.

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