

City Level Applied Research Project - A Summary

ENERGY EFFICIENCY CONSIDERATIONS IN BUILDING BYELAWS AND DEVELOPMENT CONTROL REGULATIONS OF A CITY- A STUDY OF TIRUPATI

1. Overview

The Existing Development Planning approach in India does not integrate energy efficiency in urban areas. The GIS Based AMRUT Master Planning Approach for India does not incorporate GIS Based Data set for sectoral urban energy consumption nor is there any quantification of energy consumption with respect to population, built-up density, land-use mix entropy index and other relevant factors. In the multiple layers of data which are used in existing GIS-based master planning approach, urban energy consumption is not included. There is need to include Urban energy consumption as an important component for guiding future urban development in a more energy efficient way to ensure a sustainable urban future, in the midst of ever-increasing urbanization and carbon footprints. The global annual energy consumption is estimated to rise by 77% in between 2000 to 2040, to approximately 13,860 Mega Tons of Oil Equivalent (MTOE). 83 % of the global energy used comes from fossil fuels. (Energy Institutes Statistical Review of World Energy, 2023). As per International Energy Agency (2021) India's share of global energy consumption was 6.1 % in 2021. It is expected to increase to 9.8% by 2050. Cities are the largest consumers of supplied electricity. In India, urban population consumes more than 70-75% of national electricity. (Ministry of Power, Gol,) In India, Sector wise energy consumption is the highest in the Industrial Sector, followed by Transportation sector and Construction Sector. (Source: India Energy Outlook 2021) Globally, Development Planning approach has integrated energy efficiency in various ways like Integrating Energy Issues into Policy Documents (Amsterdam), preparing Energy Atlas, (Berlin), Energy Zoning Concept (Vienna), etc. India also needs to seriously think on similar lines, as in the prevailing scenario of climate change, increasing heat stress, depleting fossil fuel-based energy resources intensifying urbanization, it is essential to conserve energy at building level, neighbourhood level and at urban scale. At present, Development Control Regulations in India do not consider Energy-Efficiency related aspects. Even though Energy Conservation Building Code (2018) and Eco-Niwas Samhita (2018) for Commercial/Institutional Buildings and Residential Buildings respectively, touch upon some aspects of the above, the provisions mentioned there are not been implemented in a

vast majority of cases. In view of the above, it is imperative to assimilate energy-efficiency considerations into the existing building bye-laws and Development Control Regulations of the city, and ensure adherence to the same in select pockets of the city where energy-consumption is higher. The same can be done by a holistic study and analysis of how existing Development Control Regulations (DCR) impact urban energy consumption in Residential and Commercial buildings as well as assessing vulnerable parts impacted by Urban Heat Island phenomenon in the city and assessing the role of DCR modification and land use control for the same. The above is the genesis of this project and the justification of the need for this project.

2. Project Major Milestones (Timeline: December 2024 to September 2024)

- **Project Initiation, Base Map Preparation & Secondary Data Collection**

Initiation & Secondary data collection: Quantification of energy consumption pattern in selected pockets through secondary data collection reg. Population, built-up density, electricity bill, energy consumption, land use mix entropy index, assess vis-a-vis existing master plan provisions, LULC, URDPFI guidelines, other related guidelines, leading to Inception Report.)

- **Visit To Study Area: Tirupati (For Data Collection) & Stakeholder Workshops**

Required primary data collection for neighbourhood and building level:

Neighbourhood level data: land use & building use verification, building footprint assessment in pockets, capturing albedo properties, vegetation, building height to street width (street canyon configuration) and other relevant factors.

Building level Data: Building height, Aspect Ratio, window wall ratio, transmittance & heat capacitance for envelope, electricity bills. (Instruments like loggers and surface temperature guns, etc to be used and, assessment of impact of UHI on urban micro-climate and energy consumption pattern to be done)

- Interpretation of primary and secondary survey data, analysis
- Report compilation and submission

3. Methodology

The project study area is the Tirupati Municipal Corporation. The project would be approached from bottom up and top-down approach simultaneously. It begins at building level assessment with regards to energy consumption w.r.t development control regulations and their impact on building design vis-à-vis study of building level factors like Building height, Aspect Ratio, Window Wall Ratio, Building envelope transmittance and heat capacitance values for, Energy Consumption Indicators (Like electricity consumption records), moving onto neighbourhood level assessment for selected neighbourhoods wherein land use & building use verification, building footprint assessment in pockets, capturing albedo properties, vegetation, building height to street width (street canyon configuration) are assessed along with other relevant factors. Simultaneously, assessment of impact of UHI on urban micro-climate and energy consumption pattern in selected neighbourhoods would be done.

For selecting the neighbourhoods to be assessed for analysis, non-Probability cluster sampling is used. Non-probability sampling is also known as deliberate sampling, purposive sampling, and judgement sampling. The samples are purposively selected on personal observation and judgement of the researcher after conducting pilot visual study for determining a more appropriate and efficient stratification plan. In this case, sample pockets are neighbourhoods in Tirupati having mixed used development, wherein both residential as well as commercial land use is prevalent, in four different parts of Tirupati Municipal Corporation limits is selected. The samples have been selected based upon the judgement of the researchers primarily on the following parameters: Energy Consumption Patterns, Socio-Economic Data available for the pockets, Use, Typology & Density of Built Form, Macro and Meso UHI patterns, etc.

4. Tools & Techniques

Software and Statistical Tools and Techniques to be used include, (but not limited to) are as follows:

- ARC GIS Pro for Spatial Mapping and Spatial Correlation between energy & urban form.
- ENVI MET for urban micro climate simulation. As well as to evaluate thermal environments of identified pockets.
- SPSS and R Statistical Software for statistical analysis of primary and secondary data collected.
- Primary and Secondary Data-Collection & Surveys
- Field Measurements
- Time series statistical tool. (For Sectoral energy consumption pattern analysis)
- Instruments like loggers and Surface temperature guns to be used and, assessment of impact of UHI on urban micro-climate & energy consumption pattern is to be carried out.

5. Analysis

Analysis of energy consumption in buildings in selected pockets would be done vis-a-vis existing development control regulations (DCRS). (Building energy consumption analysis would be considering building envelope materials and construction technologies used)

Analysis of identified vulnerable UHI pockets in the context of prevailing DCRs would be done and assessment as to whether increased UHI in a neighbourhood is linked to increased energy consumption as well would be carried out. Statistical and Scientific assessment of above using tools and techniques as mentioned above.

Finally, Identification of projects which can be taken up by Municipal Corporation, as well as, Report Compilation and Submission would be done. (Project Closure Report, Dissemination Workshop)

6. Deliverables and Outcomes:

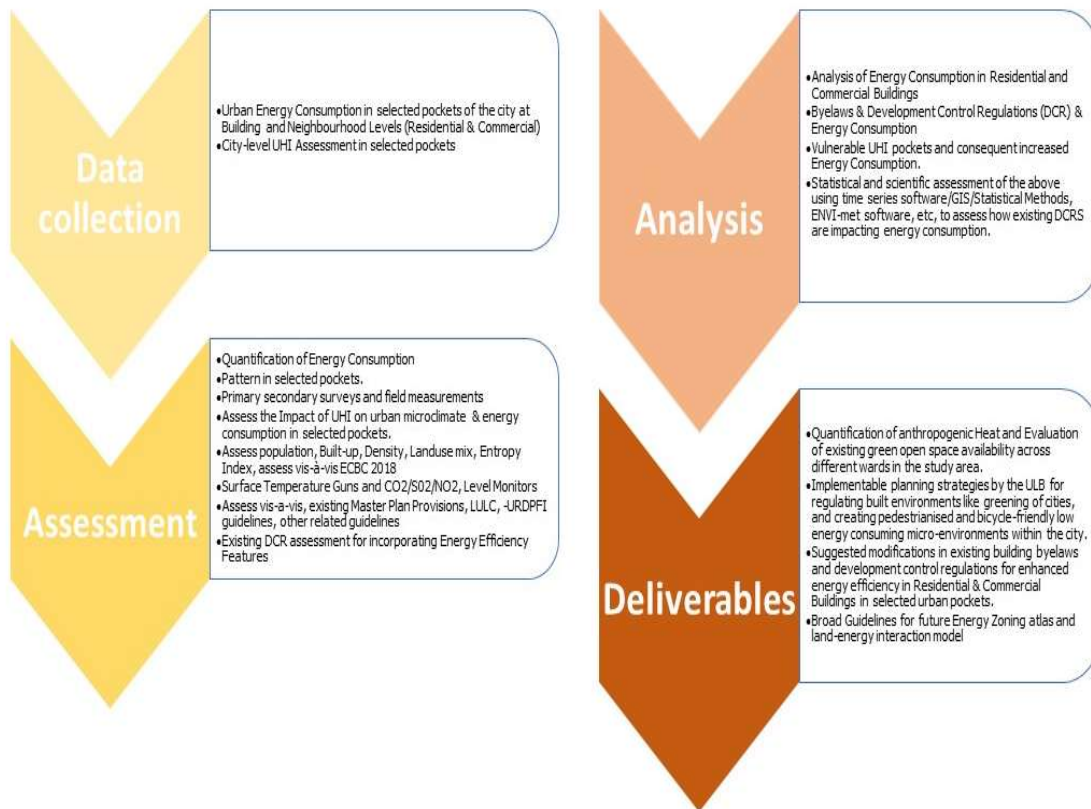
- Quantification of anthropogenic heat and evaluation of existing green open space availability across different wards in study area.
- Implementable planning strategies by the ULB for regulating built environment like greening of cities, creating Pedestrianised and bicycle friendly low energy consuming micro-environments within the city.

- Suggested modifications in existing development control regulations for enhanced energy efficiency in residential, mixed-use and commercial buildings, as well as for minimising UHI, in selected urban pockets.
- Broad guidelines for future energy zoning atlas and land use-energy interaction model.
- Identification of projects which can be taken up by Municipal Corporation for future implementation for city level energy conservation.

7. Relevance of this project to Tirupati Urban Local Body:

As is the case with many Indian cities, some areas of the city are too densely developed and consume excessive energy whereas there could be more equitable urban development. Through this research, where urban energy consumption quantity and patterns in selected pockets within municipal corporation limits would be assessed and quantification of energy consumption with respect to population, built-up density, land-use mix entropy index will be done, in context to existing DCRs followed, it would enable the Municipal Corporation to regulate urban development patterns in certain areas, simultaneously promoting development in areas which have lower urban energy consumption but otherwise have potential for further urban development. This would be primarily done through appropriate revisions in existing bye-laws and Development Control Regulations to be applied to future constructions in order to reduce energy consumption in select pockets of the city where per capita energy consumption is on higher side. This would also guide future land use. ULB can regulate energy-consumption based land use zoning more effectively using the land use-energy interaction model. This study would also carry out City level UHI assessment in selected pockets and assess impact of UHI on urban microclimate and energy consumption in selected key pockets of the city. This would enable the Municipal Corporation to evaluate existing green open space availability in context to increasing UHI and energy consumption across different wards, ultimately leading to planning strategies by the ULB for regulating built environment and optimising sustainable urban planning practices, like greening of cities, creating pedestrianised and bicycle friendly low energy consuming micro-environments within the city and regulating land use. Further, revenue can be generated based on energy consumption, by levying charges on excess energy consumption over and above a certain threshold and giving incentives for low energy consuming zones of the city. These steps will help decongest certain cores of the city helping guide future development of the city in a regulated and sustainable manner.

8. At a Glance: The Project Methodology Flowchart



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