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Assessment of attributes: Overall Contribution in energy consumption of a Neighborhood

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Abstract:
The built environment counts most of the world's primary energy which states approximately 40%, energy is being used for different provisions such as for ventilation, lighting cooling and heating. Renewable energy can be a promising feature for reducing the use of primary energy at large scale with latest efficient techniques. There are various factors involved which are influencing energy consumption. Paper focuses on how to find out various attributes which contributes in overall consumption of energy at neighborhood level. This paper includes number of variables of the built environment. The significance of this investigation is identified with the reality of the energy utilization at neighborhood scale with the help of identification of various tools and GIS mapping for the neighborhoods. The result will aim the focus where policies should be framed to reduce the energy level by finding out the relationship between the variables or independent variables.
Key words: Energy consumption, Climate, Urban attributes Built and unbuilt form.

1. Introduction

The energy demand is increasing day by day as there is increase in population. Accessibility of the assets that are sustainable and non-inexhaustible bio-mass, solar energy, hydro-power, wind energy and a lot more are useful in gathering up the energy prerequisites. "It has been found that the rate of consumption of fossil fuels is higher that its rate of generation that degrades the surrounding and increases the problem related to resource scarcity" (Abdullahi, et al., 2015). Global energy consumption is the energy consumed all across the world by different individuals or organizations; globally the use of energy has risen exponentially as in [4]

2. Energy consumption

As Per BP Statistical Review of 2019 India was the third-largest energy consumer in the world after China and the United States in 2018, and its need for energy supply continues to climb as a result of the country's dynamic economic growth, population growth, and modernization over the past several years. Primary energy consumption in India has nearly tripled between 1990 and 2018, reaching an estimated 916 million tons of oil equivalent. India's coal consumption increased to an estimated 1,037 million short tons, up 3% from 2017.India's coal consumption, the second-largest in the world behind China, is driven by the power sector, which makes up about two-thirds of consumption, iron and steel industries, and cement production.

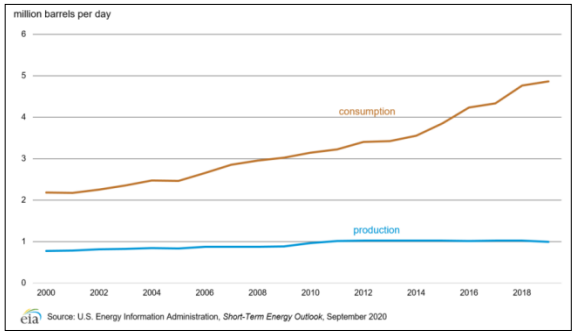

Figure 1: India's petroleum and other liquids production and consumption 2000-2019.

Greater connection to the electricity grid for the rural population, Because of insufficient fuel supply for power generation and transmission capacity.

Coal continued to supply most (45%) of India's total energy consumption in 2018, followed by petroleum and other liquids (26%), and traditional biomass and waste (20%). Other renewable fuel sources make up a small portion of primary energyconsumption, although thecapacity potential is significant for several of these resources, such as solar, wind, and hydroelectricity. India was the third-largest consumer of crude oil and petroleum products after the United States and China in 2019. The hole between India's oil interest and supply is broadening.

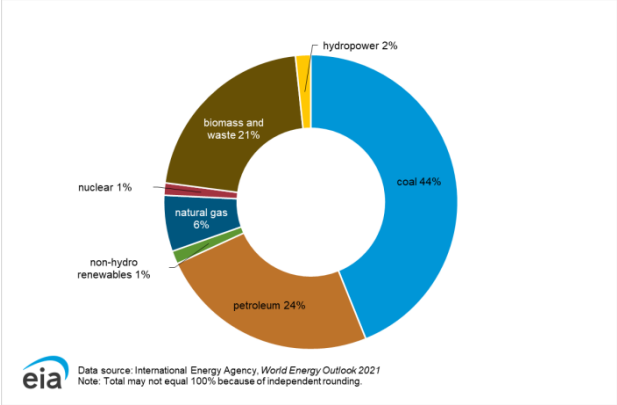

Figure 2: Total primary energy consumption in India by fuel type, 2022

Primary energy consumption in India decreased nearly 6% in 2020 but returned to average levels in 2021, growing by 10%.6 In 2020, coal continued to supply most (44%) of India's total energy consumption. Petroleum and other liquids accounted for 24% of total energy consumption, and traditional biomass and waste accounted for 21%. (Figure 2) as data source given by International energy Agency, world energy outlook 2021. India suffers from electricity shortages, although electrification rates in India vary by source, based on definitional differences of electricity access, the International Energy Agency estimates that 5% of the population lacked basic access to electricity in 2018. India produced about 1,487 terawatt hours (TWh) of net electricity in 2018, up more than 3% from 2017, Coal, which accounted for 74% of India's electric generation in 2018, is the cheapest and most abundant power source for the country. Renewable energy made up the second-largest portion (18%) of power generation and is the fastest-growing power source.

Energy Crisis-

Electricity generation India's electricity generation has increased exponentially in the last decade, with an average annual growth rate of 6%. In 2017 total generation was 1 532 TWh, an increase by 86% since 2007. Coal power has met over 80% of this growth in electricity generation. Its share of total electricity generation has increased from 65% in 2007 to 74% in 2017. In 2017 gas power represented under 5% of complete power age, down from more than 10% every decade sooner. The mechanical and administration areas are the biggest clients of power in India, representing 74% of all out definite utilization.

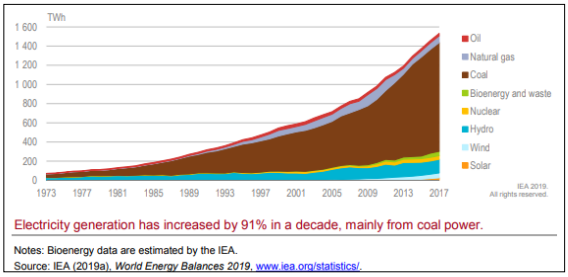

Figure 3: Electricity generation by source, 1973-2017 by IEA

The built environment represents more than 40% of the world's complete essential energy use and 24% OF ozone depleting substance emanations. The combination of making buildings (refurbishing and new developments) more energy efficient and utilizing a bigger part of renewable energy power which is a central point of contention. The Indian power area is witnessing a significant change in regard of growth of demand, energy transformations and market activities.

3. Factors influencing energy consumption:

The National Building Code of India (NBC) 2005 describes human thermal comfort, as the state of encompassing thermal comfort under which an individual can keep a body heat balance at typical internal heat level without detectable perspiring. It depends on factors like age, metabolic rate and clothing, which in turn are affected by air temperature, relative humidity, radiation from solid surroundings and rate of air movement. Thermal comfort of a person in India lies in between TSI temperature values of 25°C and 30°C. As observed by studies thermal comfort expectations are greater in buildings where building internal temperature is strictly under control, Individuals become acquainted with cooling and detest its inaccessibility. Cooling is perhaps the most energy concentrated advancements which are utilized in buildings. With expansion in the take-up of this energy guzzler, generally energy impression of Indian structure stock has gone for a throw. Therefore India is seeing critical spike in energy demand and further augmenting the demand supply gap. The construction and energy use in India is alarming. The energy consumption in new commercial Indian buildings has definitely expanded particularly for heating and cooling. The Bureau of Energy Efficiency's Energy Conservation Building Code (ECBC), which aims to regulate energy consumption of commercial buildings that are expected to have ACs, does not define temperature and humidity standards. Air-conditioned office buildings in India functions at 22.5 (± 1°C), thermal comfort standards are not however customized for Indian climatic conditions.Subsequently massive energy is used in mechanical systems to cool temperatures down from 42- 45°C to 21-22°C.Approximately 40% of the total world annual energy consumption is used in buildings. Environment friendly cooling and heating technologies are evolved as a result of awareness of environmental impact of CO2 and NO emissions and chlorofluorocarbons. CO2 and CO emission are generated mostly due to electricity generation, in year 2010 it contributed 35.5% of total CO2 emission.

Urban attributes:

Attributes which contributes in overall consumption of energy at neighborhood level are as Landform topography, slope, orientation, water bodies, Vegetation type and pattern, , street width and built spaces, , plan form, Building orientation, ground character, Fenestration pattern and orientation, roof materials, walls, internal materials. Climatic data is been used by various authors given by U.S.A Energy Department for energy analysis in various sections. Wind behavior in and around urban blocks and streets were determined by Fluid dynamics analysis. The results of wind speed around urban blocks and neighborhood streets can be appropriately used in designing optimal urban structures so that wind flow is led to correct routes. Eventually natural ventilation is allowed which results in the purification of air from roads and creating comfortable environment. Urban block heights and the width of streets have the major effect on wind pressure difference around urban blocks. Subsequently green open spaces will facilitate wind flow, in result it will create pressure difference in adjunct blocks. "The width of streets is a major effective factor in air flow. Air passage is very difficult in narrow streets and wind speed is very low"as in[5].Urban design at the neighborhood scale has profound effects on urban microclimate, urban buildings energy consumption (in particular heating, cooling and lighting) extent of applicability of passive heating/cooling strategies, indoor/outdoor thermal comfort and street vehicle emissions dispersal (air quality),as in [6]

4. Methodology:

This Paper Aims to Understand and asses the impacts of Urban attributes at neighborhood level. There are various factors involved of great contribution in energy demand which includes Urban Physical attributes, Building characteristics and socio economic characteristics. However this research focuses on Urban Physical attributes and remaining are assessed with the help of various literature studies. The conceptual Model of the study is depicted in Fig. 4), Fig 5) shows surrounding areas of selected neighborhood and Fig 6) shows neighborhood in reference to CBD area.

Figure 4: study area

Figure 5: sector study area

The study area:

Study area Lucknow, the capital of Uttar Pradesh, with population (37.65L) increase of 2.34% every year as per Statics of Lucknow with second most populated city of UP. Location has been chosen on the basis of new developments emerging in city along with urban density.Gomti Nagar is located at outer peripherals of the city having distance of 8Kms from CBD area.

Figure 6:Study area –Gomti Nagar, Lucknow

Climate Study:

Climate study of the selected neighborhood was done using software Climate consultant 6.0, hence it is found that dominant climate is summer wherein temperature ranges from 35degree c to 45degree Celsius which is evident from the data given in Fig (a), Fig (b) and Fig (c) .Temperature variation around the year is visible in the climatic data shown in Fig no (d)

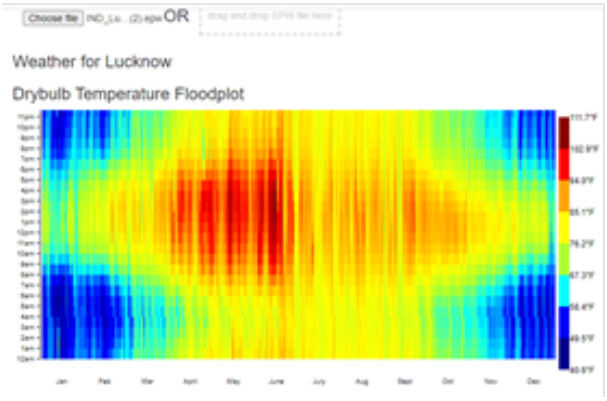

Figure (a) Temperature range

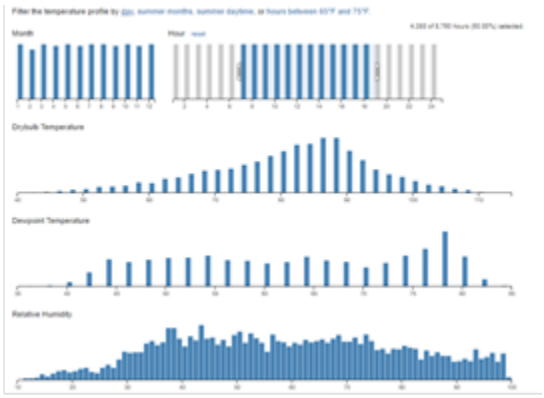

Figure (b)

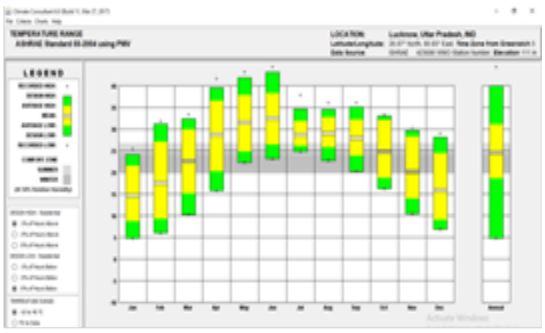

Figure (c)

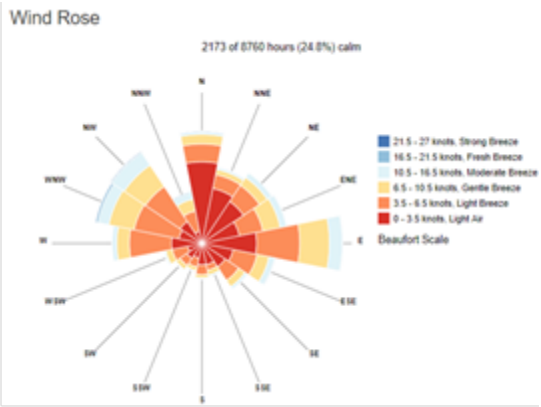

Figure (d) wind pattern

Urban data was extracted from GIS database and incorporated with GIS blender to export the data for spatial analysis. Questionnaires were done by residents of the case study to understand the behavioral pattern of energy consumption.

The spatial statistical analysis was done and GIS applied to analyze the consumption pattern of energy consumption in the study area.

Author observed that a sensitivity analysis survey was conducted in order to determine the effects of building and neighborhood characteristics and of building inhabitant behavior on calculated energy consumption. From the results it is very clear building insulation, distribution, heating and cooling system along with neighborhood site context are basically important factors for energy efficiency.

The outputs of the urban-scale energy models allow to visualize the distribution of energy consumption, identifying for example the most critical areas (high consumption), and in these urban areas, the thermal comfort conditions are scares compared to other ones. The energy consumption of buildings were mapped, at an urban scale, using a bottom-up and top-down methodology, which was based on information provided by an open-source database on geometrical, morphological, and typological characteristics (TABULA and Energy Performance Certificates data) as in [7]. Authors assessed the annual thermal consumption of buildings applying a hybrid energy model as in [7]. Hybrid Energy Model uses a statistical approach to identify urban-scale variables which are dependent on energy such as the period of construction and on the compactness of the buildings. “Various tools and models were compared in order to describe the distribution of energy consumption at urban scale taking into account the characteristics of the built-up environment” as in GIS tools can be used for mapping 3D city Model as in in [7]. The oddity of this urban energy model is that it adds a number of variables to the energy balance of the built environment.

5. Conclusions

As per intensive literature review it is been observed that Geometrical aspects have influence on energy losses, author concludes that building design affects energy consumption by 2.5 timesas in [8].Orientation has direct influence on energy consumption which affects energy between 10-13% as in [9].Dwellings types also effects the energy as in [10].Relationship between density and energy consumption, building height & energy, little consideration is given to relationship between land use planning and energy use as in [11]. Mutual shading between buildings is required in low density area and external shading from landscaping is also requiredas in [12].In compact urban planning aspect ratio (ratio of building height to street width) can be the key influence on residential energy use as in [13].

Energy consumption has direct impact on urban design at the neighborhood scale in considerations to heating, cooling, and lighting. Application of passive heating/cooling strategies will affect indoor/outdoor thermal comfort .Previous studies in UBEM models suggests that building type, density, layout/orientation and facade/fenestration treatment has direct impact on neighborhood energy. energy efficiency is a strategy that can be in a positive situation through better utilization of energy resources as suggested by Economic survey held in September 2020 .energy efficiency programs should be provided in different sectors for enhancement of the economy as well as technological solutions should be provided for utilization of the natural resource enrichments of the country .

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