Benchmarking Energy Use for Improving Building Energy Efficiency in Nagpur - Good Practices and Lessons Learnt

CASE STUDY

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Senthil Kumar Arumugam, *ICLEI South Asia, India*

Nikhil Kolsepatil, *ICLEI South Asia, India*

Nagpur is a fast-growing city in central India and is an administrative centre and a trade hub for the region. The city, dubbed the heart of India, has an ambitious vision to transform into the most liveable, and eco-friendly city under the Smart City Mission[1] of the Indian government. Planning and infrastructure development are being undertaken in the city with the aim to build a smart and sustainable city that is inclusive for all. The city also aims to undertake social housing projects to build sustainable and cost-effective homes that enhance housing opportunities for all under the Smart City Mission. Thus, the Nagpur Municipal Corporation (NMC) and the city's Smart City agency, the Nagpur Smart and Sustainable City Development Corporation Limited (NSSCDCL) are keen to build energy efficient, comfortable and affordable homes and also to undertake energy efficiency retrofits in the existing buildings to reduce the electricity consumption and GHG emissions associated with them.

In 2018, Nagpur joined the Building Efficiency Accelerator (BEA)[2] Initiative under the Sustainable Energy for All (SE4ALL) program of the UN, and was selected as a deep-dive partner city by the Initiative for provision of deeper technical support to the city's initiatives to accelerate uptake of energy efficiency actions in its community.

This case study captures Nagpur city's efforts in understanding the energy performance and identifying the potential and opportunities for energy efficiency actions in a small portfolio of buildings in the city, supported by the BEA. In the process, an approach for benchmarking and prioritization of buildings for action was tested and established locally by the city. The city's local government agencies plan to implement larger city-wide benchmarking efforts and develop appropriate programs and policy measures aimed at improving energy efficiency of buildings across typologies.

Key Take-aways

- **Energy use benchmarking for a sizeable stock of buildings is a low-cost high impact tool** that can help cities in their decision making. The potential and opportunities identified from benchmarking efforts can help inform design of appropriate city level policy measures and programs to improve energy efficiency of buildings. Benchmarking of energy use in buildings and facilities is useful for different stakeholders such as

1. National Smart Cities Mission is an urban renewal and retrofitting program by the Government of India with the mission to develop smart cities across the country, making them citizen friendly and sustainable.
2. The BEA Initiative is a multi-sectoral collaboration that aims to enhance energy efficiency of buildings in cities across the world by accelerating local government implementation of building efficiency policies and programs through global expertise sharing and action, with the goal of doubling the rate of energy efficiency improvement in the building sector by 2030. Further information on the BEA is available at www.buildingefficiencyaccelerator.org

Promoting energy efficiency in commercial and public buildings is important to showcase to Nagpur's citizens the importance and benefits of an eco-friendly and low carbon built environment. The energy benchmarking and audit process has helped to recognize where and how we can improve energy efficiency and set the stage for us to develop policy actions to promote building energy efficiency at the city level

Mr. Mahesh Moroney, Chief Executive Officer in-charge,
Nagpur Smart & Sustainable City Development Corporation Limited (NSSCDCL)

Image 1: A Public office building benchmarked for energy performance

Image 2: Energy audit in progress and deliberation of audit findings between energy auditors and city government officials

the local government authorities, property owners, facility operators, managers, and designers as it facilitates energy accounting, comparing a building's energy consumption to similar buildings to assess opportunities for improvement, and quantifying or verifying energy savings.

- **A planned approach to energy use benchmarking of buildings** is necessary to account for the end-to-end challenges of the local context while setting the goals and scope of the benchmarking effort. Since a benchmarking process involves collection and aggregation of data from a variety of sources and a multitude of stakeholders, a **well-defined benchmarking plan** or framework is required. The plan can clearly define the scope of the benchmarking effort to help realize goals, to identify data requirements, and to engage with stakeholders who will be involved directly in the effort.

- **Cities can start benchmarking efforts on a smaller scale to test the local context and capacity. A gradual approach enables** taking necessary measures to overcome challenges and strengthen readiness based on the experiential learning, especially pertaining to stakeholder engagement and data requirements. City agencies can then gradually build-up to city-wide efforts based on a **locally tailored benchmarking plan and a strengthened data ecosystem** to ensure successful implementation and significant impacts as envisaged.

- **Securing buy-in from leadership and stakeholder engagement** are critical elements of a successful benchmarking effort, as it is important for decision-makers to communicate commitment and to ensure greater participation from all actors involved. Active stakeholder engagement and leveraging the city government's network and existing relationships ensured successful completion of the benchmarking study, facilitating stakeholder buy-in and enabling to address data collection challenges. Also, building a benchmarking team under the direct supervision of the city leadership gives benchmarking efforts the required validation and momentum.

- **Multiple sources of information should be explored for data collection to address data gaps and to validate the accuracy of data.** Energy benchmarking requires collection of information related to input metrics such as building energy consumption, floor area, along with supporting functional information on building occupancy, operating hours, and connected electrical load. Energy utilities are a central data repository for energy consumption across consumers, and can offer services to exchange data and provide historic energy consumption to track performance of buildings over time. In the case of Nagpur, apart from direct engagement with building owners and operators for data collection, working with the local electricity utility or energy service provider helped collect time-series energy consumption data for buildings, where such data was difficult to obtain or was not available readily. **Thus, targeting centralized data sources helps optimize efforts and timelines, while facilitating validation of data obtained at building level.**

- **Cities should strengthen their data ecosystem through building energy disclosure laws or through effective stakeholder engagements.** This will go a long way in ensuring data availability, their quality and transparency when planning for city-wide benchmarking efforts. In absence of local mandates with respect to data recording and sharing, the city's data ecosystem for benchmarking can be strengthened through regular and effective stakeholder engagement. This results in improved stakeholder relationships that enable cooperation for scale-up, data sharing and disclosure agreements, and implementation of energy efficiency actions based on opportunities identified during benchmarking study.

Context

Nagpur is a central Indian city, located in the state of Maharashtra, with a population of 2.4 million[3] and spans an area of 227.4 sq. km. Nagpur is an administrative and commercial centre of the Vidarbha region, with limited industrial developments within the city. Nagpur is also known as the "Orange City" throughout the country for being a major trade centre of oranges cultivated locally. The city is one of fast-growing cities in India and witnesses a horizontal urban development pattern, with a building stock comprising mainly of commercial and residential properties.

Maharashtra's performance on the state energy efficiency index in 2019 was behind several other India states. The state government is yet to locally adopt the revised Energy Conservation Building Code (ECBC), 2017 that targets energy performance improvement in commercial buildings. Maharashtra is set to roll-out uniform building rules across all buildings, all municipalities and cities (Unified Development Control Regulations). It is imperative that the state government notifies the ECBC code and subsequently rolls out this policy code to the local level through its regulatory framework and appropriate measures.

Nagpur is also a smart city, part of a select group of 100 cities in India, that have financing support under the Smart City Mission of the Government of India to implement pilot projects that can be scaled up for smart and sustainable development of the cities. For this purpose, an independent agency in the form of a Special Purpose Vehicle (SPV) that works closely with Nagpur's Municipal Corporation, the Nagpur Smart and Sustainable City Development Corporation Limited (NSSCDCL) was setup with the vision of transforming Nagpur into the most liveable, eco-friendly and educational city that electronically connects people with the government to co-create an inclusive ecosystem.

The city's governing agencies, NMC and NSSCDCL, were interested in integrating green building principles into the design of social housing buildings and in improving the energy efficiency of existing stock of commercial and institutional buildings in the city. By joining the BEA initiative in 2018 the city demonstrated its commitment to improve energy efficiency of buildings within its jurisdiction, to reduce energy costs, and to create new market opportunities and to reduce the GHG emission associated with them. Nagpur was selected by the Global BEA Partnership as a deep dive city partner for deeper engagement and technical support.

As part of its deeper engagement with Nagpur, the BEA initiative supported the city in conducting pilot level benchmarking study and energy audits to understand and identify the energy efficiency improvement opportunities in the city's buildings. Commencing in May 2019, the benchmarking study was undertaken for 10 public office buildings owned by the NMC and 10 private hotels in Nagpur city. The aim was to understand the energy use scenario and establish local energy performance benchmarks, identify opportunities (especially easily implementable measures), and prioritize existing buildings for energy audits and adoption of solutions. The benchmarking process would also help to create a project pipeline for energy efficiency investment.

A key challenge for the city's agencies in carrying out energy use benchmarking and energy audits in buildings was their lack of experience in undertaking such efforts. ICLEI South Asia, as a technical partner for the BEA Initiative in the region, supported the city in developing a benchmarking plan and executing it for a smaller sample of buildings as a pilot. The BEA initiative envisaged the pilot-scale benchmarking process and energy audits as a first step towards building the city's capacity to implement a scaled-up city-wide plan for energy management or program for energy efficiency in buildings, led by the NMC and NSSCDCL.

Energy Benchmarking of Buildings in Nagpur – Key Steps and Decisions

Figure 1 depicts the steps followed during the benchmarking process in Nagpur and a brief description of activities that were undertaken in each step. The benchmarking study spanned

3. Population based on Census of India, 2011

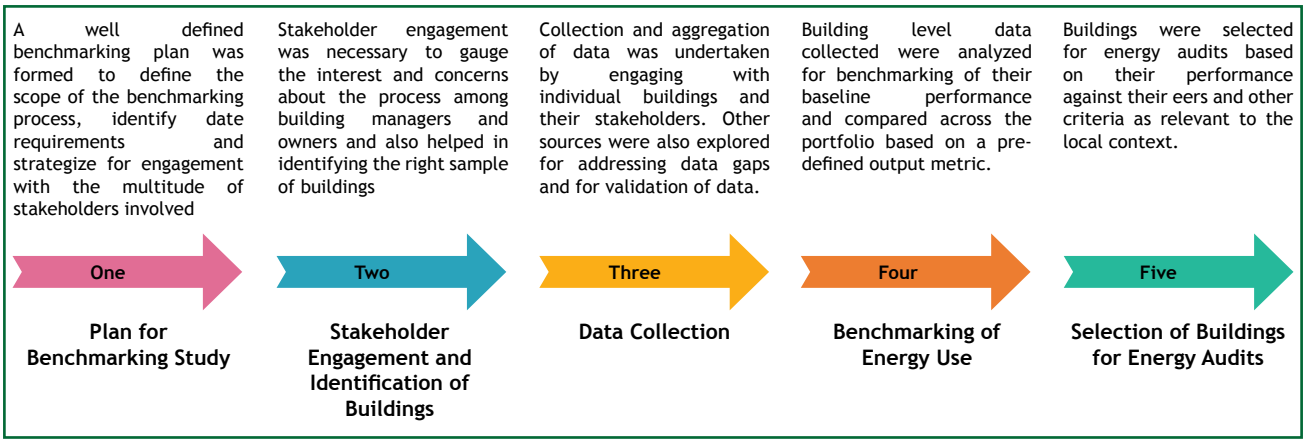

Figure 1: Benchmarking Process Adopted in Nagpur

for about 1 year, starting with a kick-off meeting with the local stakeholders in the city. This kick-off meeting was crucial in collectively understanding the needs and interests of the city and the local stakeholders and also served as a platform to initiate stakeholder engagement.

Key decisions in the process

Identification of 10 public office and 10 private hotel buildings for benchmarking: For benchmarking of office buildings, 10 publicly owned office buildings of the NMC were selected, mainly for two reasons. Targeting NMC's own office buildings demonstrated commitment from the city's leadership and enabled to optimize efforts for data collection and implementation of energy efficiency measures identified.

Also, any energy efficiency opportunities identified in the selected NMC-owned office buildings can be replicated across other public office buildings in the city, given that Nagpur is an administrative capital of the state and houses several regional and state level public buildings apart from local government buildings.

For benchmarking of private hotels, a sample of 10 hotel buildings were selected based on the size and service rating of the hotels, since Nagpur typically has economy hotels of up to 3-star service rating. The ease of engagement with the hotel owners and managers was also considered. For example, approaching the owner of a group of hotels added to the sample a set of hotels through single-point engagement, facilitating buy-in and data collection.

Table 1: Buildings identified for benchmarking

Public Offices (typically <50% air conditioned		Private Hotels (up to 3 star rated hotels)	
Distribution by Connected Load	No. of Buildings	Distribution by Connected Load	No. of Buildings
<50 kW	8	<100 kW	4
>50 to 199 kW	1	>100 to 300 kW	4
>100 kW	1	>300 kW	2

Selection of Energy Performance Index (EPI) as the Output Metric: Based on the granularity, frequency and level of data available from buildings selected for the study, **Energy Performance Index (EPI)**, an indicator often used to gauge the energy performance level of a building irrespective of their size was chosen as the benchmarking output metric. EPI is the ratio of the annual energy consumption to the floor area of a building and is denoted as **kWh/sq. m./year**. In a few buildings, where floor area was not readily available, other means such as Google Maps were used to identify this data point. For gaps in energy consumption datasets, the data available from local electricity distribution utility was useful.

Selection of 'Comparison across Portfolio' as the analysis technique: The intent of the benchmarking study in Nagpur was to understand energy performance and identify potential for improvements for a small sample portfolio of

existing commercial buildings (public offices & private hotels) in the city. Empirical benchmarks based on statistical data collected from the sample of buildings were used to establish the baseline performance of each building and were compared across the portfolio statistically, in order to identify potential for improving energy efficiency and to prioritize buildings for deeper energy audits that would demonstrate the opportunities.

Selection of buildings for energy audits: Building energy use benchmarking is the first step among several levels of analysis, with varying degree of depth that is possible pertaining to energy performance improvement in buildings. Energy audits are an advanced level of building performance assessments and can be time consuming and resource intensive. Thus, the benchmarking study helped to get an understanding of energy performance of the portfolio of buildings. Select buildings were then prioritized for energy audits based on the energy performance, their representativeness of the particular building stock at the city scale, and stakeholder interest to implement building specific energy efficiency project recommendations emerging from the energy audits. Two buildings each from the portfolio of public offices and private hotels were selected for energy audits, which were conducted with the help of external expert auditors.

Results from the Benchmarking Study and Energy Audits

Energy Performance Index (EPI), was calculated for all buildings in the respective sample of public offices and private hotels. **For comparison across portfolio, the median EPI[4] value was used** against which individual building EPIs are compared for categorizing buildings into low and better performaing categories. **The median EPI found for public office buildings was 34 kWh/ sq. m./year and for private hotels the median EPI stood at 124 kWh/sq. m./year.**

As mentioned earlier, four buildings prioritized through the benchmarking exercise were subsequently targeted for energy audits. The energy audits provided a deeper understanding of the energy performance and examined aspects of building operations and energy management that are responsible for higher energy consumption. The audits enabled to identify no-cost and low-cost retrofitting measures in public offices and hotels along with appropriate appliance and technology selection. Implementation of such energy efficiency measures for public office buildings can be funded by the NMC or NSSCDCL through their budget allocation, while the city agencies can design and roll-out larger programs for enhancing energy efficiency in private hotels.

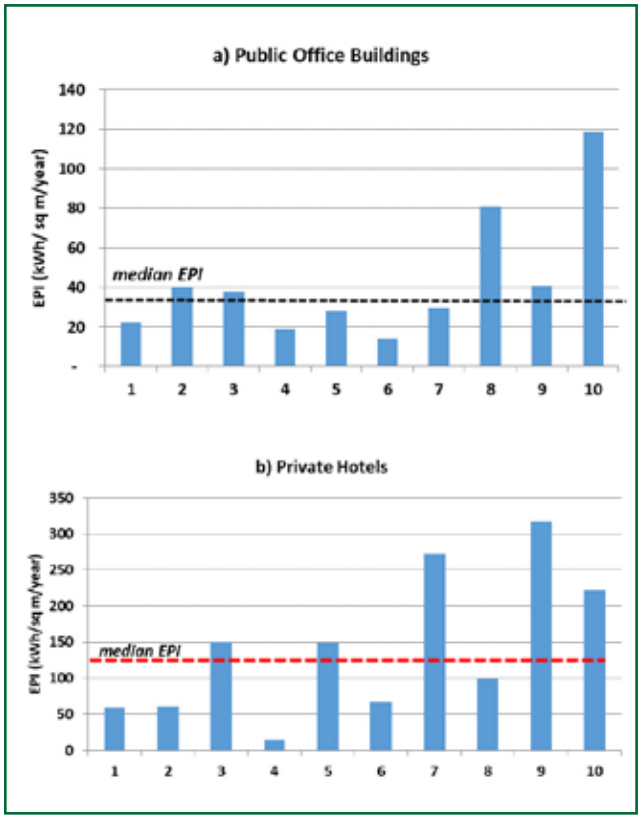

Figure 2: Energy Performance Index of the sample of a) Public Office buildings and b) Private Hotels

Key findings from the benchmarking study

From the study it was observed that for public offices, EPI increases with connected load since energy consumption at public offices of similar size were significantly different. This can be directly attributed to factors such as the occupancy pattern and density, and the footfall of citizens visiting these public offices. Also, for offices with floor size between 500 to 1600 sq.

4. Using average values in such a small sample would artificially inflate or deflate the performance of the buildings. Though median EPI will also have undue influence in such small samples, they are better for identifying outliers and categorization of buildings

m, EPI values are seen to decrease as expected from buildings of similar typology and use, as the metric EPI is indirectly proportional to floor area.

EPI for hotels in general was observed to increase with the hotel size and with hotel service/star rating. For hotels, it is also common to benchmark energy use based on the number of occupied rooms in addition to floor area, as a hotel's occupation pattern can vary significantly over seasons. Further examination of this correlation would enable a better understanding of the drivers of high energy consumption witnessed in hotels during specific time periods.

Key findings from the energy audits in selected buildings

In public office buildings, lighting, ceiling and exhaust fans, and air coolers were the major contributors to the connected load of the buildings. Air conditioning is limited to select space within the offices and its utilization is very seasonal. **Low cost energy efficiency measures, especially focusing on lighting and ventilation, were found to have potential energy savings of about 10 to 30% with investments as low as INR 20,000 to INR 125,000 (USD 272 to USD 1,705).** An assessment of the energy bills revealed that the offices can further save energy costs by reducing their contract demand to avail lower fixed demand charges and also by using optimally designed capacitor banks to reduce their power factor surcharges.

Energy audits performed at private hotel buildings showed that the service rating of the hotels was an important factor impacting the energy savings potential through low-cost energy efficiency measures. While **unrated economy hotels can achieve up to 10% of energy savings with an investment of up to INR 100,000 (USD 1364)**, star rated hotels need higher investments to achieve significant energy savings owing to their facilities largely including air conditioning and other premium end-uses. However, it was witnessed that the energy bills could be reduced through the use of capacitor banks and lowering of contract demand, given that charges owing to power factor and contract demand were considerably high for their energy consumption trends

Stakeholder Engagement – A Key to Overcoming Challenges

Support from the city leadership and continuous stakeholder engagement played a crucial role in successfully completing the benchmarking study in Nagpur. The NMC and NSSCDCL were keen to implement measures to improve building energy efficiency in the city, and after joining the BEA initiative, provided continuous support to the activities implemented with technical support from the initiative. This buy-in from the city leadership was crucial in the engagements with stakeholders such as the Maharashtra State Electricity Distribution Company Limited, Town Planning & Lighting Department of Nagpur Municipal Corporation, and the Nagpur Residential Hotels Association (NRHA) who were involved in the benchmarking process.

In Nagpur, the presence of the Smart city SPV, NSSCDCL, and an Environment Division team therein with requisite manpower and capacity was useful in coordinating the activities of the benchmarking process and energy audit. This dedicated in-house capacity which is enhanced through the pilot activities supported by the BEA initiative, will help the city when replicating and scaling up such initiatives going forward.

Data collection is an important component in a benchmarking study but can also be very challenging. In Nagpur, several data gaps had to be addressed and validation of data was required due to inadequate data management practices, both in public offices and private hotels. During the data collection, in addition to the inputs required for calculation of EPI, other building related information such as connected load, service-rating and number of rooms/ floors in hotels was also sought. Such additional information helps to better understand the performance trend of the buildings and also in categorizing buildings, if required; for singling out outliers and anomalies; and also, in larger samples for better understanding of the data.

Data collection for the public office buildings was challenging since some of the buildings were very old and lacked information on building specifications. The records maintained by the offices on energy consumption were irregular and

not in standard formats, highlighting the scope for improvement in data management practices. This necessitated on ground engagement and face-to-face dialogues with concerned departments, heads of the NMC zonal offices, and other stakeholders such as local architects for the collection of physical energy bills, building layouts and architectural drawings. Data obtained from direct engagement with the local electricity distribution company (DISCOM) and their online portal was useful in validating some of these datasets and in addressing data gaps.

In engagements with private hotels involved in the study, the hotel owners were initially wary of sharing key operational and building related information to third parties. The data made available from the DISCOM on several hotel properties proved to be useful in addressing these challenges and in validation of data directly obtained from hotel owners. Notably, the city agencies could leverage existing relationship with the Nagpur Residential Hotels Association (NRHA) to help secure buy-in from several hotel owners, who were then actively engaged throughout the benchmarking process.

Resources and Tools

Resources and tools relevant to energy use benchmarking, available with open access:

Building Efficiency Targeting Tool for Energy Retrofits (BETTER)

Energy Star Portfolio Manager

Office of Energy Efficiency and Renewable Energy, U.S. Dept. of Energy: Framework for designing a plan for building energy use benchmarking

Lawrence Berkeley National Laboratory, 2016: Establishing a Commercial Buildings Energy Data Framework for India: A Comprehensive Look at Data Collection Approaches, Use Cases and Institutions

For more information:

Asia LEDS Partnership Secretariat
ICLEI - Local Governments for Sustainability, South Asia
C-3 Lower Ground Floor, Green Park Extension, New Delhi - 110 016, India
Tel: +91 11 4974 7200, Email: alpsecretariat@iclei.org