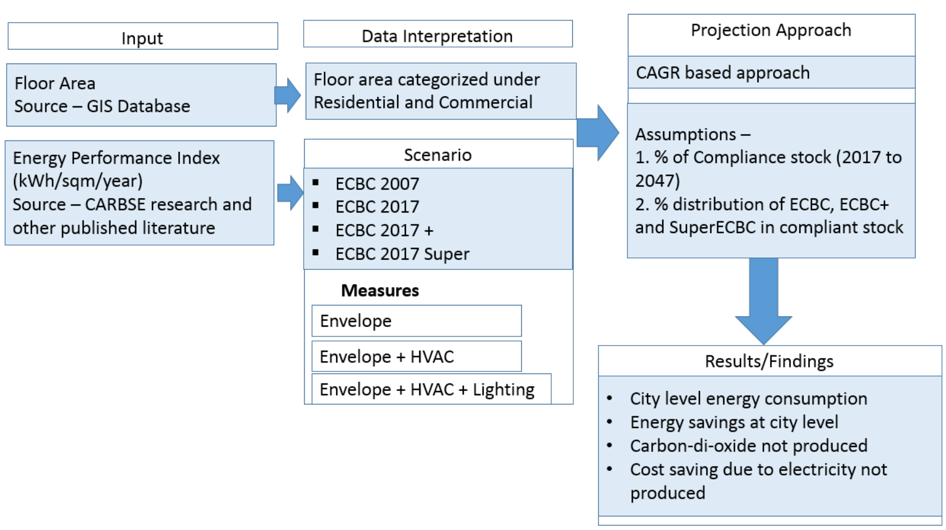
# Geographical Mapping Approach for Energy Savings Projections at City Level

Case Study of Ahmedabad

**Background**

The growing population and rapid urbanization is constantly increasing the demand for the energy. With the adverse effects of this increasing demand being visible upon the climatic and ecological conditions, it becomes very important to shift towards the sustainable approaches for managing these urban energy demands. Energy Conservation Building Code (ECBC) is one such major step taken by the Ministry of Power, Government of India in 2007 towards promoting the energy efficiency at the building levels. The implementation of ECBC has been at very lower extent, as there has been lack of acts and rules mandating the implementation of the same at the stale levels and at the Urban Local Bodies (ULB) levels. The current work focuses on quantifying the impact of the ECBC at the state/city levels. The work demonstrates the usage of the spatial distribution based on GIS applications, building energy simulations and literature resources in determining and estimating the energy consumption of the building. Further, the energy consumption at the building level is derived and based on this, the energy performance at the city levels are projected and identified.

**Methodology**




Existing building stock and land use data for Ahmedabad was represented in the form of spatial data using ARC GIS software, using following steps:

Step 1: Spatial data was acquired from AUDA and Geomatics lab of CEPT University and mosaicked along with error rectification. Figure 1**Error! Reference source not found.** shows a map of plot boundary along with ward boundary of Ahmedabad city.

Step 2: Spatial data for plot-wise land use was updated based on Google Map Imagery and secondary sources as shown in Figure 2.

Step 3: The transportation network of the city (railways, roads, BRTS & MRTS) was assigned to spatial data. Transit zone was identified to find FSI (Floor Space Index) and building height for the surrounding plots as shown in Figure 3.

Step 4: Road side margins were measured based on GDCR (General Development Control Regulation) to deduct from plot boundaries to find the buildable area, as shown in Built up area map in Figure 4.

Step 5: Floor space index map was developed as shown in **Error! Reference source not found.** showing zone wise maximum permissible FSI (Base + Chargeable) assigned based on land use data, road width and transit zone data.

Step 6:  Figure 6 shows the height of the building calculated based on Floor Space Index (FSI), road width and buildable area.

Step 7: Floor area (Plot area * FSI) was converted to spatial data as shown in Figure 7.

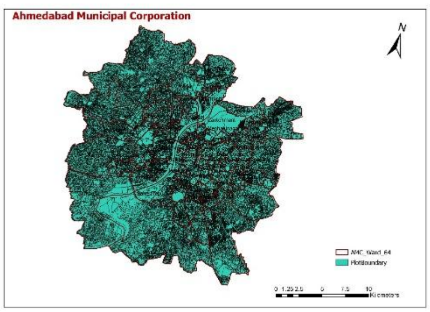



*Figure 1 Plot and ward boundary map*

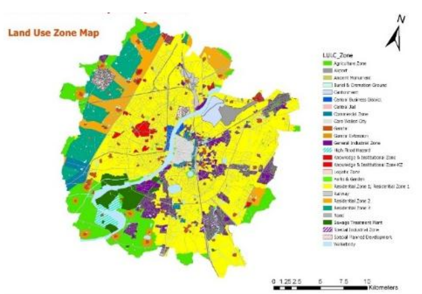



*Figure 2 Plot-wise land use map*

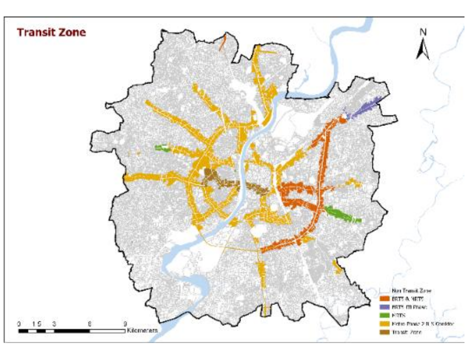


*Figure 3 Transit zone map*

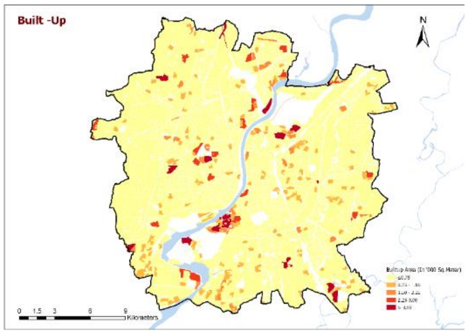



*Figure 4 Built up area map*

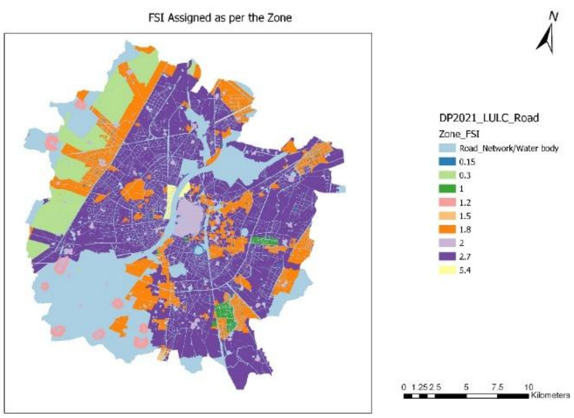



*Figure 5 Zone wise FSI assigned map*

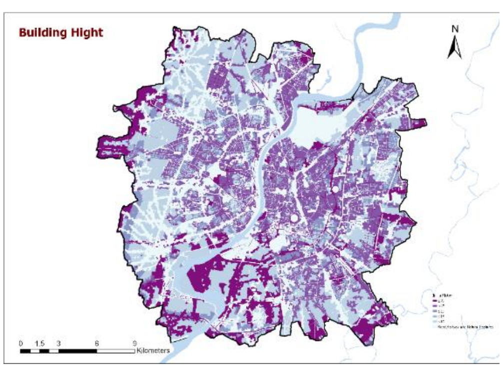



*Figure 6 Building height map*

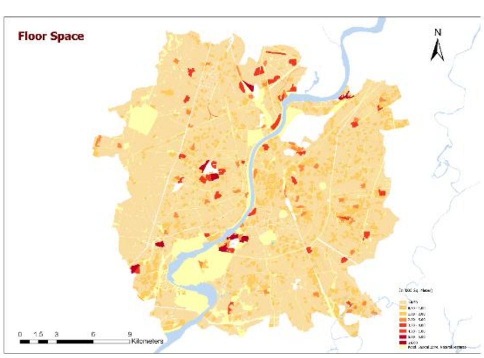


*Figure 7 Floor space map*

**Energy performance at the building level**

A comparison in energy savings for all 12 scenarios of 16 building typologies (refer Figure 10) among Energy Conservation Building Code (ECBC) 2007, ECBC 2017, ECBC 2017+, ECBC 2017 Super and baseline model was simulated for the envelope, HVAC and lighting ECMs (Energy Conservation Measures).

Energy models were prepared as per the description provided for the baseline models (for ECBC 2017) to obtain the Energy Performance Index (EPI) of the buildings considered in the study. The simulations for all the models were run in DesignBuilder v5.2 and Energy Plus v8.6. Once the baseline models were simulated, the parametric simulations for ECBC 2007 and ECBC 2017 were run as shown in Figure 8

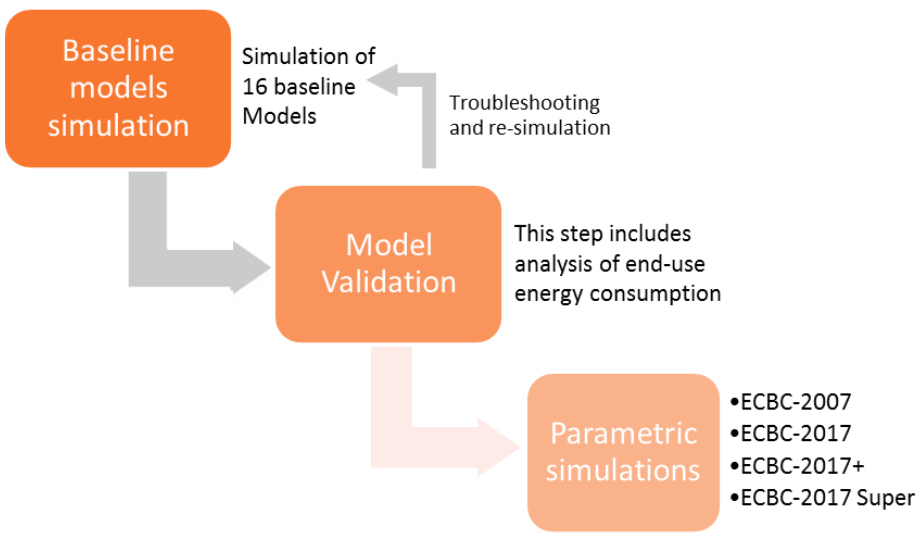



*Figure 8 Steps to find EPI at the building level*

To understand the deeper impact of ECM type on the energy performance of the building, ECMs were applied in three steps while running parametric simulations, as shown in Figure 9.

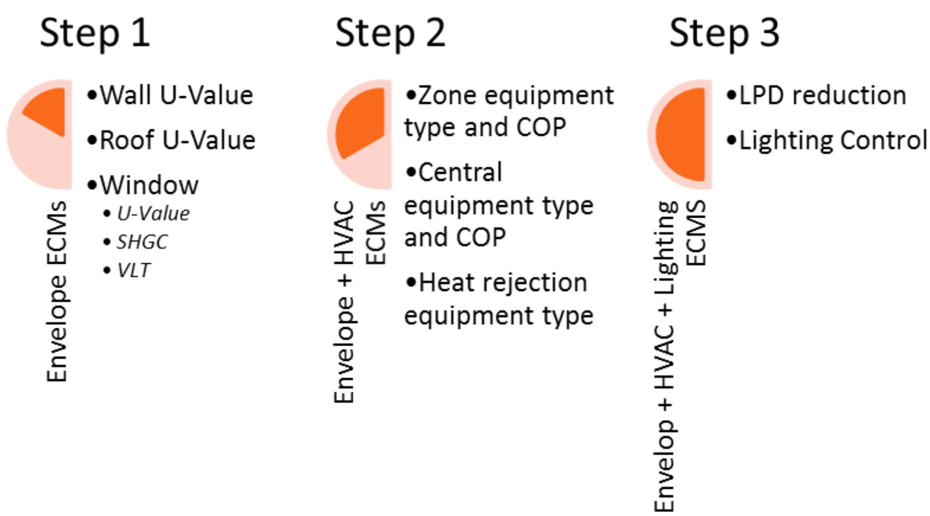



*Figure 9: Impact of ECM on EPI at the building level*

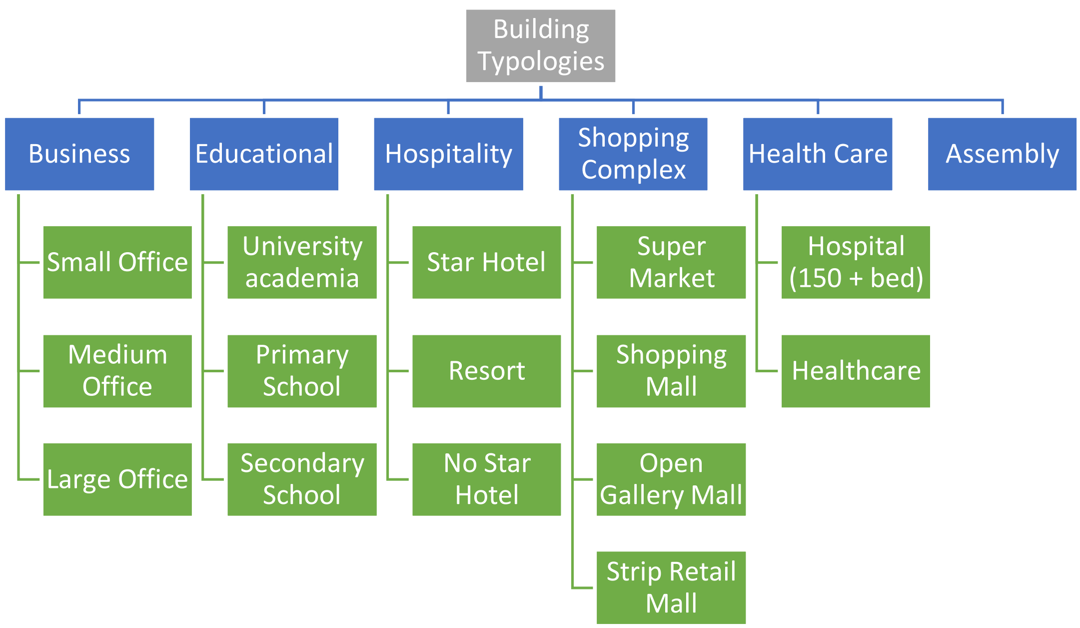



*Figure 10 Building Typologies considered*

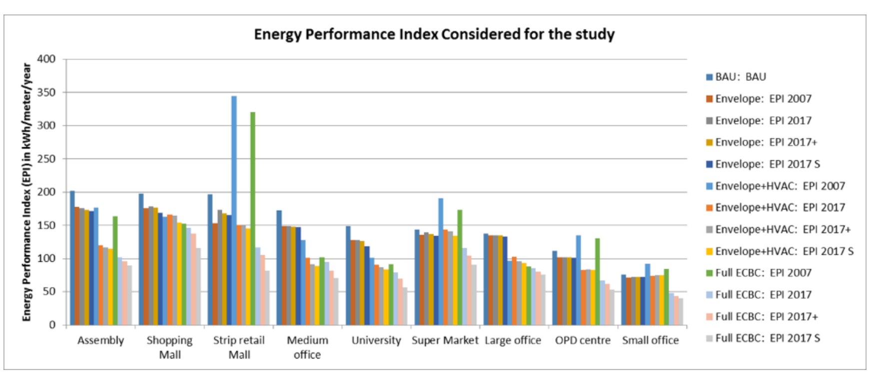


*Figure 11 Energy Performance Index of the building typologies considered for the study*

From 16 building typologies as per ECBC as shown in Figure 10, only 9 building typologies were considered for the study. Change in EPI's was calculated and reported in each end use including cooling EPI, heating EPI and lighting EPI. (Refer Figure 11)

**Energy performance for Ahmedabad (BAU and Projection)**

Interpretation of energy performance at city level was dependent on the existing building stock data of Ahmedabad, retrieved through the GIS approach and energy performance index of building typologies along with ECM measures. Commercial floor space was projected for years from 2017 to 2047, based on CAGR (Compounded Annual Growth Rate). City level total energy consumption for Ahmedabad for different scenarios was calculated and projected for building typologies, as shown in Figure 12.

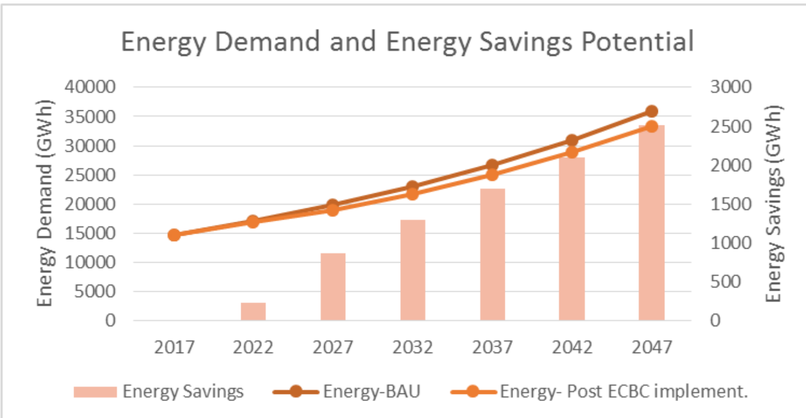



*Figure 12 Energy demand and savings potential*

Based on this data, energy demand and savings potential were analyzed along with a share of savings as per building typologies shown in Figure 13.

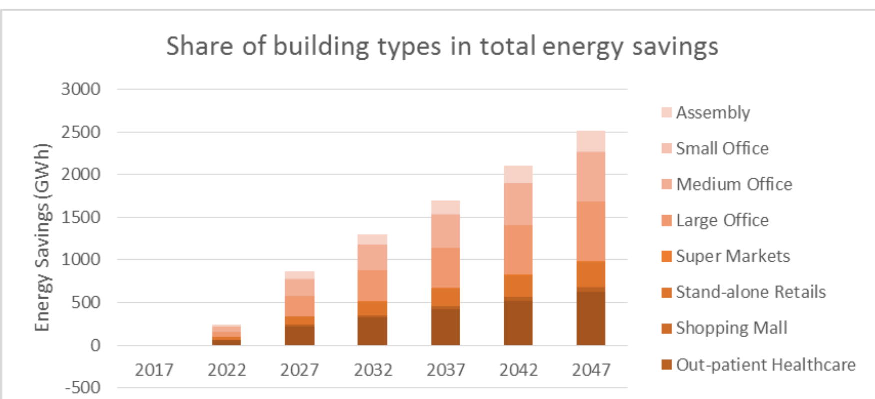



*Figure 13 Share of building types in total energy savings*

Energy savings not just save energy or cost of production but it also helps in reducing the amount of greenhouse gas production, of which carbon-di-oxide is a major component. $CO_2$ emissions were calculated based on the amount of energy savings. Western grid emission factor was considered, as provided by Central Electricity Authority of India for the emission calculations. There can be savings of 0.3 million tons of $CO_2$ savings in the year 2022, which can significantly increase to 3.5 million tons of $CO_2$ by the year 2047.

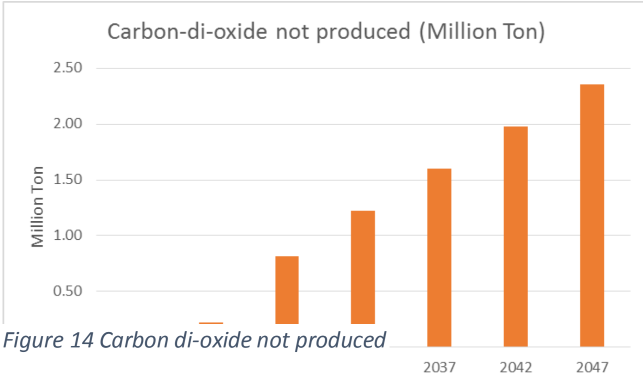


*Figure 14 Carbon di-oxide not produced*

ECBC 2017 code implementation lead to substantial cost savings by not producing electricity due to a reduction in energy demand at the city level. Ahmedabad can save approx. INR 1400 million by the year 2022, assuming energy cost at a constant price of INR 6 per unit of electricity (KWh). These savings are expected to reach approximately to 15000 million by the year 2047.

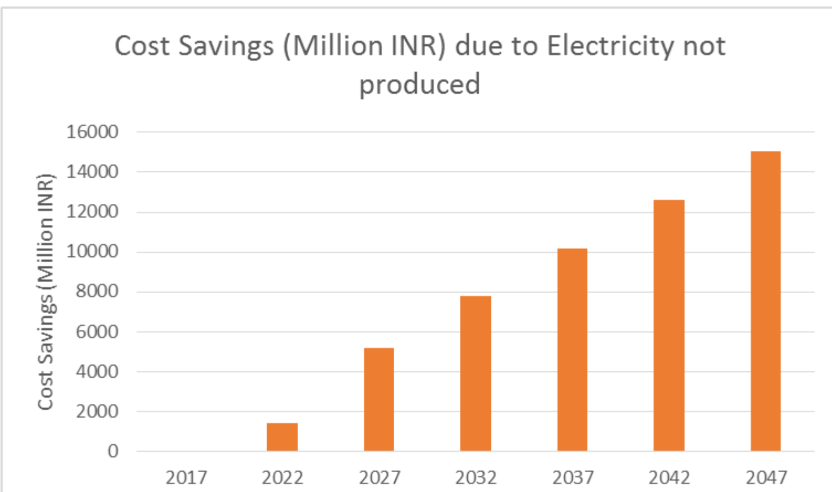


*Figure 15 Cost savings due to electricity not produced*

**Conclusion**

The study explored the geographical mapping approach using Geographical Information System (GIS) to map the plots in accordance to the town planning schemes and other details from Ahmedabad Development Plan. This distinct approach was taken to develop a better and detailed understanding of floor space and energy savings at city level. This study helps to understand that implementation of ECBC can lead to huge savings not only in terms of Energy but also as reduction in production of $CO_2$ and substantial amount of savings in terms of cost.