

# iNtelligent Urban Model for Built environment Energy Research (iNUMBER)

Sustainable urbanization requires the provision of secured energy for health & comfort. The Key to planning sustainable energy services is how energy demand changes over time, space and tools to help plan its reduction & generation. The project iNUMBER during four years (2017-2021) has worked towards:

- Developing city energy model integrating building stock & municipal-services to secure energy supply for cities to be thermally comfortable & healthy. The model estimated total & disaggregated energy demand across many spatial & stakeholder levels. With forefront model architecture, it assessed different policy intervention's impact on reducing energy demand, capacity to provide locally generated clean energy by achieving energy resilience.
- Linked latest highly-precise UAV Photogrammetry/LiDAR data-sets from current research and existing data-sets. To overcome the challenge of acquiring model input data & its validity, state-of-the-art data collection and analysis methods including 3D mesh segmentation, automated

feature extraction was developed, ranging for scenarios with varied data availability & can be utilized for many cities.

- Developed tools to support the urban energy management process. iNUMBER supported Indian municipalities and local partners develop a data-driven intelligent digital twin for built environment energy research & municipal planning, providing a framework for creating & maintaining a database. Such databases bolster urban energy use analysis, many other urban analyses & supports India's deep decarbonization pathway by mapping cities' current & future energy demand reduction opportunities. It successfully diagnosed urban energy problems, tested solutions, verified progress, & improved policy decisions utilizing state-of-the-art monitoring, data acquisition, data science & analytics. iNUMBER primarily focuses on meeting the India/UK Newton research topic 'Integration of information, communication and renewable energy technologies at building, community, and city-level interventions'.



## Benefits and Outcomes

The project has:

- Undertaken innovative urban data collection methods, UAV Imagery collection, big data analytics with the conjecture of developing technologies ranging Machine Learning, Artificial Intelligence, Deep Learning & innovative modelling.
- Provided a highly precise geometrical textured 3D city model with use-case of urban energy analysis & other applications
- Promoted economic development & welfare of developing countries by providing iNUMBER's methodology as a viable alternative, as required by Newton funding, by helping India transition to smart sustainable energy system critical to economic development.
- Engaged Urban Local Bodies (ULB), specifically Ahmedabad Municipal Corporation (AMC), energy software developers, energy meter hardware suppliers, residential construction companies, architectural firms, & user experience experts. Beyond these immediate partners, iNUMBER coordinated & collaborated with other research groups, engaged with policymakers, and benefitted the public.
- Leveraged Newton and DST funding with support from host universities & partners that provided data, test sites, equipment, and provide sector expertise.
- Demonstrated multi-tier city level dashboard; backed up by large benchmarked data sets; low-tech smarter electricity meters retrofits; reduction strategies for energy use tailored to different cities.
- Built on strength of India in IT and the strength of UK in energy epidemiology to deliver the best collaboration. During the research, the team has included leading academics from interdisciplinary fields such as engineering, spatial data science, information technology, energy analysis, architecture, building science, urban science, urban planning, energy management from leading institutions in India and UK.

It applied three intersecting levels of analysis, from large data-sets in cities & municipalities to deeper dive into domestic buildings:

1. Top-down data analytics to understand & benchmark spatial and cadastral data.
2. Middle-out learning and engagement to focus on roles of urban organisations and institutions via an intuitive visualization platform.
3. Improving data quality from the bottom-up focused energy use at the building level using both surveys and quantitative measurement with innovative ICT technologies and applications.

The project provides economic; social benefits to municipalities, urban planners, the building industry, utility companies, energy software companies, modelers, energy analysts, researchers, students, policymakers, & the public at large. The impact has been facilitated by active participation of key stakeholders in the case study of cities, high level policy meetings, workshops, CPD, iNUMBER open access tools, and the iNUMBER website (<http://www.inumber.org/>).

## R&D Partners



## Funding Agencies

