Title

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

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Disclaimer

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Abbreviations

BEE	Bureau of Energy Efficiency
BEMS	Building Energy Management Systems
BIS	Bureau of Indian Standards
CEA	Central Electricity Authority
CREDAI	Commercial Real Estate Developers Authority of India
CSO	Central Statistical Office
DC	Designated Consumer
DISCOM	Distribution Company
DST	Department of Science and Technology
ECBC	Energy Conservation Building Code
EE	Energy Efficiency / Energy Efficient
EESL	Energy Efficiency Services Limited
EIA	Energy Information Administration
EPI	Energy Performance Index
ESCO	Energy Service Company
GOI	Government of India
HVAC	Heating, Ventilation and Air-conditioning
IGBC	Indian Green Building Council
KPI	Key Performance Indicator
kW	Kilowatt
kWh	Kilowatt-hour
MNRE	Ministry of New and Renewable Energy
MOP	Ministry of Power
MOSPI	Ministry of Statistics and Programme Implementation
MOUD	Ministry of Urban Development
MW	Megawatt
NSSO	National Sample Survey Organisation
PAT	Perform Achieve Trade
PPD	Plug Power Density
TOE	Tons of Oil Equivalent
ULB	Urban Local Body
W	Watt

1 INTRODUCTION

Enhancing energy efficiency of the commercial building stock is an important aspect of any national energy policy. Understanding how buildings use energy is critical to formulating any new policy that may impact energy use, underscoring the importance of credible data. Data enables informed decision making and good quality data is essential for policy makers to prioritize energy saving strategies and track implementation. It can also arm consumers with a tool to compare their energy performance to their peers and allows them to differentiate their buildings in the real estate market on the basis of their energy footprint.

During 2002-12, the services sector in India registered an annual growth rate of about 10% and accounted for over 60% in gross value addition in 2012 – one of the highest rates of growth in this sector in recent times in the world (MOSPI 2015, GOI 2015).[i,ii] In view of this accelerated growth, and given that buildings account for the bulk of the electricity consumption of the sector, there is significant potential to improve the sector's energy performance through improvements in the buildings sector. The Bureau of Energy Efficiency (BEE) in India developed the Energy Conservation Building Code (ECBC) and launched the Star Labeling program for a few energy-intensive building segments as a significant first step. However, a data driven policy framework for systematically targeting energy efficiency in both new construction and existing buildings has largely been missing. There is currently no quantifiable mechanism in place to track the impact of code adoption through regular reporting or surveying of energy consumption in the commercial building stock – something that is essential for developing updates to the codes. As part of the effort to foster a more systematic approach to commercial building energy data collection and reporting, the current study aims to develop a data framework that could be applied to this sector in India.

Given the uniqueness of the buildings sector and challenges to collecting relevant energy data, this study aims to characterize various elements involved in pertinent data collection and management, with the specific focus on well-defined data requirements, appropriate methodologies and processes, feasible data collection mechanisms, and approaches to institutionalizing the collection process. This report starts with a comprehensive review of available examples of energy data collection frameworks for buildings across different countries, covered in section 2. The review covers the U.S. experience in the commercial buildings sector, the European experience in the buildings sector and other data collection initiatives in Singapore and China to capture the more systematic efforts in Asia in the commercial sector. To provide context, the review includes a summary and status of disparate efforts in India to collect and use commercial building energy data. The overall aim of this activity is to help understand the use cases that drive the granularity of data being collected and the range of methodologies adopted for the data collection effort. Using this review as a key input, the study developed a data collection framework for India with specific consideration to relevant use cases, which is discussed and elaborated in section 3. Continuing with the framework for data collection, section 4 outlines the key performance indicators applicable to the use cases and their collection feasibility, as well as immediate priorities of the participating stakeholders. The section also discusses potential considerations for data collection and the possible approaches for survey design. With the specific purpose of laying out the possible ways to structure and organize data collection institutionally, the study team collated the existing mechanisms to analyze building energy performance in India and opportunities for standardizing data collection. Section 5 of this report describes the existing capacities and resources for establishing an institutional framework for data collection, the legislations and mandates that support such activity, and identifies roles and responsibilities of the relevant ministries and organizations. The final section presents the study's conclusions and identifies two major data collection strategies within the existing legal framework.

2 REVIEW OF BUILDING DATA FRAMEWORKS ACROSS COUNTRIES

This section documents examples of existing global energy data collection frameworks for commercial buildings. Efforts were generally reviewed with specific attention to their policy objectives, function, scope, survey approach and methodology, type of data collected, derived energy efficiency indicators, data access, and strengths and weaknesses. Given the variation in the robustness of these efforts as well as accessibility of their documentation, some efforts include additional parameters and others, fewer.

The overall aim of this activity is to help understand the use cases that drive the granularity of data being collected and the range of methodologies adopted for the data collection effort. This review is a helpful reference for the development of any commercial building data framework, and also clarifies general thinking on the institutional structure that may be amenable for such data collection efforts. Potential use cases are examined in detail in section 3.

2.1 U.S. Commercial Building Energy Data Framework

2.1.1 CBECS

The Commercial Building Energy Consumption Survey (CBECS), conducted by the U.S. Energy Information Administration (EIA), was commissioned to capture commercial building sector energy consumption and expenditures.[iii] The CBECS has been conducted every four years (since 1972)- with ten surveys completed to date. The CBECS sample size has continued to grow; the 2012 survey had a sample size of 6,700 buildings, an estimated 28 percent increase from the 2003 survey.[iv]

CBECS is a mature survey with technical and statistical rigor that collects extensive data on parameters relevant to energy use in commercial buildings. CBECS presents its results in an effective, user-friendly format. Key outcomes include microdata files for custom queries, and summary tables that provide a wealth of information on building characteristics, building activities, operating schedules, energy consumption, and energy expenditures. End-use specific energy consumption and intensity estimates are also provided based on survey results paired with engineering models in recent surveys and from Facility Energy Decision System (FEDS) in the prior survey years. CBECS data is frequently used for benchmarking and rating systems (e.g. Energy Star), and energy demand forecasting, as a key input to the National Energy Monitoring System (NEMS), among other things. Due to the large number of variables captured in the CBECS survey, the table below is intended to provide a sample of the types of data available rather than an exhaustive list.

Table 2.1 CBECS Overview

Building Segment	Commercial
Policy Objective	Develop a repository of statistical information about energy consumption and expenditures in the commercial building stock, and information about energy-related building characteristics
Common/ Potential Applications	Data could be applied for benchmarking, ratings systems, energy forecasting, tracking industry progress in energy efficiency, as well as other modelling efforts and policy-making
Scope	United States (All 50 states & D.C.), data presented by U.S. census region & division. Commercial buildings greater than 1,000 square feet only
Frequency	Conducted on a quadrennial basis beginning in 1972; most recent survey is 2012
Sampling Methodology	• Multi-stage sampling approach: Buildings from the sample frame were sorted into subgroups with similar qualities, optimal sample rates for each subgroup were calculated, and the final sample of buildings was selected using a systematic PPS selection procedure • Larger buildings represented at a higher rate to capture diversity in energy consumption[v] • Sample size has grown- 2012 survey had a sample size of 6,700 buildings, an estimated 28 percent increase from the 2003 survey [vi]
Data Collection Method	• On-site surveys to collect building shell characteristics and energy usage data (consumption and costs) • Energy supplier survey to collect energy usage and expenditure data from utilities for buildings that supplied inadequate data in the on-site survey (about 50% of sample) • Engineering models for key end-uses and cross-sectional regressions for other end-uses
Data Collected	• Building Characteristics: e.g. size, age, energy source, # of establishments, wall material, renovations, equipment, end uses, heating/lighting equipment • Building Activity: e.g. principal building activity, operating hours, occupancy, employment, energy sources & end uses, heated/cooled/lit floor space, operating hours • Energy Indicators: See below
Key Energy Indicators	Measures of energy expenditures, intensity (e.g. kWh/sq. ft), and consumption by major fuel type, end use, building floor space, principal building activity, year constructed, census region/division, climate zone, number of establishments, occupancy, and more
Data Availability-	• Microdata: The 2012 CBECS microdata file contains 6,720 records. Each record corresponds to a single responding, in-scope sampled building. All variables available in the microdata can be found in the variable and response codebook. Microdata enables custom queries • End-Use Data: End-Use specific energy consumption and intensity estimates are also provided based on survey results paired with engineering models in recent surveys and from Facility Energy Decision System (FEDS) in the prior survey years • Summary tables also available
Data Modelling	Engineering models and cross-sectional regressions for key end-uses including space/water heating, space cooling, ventilation, lighting, office equipment, cooking, and refrigeration
Data Access	Results publicly available on the EIA's website. Data provided in PDF, SAS & CSV format
Recommendations from Users	• Increase frequency of data releases via a rotating sample design, revised editing procedures • Improve data collection efficiencies by conducting part of the survey online, partnering with suppliers to collect data from centralized sources, or partnering with energy auditors. • Increase sample size for more robust customized analyses • Increase geographic granularity and provide more precise building location information • Explore opportunities to partner with other government statistical agencies, organizations, or energy suppliers to collect data on specialized topics • Periodically review questionnaire content/wording, specifically new energy end uses

2.1.2 CEUS

The Commercial End Use Survey (CEUS) is a comprehensive study of commercial sector energy use in California. While designed primarily to support California's energy demand forecasting activities, CEUS has several additional objectives (see Table 2.2). CEUS is conducted under the aegis of the California Energy Commission (CEC) with support and partnership from several utilities. CEUS was first piloted in 1996, with the most recent survey released in 2006. CEUS collects detailed data on building shell characteristics, building activities, operating schedule, equipment, and fuel source. CEUS is an excellent example of a resource-intensive approach with a high level of depth and detail through on-site surveys and advanced software modelling component, DrCEUS.

The scope of data collected in CEUS is similar to that of CBECS. CEUS, however, differs in several key areas. CEUS surveys California commercial buildings only. CEUS also collects highly detailed information for certain topics. For example, for building equipment, CEUS obtains data on the efficiencies and typical operating schedules of energy-consuming equipment, enabling granular end use energy consumption estimates. CEUS collects more robust data on building activities and schedules through its use of activity areas and schedule sets, allowing participants to allocate up to 8 different activity areas, which allows buildings to be disaggregated into smaller components. This flexibility in the survey enables a more precise characterization of energy-consuming activities in specified building zones. Despite the high granularity of survey questions, however, the utility of this data is somewhat limited as no microdata are released.

Table 2.2 CEUS Overview

Building Segment	"Non-residential" (i.e. "Commercial")
Policy Objective	Designed primarily to support California's energy demand forecasting activities, CEUS identifies four main objectives: • Develop estimates of end use saturations, energy use by end use, hourly load profiles for commercial market segments, • Collect data on end-use energy efficiency to support the design and planning of energy efficiency programs and policies, • Construct a flexible building energy demand analysis model to support the estimation of the hourly end-use load profiles, and • Develop a means to estimate hourly impacts of energy efficiency measures, load management strategies, building standards, alternative rate designs, etc.[vii]
Scope	California- (only covers the electric service areas of the participating utilities)
Frequency	Not defined, latest CEUS released in 2006, CSS in 2014.
Sampling Methodology	Data obtained from three California electric IOUs. CEUS stratifies the sample by climate, building type, utility area, and size. Some sample sites are selectively replaced with sites that contain interval-metered electricity consumption data in an effort to maximize the number of sites with hourly usage information.[8]
Data Collection Method	• On-site surveys to collect building characteristics data. • Monthly utility billing data obtained. • Short-term data logging and/or interval metering performed at certain sites.
Data Collected	• Building Characteristics: e.g. year built, square footage, floor-to-ceiling height, orientation • Building Activity: Up to 8 different activity areas and 3 schedule sets in which respondents identify measures such as % cooled, typical # occupants, & equipment operation • Energy Indicators: End use indicators (see above) for a variety of end uses[1] available by day type (e.g. hot day, weekend day); implemented energy efficiency measures
Key Energy Indicators	• Fuel Shares; Electric and Natural gas consumption • Energy intensities; Energy-use indices (EUIs) and distributions[2] • 16-day hourly end-use load categories for 12 commercial building type categories • End-use intensities by major fuels; Monthly and daily load profiles; end-use load profiles • Non-Coincident Peak Loads: The maximum annual hourly load in watts per total segment of floor stock (watts/segment FS) for each end use
Data Modelling	DrCEUS uses survey and billing data to produce calibrated building simulations, and graphical views and comparisons of energy information by user-defined segments[8]
Data Availability/ Access	• Interactive CEUS results are publicly available via ITRON's website. Results can viewed with up to three simultaneous filters: sector, building type, fuel type, and result type (e.g. load profiles by end use). Building Data or Energy Indicators filters can also be applied[viii] • Excel workbooks are also available for public download. Many of the variables collected are not disclosed. No micro-data is made available due to privacy concerns
Recommendations from Users	• Inclusion of more building characteristics, activity, and equipment operation data (ideally in the form of microdata), would increase survey utility • Increase the proportion of new construction in the sample • Improve administrative mechanism for exchanging data between utilities and contractors • Develop a finer resolution of building types and HVAC end uses

[1] end uses include: Heating, cooling, ventilation, water heating, cooking, refrigeration, exterior lighting, interior lighting, office equipment, miscellaneous, process, motors, air compressors, and segment total.
[2] The fraction (%) of the total segment energy that is attributable to a specific end use.

2.2 E.U. Building Energy Data Framework

This section documents the key aspects of various systems, tools and data available at the Buildings Performance Institute of Europe (BPIE) Data Hub[ix], which are used by European policy makers, builders and others involved in improving building energy efficiency. The BPIE systems and data are a fairly good source of information in terms of type of data to collect on building structure, energy use and intensity. There is also relevant information on the types of policies in different countries, as well as detailed information on pilot projects to improve the building performance via retrofit projects.

However, in contrast to the aim of the Commercial Building Data Framework for India, most of the EU data, systems, projects and policies are developed for the existing residential building stock, with the aim of improving the energy efficiency of these buildings through retrofits. Though there are some data indicators for "tertiary" or commercial buildings, they are not as well developed. Most of these tools obtain their data through existing databases, housing surveys, population censuses, existing literature, building registries, etc. Most tools include detailed information on building characteristics. Key energy indicators are typically for space and water heating energy consumption, as well as total building energy consumption. Some of the BPIE systems have very detailed data on heating systems as most EU projects and policies for improving energy efficiency in buildings are aimed at reducing the energy for space heating and hot water. The table below briefly summarizes several of the European Data tools and systems- specifically their policy objective and function.

Table 2.3 Overview of European Systems and Tools Related to EE in Buildings

System	Description
Tabula	• **Policy Objective**: Maintain a database of "exemplary" buildings covering the main building typologies in a country and provide estimates of energy use, energy cost and CO_2 emissions based on various levels of building refurbishment. • **Function**: Tabula provides data on each country's exemplary buildings including their estimated energy use, energy costs and CO_2 emissions based on the current typology, basic refurbishment and advanced refurbishment. The energy data is calculated using a common reference procedure across the participating countries to enable cross-country comparisons.
Episcope	• **Policy Objective**: Develop energy performance indicators for residential building stock to increase knowledge of energy saving opportunities. Indicators used for policy, education, standards, etc. • **Function:** Tracks and monitors the implementation of energy refurbishment projects. The tool uses data from Tabula and feeds updated information back in. Data characterizes building stock in a country with respect to parameters including building type, age, type of heating and hot water systems, other technical systems, insulation levels, etc. Episcope's modelling component generates current and future scenario energy balance indicators.
Mure	• **Policy Objective:** Create a data warehouse of EE policies in various EU countries and their policy expectations, implementation status, and impact. • **Function:** Users can search the database by country, target end use, actor (e.g. utility), target audience (e.g. owners,) and type of policy implementation (e.g. regulation, financing).
Odyssey	• **Policy Objective:** Monitor energy consumption & EE trends through EE and CO_2 indicators. • **Function:** Odyssey has several data components, including a database, EE Indicator scorecard, energy savings trends, benchmarking between countries, change in energy consumption year to year), market diffusion of EE appliances, fuel switching, and 30 key energy and CO_2 indicators.
Entranze	• **Policy Objective:** Provide data, analysis and guidelines for evidence-based policy to achieve a significant level of penetration of nearly Zero Energy Buildings and Renewable Heating/Cooling. • **Function:** The Entranze Data Tool shows country-wise consolidated data on building characteristics, energy use, energy source, etc. Scenario Tool shows potential demand, consumption, etc. based on Low, Medium & High levels of policy implementation. Uses data from Odyssey, Tabula, Eurostat, UEPC.

2.3 Singapore Building Energy Data Framework

The Government of Singapore launched the Building Energy Submission System (BESS) in 2013, with a view to monitor the energy efficiency of the existing commercial building stock and to formulate a national energy benchmarking system. The system requires reporting of building energy related data[3] by building owners. BESS collects data on building ownership and activity (e.g. building ownership setup, activity type, etc., building characteristics (e.g. floor area), building service information (e.g. # of escalators), and building energy consumption.

[3] including detailed data on ownership and activity (building occupancy type/ activity type/ green mark labelling), building data (gross floor area, carpark area, number of rooms, major retrofitting), building services information (lifts/ ACMV/ lighting/ hot water systems/ building electricity and other fuels consumption.

The benchmarking data is made available to the building owners so that they can pro-actively improve their building energy performance and consumption, as well as user behavior.[x] Though the building energy consumption details are made available only to building owners, the Building and Construction Authority (BCA) releases an annual report highlighting energy consumption patterns among commercial buildings, as well as a comparison of green-rated building performance to the rest of the building stock. BESS is conducted annually, and surveyed 1,108 buildings in 2014.

Table 2.4 Overview of BESS[xi]

BESS	• **Policy Objective:** To present a snapshot of evidence based energy performance of existing commercial buildings and to formulate the national energy benchmark. Encourage buildings owners to pro-actively engage to improve their building energy performance and energy consumption behaviors of users. • **Function:** Building owners can access the benchmarking data so they can pro-actively improve their building energy performance and energy consumption behaviors of users. With comparative energy consumption information available, building owners of offices, hotels, retail buildings and mixed development are better equipped to understand the performance of their buildings. • **Data Outcomes:** Key data outcomes include summary tables on building total annual energy demand, monthly energy demand and EUI. • **Key Energy Indicators:** 1. Total annual energy consumption (kWh) 2. Energy Utilization Index (EUI-kWh/m^2/yr) 3. Monthly Energy Consumption graph (kWh) 4. Yearly Energy Consumption graph (kWh)

BESS has significant relevance to the Indian data framework as Singapore has tropical climate and most of the commercial building energy demand is driven by space cooling, similar to India. Since it will be critical for India to capture those variables that impact the cooling demand, a comparison of the data framework may prove useful. Additionally, as a fairly recent initiative, BESS gives India the opportunity to examine an evolving program in a similar environment.

2.4 China Building Energy Data Framework

China's commercial building energy use data collection efforts are considerably more fragmented than those of the U.S. Recently, China launched a more centralized effort to regularly collect data through a system-level approach. Most data collection efforts are conducted on a local level, with a series of energy use monitoring platforms (EUMPs) and databases in key provinces and municipalities. In more recent years, the Ministry of Housing and Urban-Rural Development (MOHURD) has sought to centralize this data under a national EUMP.[xii] MOHURD also conducts energy data surveys for tracking the residential energy use.

The general lack of information regarding type of data collected and methodology, as well as limited data accessibility makes it difficult to assess the relevance of China's efforts for establishing a data framework in India. As in the case of China, India could potentially consider approaching data collection both at a national as well as sub-national level. One key takeaway is that if a country-wide, unified data framework is the ultimate goal, it is best to begin with a centralized, uniform approach. China's experience demonstrates that while effective locally, and autonomous regional efforts are standardized, a bottom upwards approach could likely pose challenges for creating a consistent data network that is easily reconcilable.

Table 2.5 Overview of Systems and Tools Related to EE in Buildings in China

System	Description
Sub-National-EUMPs	• **Policy Objective:** Provide energy information on large commercial and government buildings. • **Data Collection Method**: Focus on using metering and sensing technologies to obtain building energy consumption data. Data on methodology, energy information systems, components, or reporting strategies are not known. • **Function:** Enables comparisons of building energy performance to energy standard, identification of buildings for audits/retrofits, monitoring building energy savings and performance of retrofitted or green certified buildings, software modelling component enables whole building energy use or subsystem comparisons. Many EUMPs have been successful. • **Data Outcomes:** Analysis of energy consumption data for whole buildings or system levels, benchmarking/indexing of weekly energy consumption,
National-Level Programs	• **Policy Objective**: MOHURD currently employs a national database for real-time, online energy monitoring, and is working to connect local EUMP efforts to its platform. Current project underway with the World Bank and Global Environment Facility to unify localized platforms to a national Chinese building energy performance benchmarking methodology, platform, and tool. • **Function:** Considered to be ineffective, largely due to data gaps and inconsistencies. New pilot efforts to unify localized platforms to a national Chinese building energy performance benchmarking methodology, platform, and tool (to be completed in 2018) hold promise for improving effectiveness of the national database.
CABR Hotel & Office Bench-marking Tool	• **Policy Objective**: Energy Benchmarking Survey conducted to provide access to data for 800 hotels/offices annually in order to drive energy/CO_2 reductions, sale of EE technology, policy innovation.[xiii] • **Data Collection Method**: Benchmarking survey conducted annually by Horwath HTL and China Tourist Hotel Association (CTHA). Energy consumption and costs based on utility bills. • **Data Outcomes**: Data on hotel characteristics and activity. Survey is available on request and has been replicated across the ASEAN region to support hotel benchmarking tool development efforts in Southeast Asia.

2.5 Past Efforts on India Commercial Buildings Energy Baselining

This section summarizes the efforts towards collecting building sector data in India since the formation of the Bureau of Energy Efficiency (BEE) in 2002. The efforts documented here are comprised of activities that that were pursued purely for data collection purposes, as well as activities that collected data on commercial buildings as part of a larger project. This review will also serve to highlight some of the use cases in India that have looked for a potential data source for undertaking the project tasks.

The cases presented cover details on data source and methodology, calculation/modelling approach, and normalization methods adopted so far. Data collected as part of a project have generally followed their own data framework. The different energy efficiency key performance indicators captured in these cases have not been an attempt to track impact of energy efficiency policies/measures in India, with the exception of data collected on green buildings. However, the indicators may have some relevance in the ongoing effort to develop a data framework. Table 2.6 through Table 2.12 below summarize some of the more noteworthy efforts in India.

Table 2.6 Situation Analysis of Commercial Buildings in India[xiv]

<table>
<tr><td>Summary</td><td>The study was one of the first attempts in India to assess the size and distribution of the commercial building stock and its energy consumption.</td></tr>
<tr><td>Year</td><td>2008</td></tr>
<tr><td>Carried by</td><td>Spatial decisions with support from BEE</td></tr>
<tr><td>Data Collection Methodology</td><td>Secondary Survey: Attempted to gather information from electricity supplying authorities and building sanction authorities.</td></tr>
<tr><td>Data Set Size</td><td>1,066 buildings, including Office buildings, Shopping Malls, IT Parks, Hotels, Golf Course, Stadium, etc. Since most buildings did not include data on covered area, only 269 of the 1,066 commercial buildings were analyzed.</td></tr>
<tr><td>Parameters Collected</td><td>Not fully disclosed, however, the survey results indicated building level data includes building monthly energy consumption and building covered area. System level information was not collected. The questionnaire is not available.</td></tr>
<tr><td>Analysis Methodology</td><td>No details are provided on the methodology used for analyzing data.</td></tr>
<tr><td>Result</td><td>The survey highlighted average Energy Performance Indicator (EPI) of the 269 analyzed buildings The average EPI of each of the building type is presented in the attached table.
<table>
<tr><th>S. No.</th><th>Building Type</th><th>No. of Buildings</th><th>Annual kWh consumption per sq.ft. of covered area</th></tr>
<tr><td>1</td><td>Office Buildings</td><td>85</td><td>1 - 374</td></tr>
<tr><td>2</td><td>Shopping Malls</td><td>85</td><td>10 - 895</td></tr>
<tr><td>3</td><td>IT Parks</td><td>63</td><td>0 - 190</td></tr>
<tr><td>4</td><td>Hotels</td><td>27</td><td>2 - 340</td></tr>
<tr><td>5</td><td>Hospitals</td><td>9</td><td>3 - 120</td></tr>
<tr><td></td><td>Total</td><td>269</td><td></td></tr>
</table></td></tr>
<tr><td>Challenges</td><td>The survey faced major challenge in collecting the covered area of the government buildings and thus energy benchmarking of selected Government buildings could not be completed. The study does not discuss the challenges faced in the data analysis,</td></tr>
<tr><td>Areas of Improvement</td><td>Data collection methodology is not discussed in detail, however; the analysis indicates an absence of detailed data collection framework. Following are the recommendations for building data analysis:

The range of annual kWh/sq. ft. data for each of building type is too large. Various factors can be responsible for such anomaly in the data set. These factors may be a) single shift or multiple shift operations; b) Mixing of AC or non-AC spaces; c) climate zone in which building is located; d) efficiency of building envelope and HVAC system, Lighting, etc.
Normalizations (after accounting for climate, building type, # of shifts, service levels, etc.) needed to come up with acceptable benchmarks
</td></tr>
<tr><td>Lessons</td><td>
Data collection framework should be comprehensive and clearly spell out general building characteristics as well as performance related variables.
Various data analysis methods must be considered, in order to differentiate the effect of building design and systems on the overall building energy consumption.
</td></tr>
</table>

Table 2.7 Performance Based Rating and Energy Performance Benchmarking For Commercial Buildings in India [xv]

<table>
<tr><td>Summary</td><td>The study provided BEE with energy benchmarks for various commercial buildings including office buildings, hospitals, hotels and shopping malls.</td></tr>
<tr><td>Year</td><td>2010</td></tr>
<tr><td>Conducted by</td><td>ICMQ (data collection) and ECO3 (analysis)</td></tr>
<tr><td>Data Collection Methodology</td><td>Primary Survey: The survey gathered complete information for public and private buildings- primarily offices, hotels, hospitals and retail malls. Data collected is fairly representative as it covered all the five climatic zones, as well as buildings in metropolitan cities, Tier II and Tier III cities, as well as smaller towns. Copy of questionnaire not provided.</td></tr>
<tr><td>Data Set Size</td><td>760 buildings of which 197 office buildings had information about all key variables likely to affect energy consumption in a building. This set was used to conduct the multi-variate regression analysis.</td></tr>
<tr><td>Parameters Collected</td><td>Building Level and System Level: connected load, electricity generated on site, electricity purchased from the utilities, built up area, conditioned area, occupancy, number of floors, type of air-conditioning and load, climatic condition, operating hours, etc.</td></tr>
<tr><td>Analysis Methodology</td><td>Study compares the whole building energy consumption of the building under consideration with a benchmark building of similar characteristics. The study used the following three step methodology:
• Estimate energy consumption of the benchmarked building
• Compute performance index with respect to the benchmarked building - calculated as the ratio of actual electricity consumed by the candidate building to estimated electricity use by the benchmarked building.
• Compute performance score based on the relative performance of other buildings in the sample - The Building Performance Index (BPI) of all buildings in the sample is used to create a distribution profile of relative performance.</td></tr>
<tr><td>Results</td><td>The study provided performance rating through peer group comparison for office buildings. The study also provided BEE with energy benchmarks for various commercial buildings like: Office buildings, hospitals, hotels and malls. For e.g. office buildings benchmarking is:
<table>
<tr><th>No. of Buildings</th><th>Office Building Type</th><th>Floor Area (m^2)</th><th>Annual Energy Consumption (kWH)</th><th>EPI $kWh/m^2/year$</th></tr>
<tr><td>145</td><td>One Shift</td><td>16,716</td><td>20,92,364</td><td>149</td></tr>
<tr><td>55</td><td>Three Shift</td><td>31,227</td><td>88,82,824</td><td>349</td></tr>
<tr><td>88</td><td>Public Sector</td><td>15,799</td><td>18,38,331</td><td>115</td></tr>
<tr><td>224</td><td>Private Sector</td><td>28,335</td><td>44,98,942</td><td>258</td></tr>
<tr><td>10</td><td>Green Buildings</td><td>8,382</td><td>15,89,508</td><td>141</td></tr>
</table></td></tr>
<tr><td>Challenges</td><td>Data Collection: Data collected is for the total energy consumption at the building level, with associated building characteristics. There is no specific information available to understand thermal comfort, indoor air quality or other basic amenities, etc.</td></tr>
<tr><td>Areas of Improvement</td><td>• The survey informs us about the percent of space that is conditioned in a building. However, it does not tell us about the operation schedule of HVAC system, thermal comfort levels, and indoor air quality.
• The impact of climate is not easily discernible from the regression equations. Impact of urban heat island effect, level of service, building schedule and equipment load are very different in semi-urban and rural settings.</td></tr>
<tr><td>Lessons</td><td>• Providing building owners with peer review will help them enhance their building EE.
• Detailed analysis is very important to understand the various parameters related to the building energy consumption.</td></tr>
</table>

Table 2.8 Market Assessment of Public Sector Energy Efficiency Potential in India[xvi]

Summary	The purpose of this study was to assess the potential for improving energy efficiency in public buildings by providing preliminary estimates of the size of the public sector buildings market, the patterns of energy use in public buildings, and the opportunity for reducing energy use in this sector. The study estimates the size of this market and the potential for carbon savings with conservative assumptions requiring moderate investment towards efficiency improvement in public sector buildings.
Year	2009-10
Conducted by	LBNL
Data Collection Methodology	The survey gathered complete information on 185 buildings which primarily included offices, hotels, hospitals, educational and retail establishments. Data collected was fairly representative as it covered all the four climatic zones, public as well as private sector buildings. The survey covered buildings in metropolitan cities, Tier II and Tier III cities.
Data set size	185 buildings. 50%of the buildings included data on key attributes impacting energy use such as type of space conditioning equipment, efficiency rating, and lighting levels.
Parameters Collected	Building and System Level: The questionnaire included information such as connected load, electricity generated on site and purchased from utilities, built up area, conditioned area, number of workers, number of floors, type of air-conditioning (including capacity, and number of units), operating hours, lighting type and lighting design levels etc.
Analysis Methodology	The study used summary statistics to estimate the EUI's and developed weighted estimates using the range of distribution of building size.
Result	The study provided EUI estimates of commercial buildings by principal building activity, some understanding of end-use level energy consumption, and helped establish baseline efficiency in the building stock for specific end uses.
Challenges	Limitations arising out of a small data set, and not being statistically representative.
Areas of Improvement	• The current survey informs us about the percent of space that is conditioned in a building. However, it does not tell us enough about the thermal comfort levels, and indoor air quality that is maintained. • Information on other envelope/building shell related parameters will help in improving efficiency of building performance
Lessons	• Provided some understanding of the energy footprint of commercial buildings in the existing stock and opportunities for efficiency improvement. • The building sample was not selected through a sampling plan and therefore was not statistically representative of the entire commercial building stock in India.

Table 2.9 Graduated Energy Benchmarking for Hotels and Hospitals[xvii],[xviii]

Summary	These studies are an example of a fairly rigorous exercise carried out in India to understand the key energy consumption parameters in Indian Hotels and Hospitals.
Year	2015
Conducted by	ECO3 (Data Collection), & CBERD India (analysis)
Data Collection Methodology	Primary Survey: Fairly comprehensive questionnaires were prepared for both the hotel and hospital studies. A copy of the questionnaire is not provided in the report, however is available for the review.
Data Set Size	133 hotels and 67 hospital buildings.
Parameters Collected	• HOTEL: 131 variables collected. General information (e.g. building size, location, energy use, hotel type, star rating,) area (e.g. total built up area), system and use characteristics (e.g. AC capacity, lighting loads, number of banquets, etc.). • HOSPITALS: 89 different variables collected. Data collected were sub-categorized under

	general information (e.g. size, location, hospital type), area (e.g. total built up area), occupancy (e.g. # of outpatients) use intensity, energy management (e.g. audits, maintenance), and energy loads (lighting loads).
Analysis Methodology	A three-tier graduated benchmarking approach (using three regression based models)[4] was implemented, structured as follows: • Level 1: 1–3 variables that are significant and easy to collect, with reasonable data quality. • Level 2: 2–3 additional variables that increase the robustness of the benchmarking. • Level 3: 1–2 additional optional variables to address special loads or uses. Based on the preliminary analysis, eleven variables[5] were further explored for their ability to predict the dependent variable (i.e., energy use in a graduated approach).. The final model included five significant variables to explain energy consumption. e.
Result	• HOTEL: Variables such as Climate zone, Service star level, Number of rooms, and Built-up area per room were the variables that were considered for benchmarking. Outcomes included: o Use room-based EPI rather than area-based EPI o Include electricity and other fuels in calculating EPI. o Star rating and climate should be included as core independent variables o Need further analysis to determine if usage variables should be included as independent variables – number of guests, room occupancy rate, number of restaurant covers, and number of conferences • HOSPITAL: The diagnostics indicate that: (1) number of beds and built up area per bed of a hospitals are the two most critical variables, and (2) the lowest-level model in the graduated benchmarking approach should include these two variables at a minimum.
Challenges	Not enough information available on the challenges.
Areas of Improvement	Policy relevance can be included in discussion.
Lessons	It is very crucial to understand and collect the right information. It is importance to understanding the critical variables driving the building energy demand.

[4] Three regression-based methods—using Independent models, Constrained Regression models, and Single models—were considered and analyzed for the graduated benchmarking approach.

[5] (Number of rooms , Star rating of hotel , Built up area per room - area excluding parking or Built up area per room - total area , Number of restaurants per room, Climate, Percentile ratio of room occupancy, Number of overnight guests/room, Average conference and weddings per year, Average room tariff, and Building Indoor Environmental Quality (IEQ) monitored)

Table 2.10 Report on Energy Benchmarks for Commercial Buildings[xix]

<table>
<tr><td>Summary</td><td>A study on the status of commercial building energy use in India. It lacks the technical and statistical rigor compared to the other past efforts.</td></tr>
<tr><td>Year</td><td>February 2016</td></tr>
<tr><td>Conducted by</td><td>BEE with support from UNDP-GEF appointed Darashaw.</td></tr>
<tr><td>Data Collection Methodology</td><td>Secondary Data: Various rounds of interviews were conducted with the concerned officials at Urban Local Bodies (ULBs), Development Authorities, Housing Boards, Power Distribution Companies (DISCOMs), and State Designated Agencies (SDAs) etc.
Primary Data: A comprehensive questionnaire was designed to collect the required information. The survey questionnaire was not shared. The target sample consisted of:
Data collection from buildings that have a connected load of 100 kW and above, or contract demand of 120 kVA and above;
Data collection of existing and new commercial buildings for a period of one year;
For new buildings, data collection was based on building plan approvals and its connected load from different departments;
Covered all climate zones for most building types.</td></tr>
<tr><td>Data Set</td><td>1,160 commercial buildings surveyed. Star rated buildings were omitted from the study to get a clearer picture of the energy consumption in regular office buildings.</td></tr>
<tr><td>Parameters Collected</td><td>Buildings Level: monthly energy consumption, covered area, gross floor area, enclosed service area, parking area, and conditioned area, of a building.
System Level: grid purchase, renewable, DG output, gas generator etc.</td></tr>
<tr><td>Analysis Methodology</td><td>No details provided</td></tr>
<tr><td>Results</td><td>The following EPIs were derived for different types of commercial building, across different climate zones. An example for offices is shown below.
<table>
<tr><th rowspan="2">Office Particulars</th><th colspan="2">EPI kWh/m2/year</th></tr>
<tr><th>Less than 50% AC</th><th>More than 50% AC</th></tr>
<tr><td>War & Humid</td><td>101</td><td>182</td></tr>
<tr><td>Composite</td><td>86</td><td>179</td></tr>
<tr><td>Hot & Dry</td><td>90</td><td>173</td></tr>
<tr><td>Moderate</td><td>94</td><td>179</td></tr>
</table>
Office buildings with higher EPIs were generally larger buildings with 24-hours, daily operations and large data centers
Shopping malls with higher EPIs were smaller-sized buildings with long operating hours and using split-unit ACs or air cooled centralized chiller systems
Hotels with higher EPIs were older, smaller-sized hotels using split AC systems</td></tr>
<tr><td>Challenges</td><td>Data Collection:
Lack of information provided by building owners to the surveyor
Building owners' unfamiliarity with the information required by the surveyor
Building owners' oversight leading to data entry error in the questionnaire
Inadequate knowledge of terminology used for technical fields in the submission form
Lack of up-to-date contact information of targeted building owners'</td></tr>
<tr><td>Areas of Improvement</td><td>The data collection task has to be detailed, including sources of data collection. Error checks should ensure that flawed entries are not in the final dataset.</td></tr>
<tr><td>Lessons</td><td>Study focuses on the whole building energy use and does not consider the impact of equipment, building operation and design on overall performance. It is possible that the worst building gets best rating because it uses the most efficient equipment.
Study analyzes net electricity consumed (or site energy) as a metric for energy consumed. Many buildings use onsite diesel or gas generators to produce energy. By ignoring the fuel mix, it omits transmission and distribution losses, and thus underestimates total energy savings potential at a societal level. Use of source energy may be a better metric for future extensions.</td></tr>
</table>

Table 2.11 Green Building Rating System – GRIHA[xx]

<table>
<tr><td>Summary</td><td>Green building rating systems have been active in India for over a decade. These systems rate commercial and residential buildings. The noted rating systems prevalent in India include: (1) IGBC – Indian Green Building Council – Initiative by CIILEED (Leadership in Energy and Environmental Design) – Initiative by USGBC, and (2) GRIHA (Green Rating for Integrated Habitat Assessment).

GRIHA was an initiative by TERI and MNRE and was adopted as the national rating system for green buildings by the Government of India in 2007. The system was developed to help ‘design and evaluate’ new buildings. A building is assessed based on its predicted performance over its entire life cycle – inception through operation. GRIHA periodically examines the GRIHA rated building information and updates their benchmarks.</td></tr>
<tr><td>GRIHA Rating variants</td><td>• GRIHA: Built up area ≥ 2500 m^2
• SVA GRIHA: Built up area between 100 – 2499 m^2
• GRIHA LD: Site area ≥ 50 hectares
• GRIHA Pre-certification</td></tr>
<tr><td>Weightage to Resources</td><td><table>
<tr><th>GRIHA V3</th><th>GRIHA V2015</th></tr>
<tr><td>Site Planning – 11%
Energy – 33%
Renewable Energy – 11%
Water and wastewater – 15%
Solid waste management – 4%
Materials – 14%
Health and Wellbeing – 12%</td><td>Site Planning – 8%
Energy – 20%
Occupant comfort and wellbeing – 12%
Water – 17%
Sustainable Building Materials – 14%
Construction Management – 9%
Solid Waste Management – 6%
Socio-Economic Strategies – 6%
Performance Monitoring – 8%</td></tr>
</table></td></tr>
<tr><td>Buildings Registered</td><td>650 projects totaling to over 230 million sq.ft</td></tr>
<tr><td>Buildings Rated</td><td>30 projects, these have led to a cumulative annual energy consumption reduction of 74,000 MWh and installation of 14.5 MWp of renewable energy.
The potential impact of the current 650 projects is expected to lead to a cumulative annual energy consumption reduction of 1600GWh/annum and installation of 315 MWp of renewable energy.</td></tr>
<tr><td>Parameters Collected</td><td><u>Building Level and System Level:</u>
Site Area, Built-up area, Heat gain through building envelope, outdoor lighting luminous efficacy and connected load, Interior lamps and luminaires connected load, EPI (lighting and space cooling), ECBC mandatory requirements (type of chiller, COP and capacity, Controls for cooling tower and closed circuit fluid coolers, time clock control, piping insulation, ductwork, system balancing, condenser location, treated water for condensers, space control, control in day lighted areas, exit signs, transformer losses, motor details, power factor correction etc.) Renewable energy capacity, hot water systems, thermal comfort conditions, building materials details (building insulation, glazing SHGC, window shading etc.), daylight penetration (Daylight Autonomy(DA)) etc.</td></tr>
<tr><td>Analysis Methodology</td><td>Building energy simulation to obtain building EPI. Buildings are rated after completion based on the simulation and GRIHA team’s due diligence. The final GRIHA rating is provided after building is 80% occupied for one year. There are five GRIHA final rated projects.</td></tr>
<tr><td>Limitations</td><td>The dataset is limited to green/high-performing buildings, and represent a particular sub-population.</td></tr>
</table>

Table 2.12 High Performance Commercial Buildings in India: Adopting Low-Cost Alternatives for Energy Savings[xxi]

<table>
<tr><td>Year</td><td>2010</td></tr>
<tr><td>Summary</td><td>The project discusses EPIs for conventional, solar passive design and ECBC buildings for all five climate zones in India. It aimed to establish relevance and impacts of low-energy passive strategies and ECBC-recommended measures on improving energy performance of commercial buildings.</td></tr>
<tr><td>Conducted by</td><td>Undertaken by the Asia-Pacific Partnership on Clean Development and Climate, the project was supported and funded by the US Department of State and the BEE. It was implemented by TERI, India, and White Box Technologies, USA.</td></tr>
<tr><td>Data Collection</td><td>Primary data collection</td></tr>
<tr><td>Data Set</td><td>The project selected 15 buildings from various climate zones of India and studied their performance. These comprised five buildings (one from each climate zone) each of conventional & solar passive type, constructed in the pre-ECBC era and the ECBC Compliant buildings from the post-ECBC era.</td></tr>
<tr><td>Parameters Collected</td><td><u>Building Level and System Level</u>: Operation schedule, area of building, function of building, Building envelope details (walls, roof, glazing), building lighting – lighting system, lighting controls, HVAC system design, building design (orientation, landscape and water bodies), Day light integration.</td></tr>
<tr><td>Result</td><td>EPI of the buildings analyzed were presented
<table>
<tr><td rowspan="2">Climate</td><td colspan="3">Building type – EPI (KWh/sqm/yr)</td></tr>
<tr><td>Conventional</td><td>Solar passive design</td><td>ECBC Compliant</td></tr>
<tr><td>Hot & Dry</td><td>199</td><td>131</td><td>121</td></tr>
<tr><td>Warm & Humid</td><td>237</td><td>70</td><td>-</td></tr>
<tr><td>Temperature</td><td>309</td><td>76</td><td>107</td></tr>
<tr><td>Composite</td><td>231</td><td>147</td><td>55</td></tr>
<tr><td>Cold</td><td>335</td><td>219</td><td>-</td></tr>
</table></td></tr>
<tr><td>Areas for Improvement</td><td>Various building energy consumption parameters are analyzed in the project, however detailed list of the parameters affecting each building energy demand are not provided. The data set is limited and is not representative of the larger building stock of either ECBC-compliant or pre-ECBC units.</td></tr>
</table>

3 POTENTIAL USE CASES FOR COMMERCIAL BUILDINGS DATA COLLECTION

This section delineates a set of potential use cases identified for India's Commercial Buildings Data Framework. The potential use cases should address the commercial building sector at the city and building level, while encapsulating new buildings as well as existing buildings. At the city level, the use cases should help determine the commercial building sector energy consumption and energy consumption by EE buildings (ECBC, green rating systems complied buildings), including the existing retrofitted buildings. Each use case is determined with respect to its:

- Goals and intended benefits
- Users and primary audience/stakeholders
- Primary and secondary data required
- Energy Efficiency Key Performance Indicators (EE KPIs), derived from primary and secondary data to achieve primary goals
- Data granularity (component, system, building, city or national level)
- Data sources
- Data calculation, normalization and modelling methods for secondary/derived data
- Data measurement, collection and calculation periodicity (daily, weekly, monthly, annually)
- Effort involved and feasibility of collecting data (technical, financial, logistical, legal)

The four use cases identified by the project are listed in Table 3.1. The table also includes the use cases' applicability to new and existing buildings and the priority for inclusion in the framework. The priorities were determined based on an understanding of observed building energy data uses in India, stakeholder discussions, as well as other policy needs including code updates, evaluation and implementation guidelines, the more recent developments such as Smart Cities Mission. Use cases marked high priority and their associated EE KPIs will be included in the first release of the India Commercial Building Data Framework.

Table 3.1 Use Cases Overview

Use Cases	New Building	Existing Building	Priority	Primary Audience
Modeling the Building Sector Energy Consumption; Understanding the Impact of Buildings at the City Level	●	●	Medium	MOUD*, MoP*, Smart Cities Mission, NITI Aayog*, BEE*, ULBs*
Develop, Update, and Implement Building Energy Codes and Guidelines	●	○	High	BEE, BIS*, MOUD, ULBs
Develop and Update Building EE Rating and Labels	○	●	High	Rating organizations (e.g. BEE, USGBC*, IGBC*, GRIHA*)
Design and Implement Enterprise Energy Management and Building Retrofit Programs	NA	●	Low	Public and Private sector organizations, ESCOs*, DISCOMs*, Energy Auditors, Facility Managers, Equipment Manufacturers
● Fully applicable ○ Partly applicable NA Not applicable				

*National Institute for Transforming India *(NITI Aayog)*, Bureau of Energy Efficiency *(BEE)*,Urban Local Bodies *(ULBs)*, The Bureau of Indian Standards *(BIS)*, Ministry of Urban Development *(MOUD)*, Ministry of Power*(MoP)*, United States Green Building Council *(USGBC)*, Indian Green Building Council (IGBC), Green Rating for Integrated Habitat Assessment (*GRIHA*), Energy Service Company (*ESCOs*), Distribution Company (*DISCOM*).

Table 3.2 below classifies the use cases based on their applicability to the macro or micro level for new and existing buildings.

Table 3.2 Use Cases Classification

Use Cases Classification	New Building	Existing Building
Macro Level (National, Urban, Neighborhood)	**Primary use cases: UC-1** Secondary use cases: UC-2	**Primary use cases: UC-1** Secondary use cases: UC-3
Micro Level (Building, System/Component, Equipment/Appliance)	**Primary use cases: UC-2** Secondary use cases: UC-3	**Primary use cases: UC-3, UC-4** Secondary use cases: UC-2

3.1 USE CASES

The sections below summarize the motivations, goals and intended impacts, and target users of each of the four use cases. Section 5 of this report discusses in detail the roles and responsibilities of the targeted users and their potential to play a role in institutionalizing the data framework.

3.1.1 Modeling the Building Sector Energy Consumption; Understanding the Impact of Buildings at the City Level

3.1.1.1 Summary and Motivations

1. Improve the accuracy of building sector growth and resulting energy use projections in national energy models
2. Better understand heat island effect in urban areas as a result of building construction
3. Develop data aggregation methodologies for developing indicators to report the EE of cities and neighborhoods

3.1.1.2 Goals and Intended Impacts

1. Enable climate and energy action planning at the national and sub-national levels
2. Convey the importance of promoting EE in the building sector
3. Help reduce the impacts of urban heat islands in major Indian cities through better planning, landscaping and treatment of roofs and pavement areas – low-cost and quick win strategies
4. Empower current and emerging market actors in their building design, construction and management decisions
5. Enable third parties to build data analysis applications that function across multiple jurisdictions and market stakeholders through a common data standard, facilitating easy aggregation of impacts
6. Better understand the impact buildings have on energy use at the city level

3.1.1.3 Potential Users

1. Ministry of Urban Development (MOUD)
2. Ministry of Power (MoP)
3. Smart Cities Mission
4. NITI Aayog
5. Bureau of Energy Efficiency (BEE)
6. Urban and Local Bodies or Municipal Corporations (ULBs)

3.1.2 Develop, Update, and Implement Building Energy Codes and Guidelines

3.1.2.1 Summary and Motivations

1. Collect information on both the level of compliance (specifically administrative challenges with the implementation of building energy codes) and the ease of specification and availability of building materials and equipment complying with the energy code
2. Determine whether prescriptive or performance-based compliance methods are widely used and the rationale behind this selection
3. Understand the challenges faced by Urban Local Bodies (ULBs) and state implementation agencies in compliance enforcement and include suggestions for improving the code
4. Gather data to assess the performance of ECBC-compliant buildings against business as usual (BAU) or pre-ECBC era buildings

3.1.2.2 Goals and Intended Impacts

1. Collect data to help inform the optimal stringency level in future ECBC revisions
2. In future ECBC revisions, data collected is expected to help specify technical details and approaches for ECBC compliance checks

3. Help determine the availability of efficient products and the cost premium being charged for more efficient products/components or systems
4. Help determine the EPI of commercial buildings meeting minimum threshold requirements of future versions of ECBC and the existing building level benchmarks to set ECBC improvement targets/stringency levels
5. Consider developing residential building energy code or guidelines based on the data being collected for commercial buildings

3.1.2.3 Potential Users

1. Bureau of Energy Efficiency (BEE)
2. Municipal corporations or Urban and Local Bodies (ULBs)
3. Bureau of Indian Standard (BIS)
4. Building developers/owners
5. Commercial Real Estate Developers Authority of India (CREDAI)
6. Distributed Companies (DISCOMs)
7. Equipment or Materials Manufacturers

3.1.3 Develop and Update Building EE Rating and Labels

3.1.3.1 Summary and Motivations

1. Bridge the gap between design intent and actual performance of commercial buildings
2. Build a database of energy use/efficiency in Indian commercial buildings that will become the basis of EE ratings
3. Estimate connected loads for commercial buildings to help set targets based on the energy-efficient characteristics of buildings and avoid rules of thumb

3.1.3.2 Goals and Intended Impacts

1. Develop an EE Scorecard for buildings with specific EE indicators at the building and/or system level
2. Set benchmarks for these indicators including asset and operational ratings; periodically review and update these benchmarks
3. Rate and certify buildings based on the EE scorecards
4. Help determine the building energy data disclosure requirements in commercial real estate transactions to attach higher market (leasing and selling price) value for more energy-efficient properties. Enable cities and/or others in planning departments to aim for higher energy performance in building stock
5. Develop a data-driven framework, consistent with the PAT (Perform Achieve Trade) methodology for industry (e.g. use of sector-focused specific energy consumption norms), to determine energy-intensive commercial buildings suitable for assigning "designated consumers" status[6]
6. Use the framework to accord any incentives or special status (e.g. reduced property taxes for low carbon footprint, reduced electrical tariffs if EE thresholds are met) to highly efficient commercial buildings

3.1.3.3 Potential Users

1. Bureau of Energy Efficiency (BEE)
2. Building developers / owners and tenants

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[6] The Energy Conservation Act (2001) classifies buildings with connected loads of 500kW or more, or contract demand of 600 kVA or more as Designated Consumers (DC), and gives state governments the mandate to direct DCs to perform periodic energy audits.

3. Facility managers
4. Commercial Real Estate Developers Authority of India (CREDAI)
5. Municipal corporations or Urban and Local Bodies (ULBs)
6. Distribution Companies (DISCOMs)
7. Energy Service Companies (ESCOs) and Energy Auditors
8. Rating organizations IGBC, GRIHA, USGBC

3.1.4 Implement Enterprise Energy Management Program

3.1.4.1 Summary and Motivations

1. Enable enterprises to reduce and manage energy costs through EE measures
2. Enable enterprises to comply with EE and environmental ratings required by government, customers or business partners
3. Enable enterprises to comply with EE and environmental ratings in line with corporate values and image
4. Enable enterprises to comply with environmental reporting requirements for listed companies
5. Enable Utilities and Distribution Companies to design and implement demand response programs

3.1.4.2 Goals/Intended Impacts

1. Collect and analyze energy usage data for the whole building with the aim of reducing and/or managing total energy usage for the enterprise
2. Collect and analyze energy usage data for various systems and components with the aim of reducing and/or managing the energy used by these systems
3. Collect and analyze operational parameters of various systems and components with the aim of increasing the operational efficiency of these systems
4. Contribute EE data on the building, systems and components to a national building performance database to help develop building, system and component design and operation guidelines
5. Use demand response as a resource to cut peak demand requirements and ease the pressure on the electrical grid

3.1.4.3 Potential Users

1. Enterprises
2. ESCO’s
3. Energy auditors
4. Facility managers
5. Equipment manufacturers
6. DISCOMs
7. BEE

4 KEY PERFORMANCE INDICATORS (KPIs) AND DATA COLLECTION CONSIDERATIONS

This section details common KPIs which are applicable to all four use cases (including the medium & low priority use cases). KPIs were identified as part of the first commercial buildings sector data framework release. A subsequent data collection template was developed based on these KPIs. This approach was followed in order to assure that the KPIs identified for the first release of the data framework are comprehensive and captures the sector holistically. The KPIs were also prioritized based on the needs of the various stakeholders. The parameters considered for the data collection template (released as the part of the project) are based on their collection feasibility. Additionally, a more detailed data template has been prepared, and may be utilized for any future data collection efforts.

When applying use cases to improve the energy efficiency of buildings, especially when setting building and/or city benchmarks and rating systems, it is important to categorize buildings based on several parameters such as climate, building age, building use, etc., since KPI benchmarks and targets can vary based on these parameters. For example, KPI targets for hotels would be different from targets for hospitals or offices. Further, KPI targets for 5-star hotels may be different from those for 3-star business hotels. Table 4.1 lists the parameters used to categorize buildings.

Table 4.1 Categorization of Parameters for Buildings

Categorization Parameter	Description
Climate Zone	Hot & Dry, Warm & Humid, Composite, Moderate, Cold
Activity	Primary use of building, e.g. Hospital, Hotel, Educational establishments, Retail establishments, Restaurants, Offices etc.
Activity Sub-category	Hotels: Heritage, Luxury, Budget, Resort Hospital: Single-Specialty, Multi-Specialty, Super-Specialty, Clinics, Diagnostic Labs Retail Establishments: Shopping Malls, Large, Medium, Small Retail Stores Educational Establishments: Institutions of Higher Education, Schools Offices: Information Technology (IT), Information Technology enabled Services (ITeS), Public, Non-IT
Age*	Building age, based on specific ranges, e.g. 0-5 years, 5-10 years, 10-20 years and above 20 years

** Building age is an important parameter in Indian context as the country has been recently experiencing rapid rise in air-conditioned buildings along with incorporation of building energy conservation codes (ECBC) and green building rating systems*

4.1 Building Energy Efficiency KPIs

Table 4.2 lists the EE KPI's, their unit of measurement, granularity and the priority for inclusion in the India Commercial Building Data Framework. Use cases 1, 2, 3, and 4 represent the aforementioned four use cases. Use case priority is indicated by H (High), M (Medium) and L (Low). Use case level of granularity is represented by C (City Level), B (Building Level), and S

(System Level). Annexure 1 has more details on each KPI and its applicability to the various use cases.

Table 4.2 EE KPIs

EE KPIs	Unit	Use Case				Granularity		
		1	2	3	4	B	C	S
Annual electrical energy consumed per unit area	$kWh/m^2/year$	H	H	H	H	B	C	
Annual total energy consumed per unit area	$toe/m^2/year$	H	H	H	H	B	C	
Average demand density	kW/m^2, W/m^2	H	H	H	H	B	C	
Maximum demand density (at any TOD)	kW/m^2, W/m^2	H	H	H	H	B	C	
Buildings with cool / green roof	%	H	H	H	H	B	C	
Buildings using wall insulation	%	H	H	H	H	B	C	
Building with single glazing windows	%	H	H	H	H	B	C	
Buildings with double glazing windows and low e-coated glass	%	H	H	H	H	B	C	
Buildings with demand response control systems	%	H	H	H	H	B	C	
Buildings with Building Energy Management systems *(BEMS to be equipped with measuring, monitoring and controlling and must include sub-metering of building HVAC & lighting)*	%	H	H	H	H	B	C	
% of electricity sourced from grid	%	H	H	H	H	B	C	
% of electricity sourced from diesel generator	%	H	H	H	H	B	C	
% of electricity sourced from renewable energy	%	H	H	H	H	B	C	
Passive-cooled (design features) area within building	% or m^2	H	H	H	H	B	C	
Active-cooled area within building	% or m^2	H	H	H	H	B	C	
Use of HVAC control system	%	H	H	H	H	B	C	
Use of lighting sensor & control system	%	H	H	H	H	B	C	
Types of HVAC system	%, Enumerated	H	H	H	H	B	C	
Space cooling efficiency area-wise	m^2/ton		H	H	H	B		
Space cooling efficiency of system	kW/ton		H	H	H	B		
Type of lighting systems	%, Enumerated	H	H	H	H	B	C	
Lighting power density	W/m^2	H	H	H	H	B		
% of total energy use to economic output	%	H	M	M	H	B	C	S
Contracted demand	kW and kVA		H	H		B		
Contracted demand utilization	% or kW		H	H		B		
Annual CO_2 emissions per unit area	$kg/m^2/year$	H	H			B	C	
Aggregate demand	MW	H					C	
Demand that can be curtailed / shed	MW, %	H					C	
ECBC compliance in the city	%	H					C	

Naturally Ventilated buildings	%	H					C	
Mixed mode buildings *(Buildings which are naturally ventilated as well as air conditioned)*	%	H					C	
Active cooled buildings	%	H					C	
Passive cooled buildings	%	H					C	
Buildings with window shading (external)	%	M	M	M	M	B	C	
Annual electrical energy consumed per occupant[7]	kWh/person/year	M	M	M	M	B	C	
Annual total energy consumed per occupant	toe/person/year	M	M	M	M	B	C	
Annual CO_2 emissions per occupant	kg/person/year	M	M	M	M	B	C	
Plug power density (PPD)	W/m^2		M	M	M	B		
Building Window-Wall Ratio (WWR)	%		M	M	M	B		
Cool pavement	%	M					C	
% of total energy used for space cooling	%				L	B		
% of total energy used for space lighting	%				L	B		
UPS System Efficiency (at full charge)	%		L		L			S
% of total energy used for hot water & steam	%		L		L	B		
% of total energy used for cooking	%		L		L	B		
% of total energy used for laundry	%		L		L	B		
Number of commercial refrigeration units	Number		L		L	B		
% of units vertical closed transparent	%		L		L	B		
% of units horizontal closed solid	%		L		L	B		
% of units horizontal closed transparent	%		L		L	B		
Type, capacity & efficiency of hot water / steam systems	Enumerated		L		L	B		
Type, capacity & energy factor of laundry systems	Enumerated		L		L	B		
Type &burner input rates of cooking systems	Enumerated		L		L	B		
Average operating hours of cooking systems	Hours		L		L	B		
% of total electrical energy consumption for ICT	%		L		L	B		

4.2 Data collection considerations

4.2.1 Data Fields

The attached data sheet (Annexure 2) contains the data fields that need to be collected in order to derive the EE KPI's listed in section 4. Broadly, the data fall into the following categories:

- Categorical data such as building activity type, age and location.
- General building-level information such as contact information, occupancy characteristics. Additionally, this category includes data fields' specific to building types, e.g., number of hotel rooms, number of hospital beds, types of meals served in restaurants.

[7] Occupant could be employee (office), bed (hospital), room (hotel), etc.

- Whole building energy consumption for electricity and fuels.
- End use system characteristics for cooling, heating, lighting, water pumping, cooking and service equipment. Data fields for this category include system capacity (e.g. total cooling connected load), demand (e.g. total hot water requirement per month), efficiency (e.g. lighting power density), and system type.

Each data field is defined by a name, unit of measure, and permissible values. Many data fields can be interpreted in different ways depending on the context and will therefore also need a definition and guidance on interpretation.

4.2.2 Prioritization of Data Fields

Data collection for building energy analysis is almost always resource intensive, time consuming and highly prone to data quality issues. Therefore, the scope and priorities for data collection should be carefully assessed and determined based on several key considerations.

- **Start with the use case, not the data.** Always use the specific KPIs and analysis requirements of a use case to determine data needs and priorities. In other words, each data field should have an explicit reason for being included in a data collection effort – either as an input for a KPI or a normalizing/clustering variable.
- **Consider the level of effort.** The level of effort required to collect data varies significantly across data fields. Obtaining the number of guest rooms in a hotel is orders of magnitude easier than obtaining a detailed end use energy disaggregation. It may be worthwhile to assign a 1-5 score for level of effort required to collect the data for each field and using that as a consideration when prioritizing which fields to collect. For critical fields that are very difficult to collect, consider proxy fields that may require less effort. For example, use the nameplate efficiency of a chiller if the actual operational efficiency is not easily obtained.
- **Assess the likelihood of poor data quality.** Some fields may seem easy to collect but may be highly prone to poor data quality. For example, experience indicates that even a seemingly basic data field such as gross floor area can be significantly misreported. For certain building types, alternative measures of floor area may be more reliable. For example, net leasable area is likely to be more reliable because it is has a critical business purpose in leased buildings.

4.2.3 Survey Design and Approach

Once the data fields have been selected and prioritized, the following are key considerations for the survey design and data collection approach.

- **Statistical sampling vs. 'opportunistic' data collection**
  Some use case analysis questions, e.g., obtaining a national or state-level estimate of sector-wide energy use, clearly require using formal statistical sampling methods. However, sampling may require collecting data from buildings for which data collection is especially difficult or even impossible. An alternative approach is to collect data 'opportunistically' i.e. pursue data collection from entities that are supportive and capable of providing data, e.g., large portfolio owners. In theory, such a dataset will not be a true statistical sample but may still be able to address most use case analysis questions with a reasonable level of rigor.

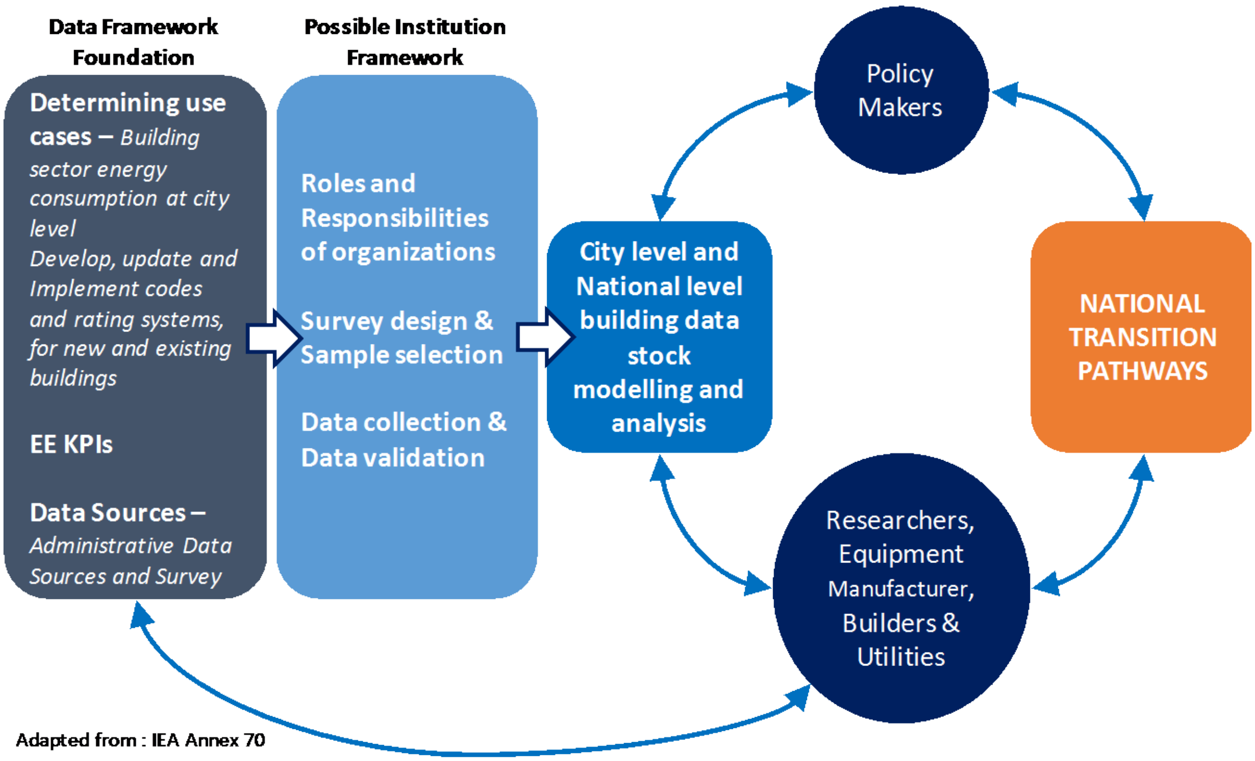
- **Breadth vs. depth of data collection**
  As with any data collection effort with a constrained budget there is a tradeoff between the number of buildings from which data is collected and the amount of data collected from each building. Use case priorities will determine this tradeoff. For example, an initial data collection effort may choose to focus on only a few geographic regions in order to afford more in-depth data for each building.
- **Remote vs. on-site data collection**
  In general, remote data collection (e.g. via telephone, web survey forms, email) requires less effort than on-site data collection. For the scope of data fields addressed with this set of use cases, it may be difficult to completely avoid site visits without seriously compromising data quality, especially for building system characteristics data fields. However, the time spent on-site could be minimized by collecting as much data as possible remotely.
- **Limit the number of touch-points for obtaining the data**
  No one person or documentation system will likely have all the data required for these use cases in any given building. However, as much as possible, the number of touch-points should be limited in order to ease data collection effort. For example, for large portfolio owners there may be a central repository that contains data across all buildings at least for certain data fields.
- **Minimize the burden on the data provider**
  Any tactics that help reduce the time spent by the data provider will help ease data collection. For example, if some data are located in certain documents (drawings, specifications, etc.), the data collector could offer to look up the data in those documents rather than requesting the data provider to do the same.

5 ESTABLISHING AN INSTITUTIONAL FRAMEWORK

A robust institutional framework is essential for ease in data collection, analysis, as well as reporting and tracking energy performance of the building stock. As already established, an up-to-date building energy use dataset enables (1) Adoption of superior energy-efficient building design, operation and maintenance practices, and (2) Better specification and procurement of end-use equipment and systems.

This section presents existing mechanisms to analyze building energy performance in India as well as recommendations to build a robust Institutional framework to enable an up-to-date and more representative understanding of energy use and energy performance of India's building stock.

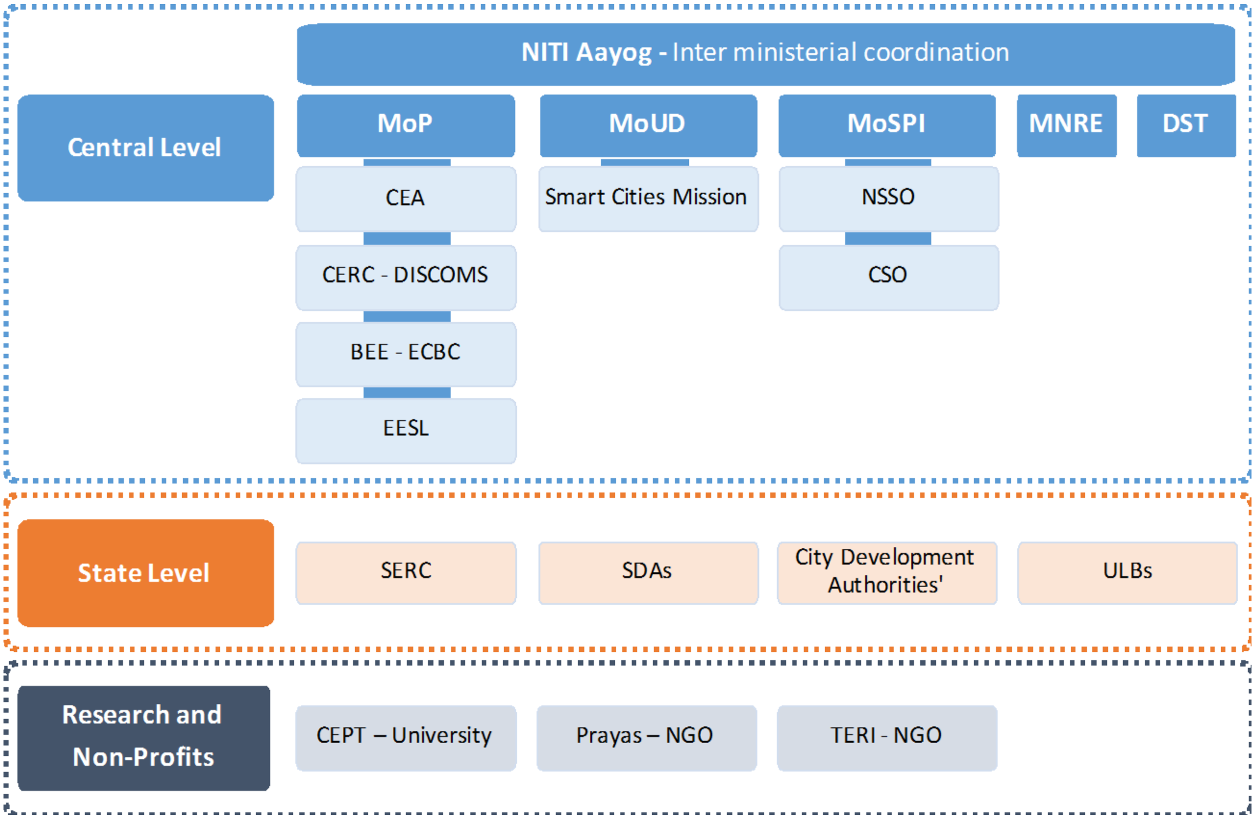
Figure 5.1 Commercial Building Data Framework



5.1 Institutions

Effective and comprehensive analyses and modelling of energy use and energy performance of India's building stock requires data on energy use, building structure & equipment and users/occupants. At present no single institution collects, analyzes and disseminates data on building energy performance. However, several government ministries and departments collect some data on energy, buildings and appliances and equipment that is required for administrative purposes within their respective departments. Figure 5.2 below summarizes government institutions at the central, state, and research or non-profit levels that collect such data.

Figure 5.2 Government and Non-government Institutions



Apart from the government, there are several stakeholders at the city, state and national levels that would benefit from building energy performance information in various ways. Additionally, they could be key contributors by providing data and expertise to institutionalize building energy performance reporting. Such stakeholders are described below.

Utilities and DISCOMS could provide consumer data such as electricity usage, contract demand, connected load, electricity from DG and RE sources, as well as the expertise in collecting and analyzing such data.

Facility managers and ESCOs who are responsible for managing facility costs and energy consumption could share collected/monitored data on building energy consumption, equipment energy performance, building activities and occupancy.

Research Institutions

Building researchers and professionals could provide expertise in collecting and analyzing data.

Real Estate Developers, Equipment and Building Materials Manufacturers

Developers and manufacturers could support the program by assisting in data collection on buildings and equipment, especially given that they may periodically conduct market surveys in order to assess needs.

Table 5.1 and Table 5.2 present an overview of the current data collection, analysis and dissemination functions of various organizations.

Table 5.1 Government Institutions' Collection & Dissemination of Building Energy Data

Institution	Data Collection, Analyses & Dissemination
NITI Aayog	• Formulates National Energy Policy • Develops and manages India Energy Security Scenarios (IESS) tool for modelling energy supply and demand scenarios • Exploring how to implement Energy Data Management at National level • Signed MoU's with IEA and EIA to improve Energy Data Management
Ministry of Power (MoP)	• Has statutory bodies, CEA and BEE, with specific mandates and functions that collect, analyse and disseminate data
⇒ Bureau of Energy Efficiency (BEE)	• Collects energy consumption data from "designated consumers" in the industry sector • Data collection on building energy performance under ECBC is voluntary • Collects sales data on labelled appliances • Limited public access to data; specific data required for research can be requested
⇒ Central Electricity Authority (CEA)	• Collects data on electricity generation and consumption • Has mandate to publish electricity data • Reports on electricity generation and consumption are available on their website
Ministry of New and Renewable Energy (MNRE)	• Collects data on RE appliances availed under schemes for subsidy, incentives, loans; however, there is no track of RE appliances bought outside the scheme
Ministry of Statistics and Programme Implementation (MOSPI)	• Collects some energy consumption data through Census and National Sample Survey Office (NSSO), for e.g. electricity, fuel consumption and appliances in households • Collects enterprise level data about building demographics through economic census conducted every 5-7 years. • Provides support in designing surveys, data collection & data analysis • Has mandate to disseminate statistics • Publishes Annual Energy Statistics Report • Central Statistics Office (CSO) disseminates data to international bodies (UN, IMF) • The Annual Survey of Industries (ASI) collects some energy data such as electricity consumed, electricity generated, fuels purchased and consumed. • An upcoming Annual Survey of Service Sector (ASSS) could be used to collect energy data on commercial buildings
⇒ National Statistics Commission (NSC) *(NSSO and CSO comes under NSC)*	• Recommends measures to improve statistical system and data collection in India

Institution	Data Collection, Analyses & Dissemination
Ministry of Urban Development (MOUD) ⇒ Smart Cities Mission	• Aims to improve public services, accountability and transparency through the use of technology, providing information and services online
State Designated Agencies (SDA)	• Some SDAs identify buildings with a relatively larger contract demand as “designated consumers” and mandate energy audits every year, alongside collection of detailed energy consumption data
Urban Local Bodies (ULB)	• Urban local bodies collect detailed data on building structure, envelope, area, age and activity for planning approval and for collection of property taxes
Department of Science and Technology (DST) ⇒ National Informatics Centre	• Responsible for portal data.gov.in through which NDSAP is being implemented
EESL	• Collects data on LED street light installations and LED bulb distribution for households • Publishes *SLNP Dashboard* with up-to-date information on total LED streetlight installations per state, average electricity saved per light per day, total electricity saved per day, CO_2 emission reduction per day and avoided capacity • Publishes *National Ujala Dashboard* with up-to-date information on number of LED bulbs distributed per state, total electricity saved per day, total cost savings per day, CO_2 emission reduction per day and avoided peak demand

Table 5.2 Other Organizations' Collection & Dissemination of Building Energy Data

Institution	Data Collection, Analyses & Dissemination
CEPT (University)	• Collects detailed building energy performance data for research purposes
Prayas (Non-profit)	• Collects data on the availability and quality of power in households • Has conducted studies on energy data gaps and energy data management
TERI (Non-profit)	• Publishes *TERI Energy and Environment Data Directory and Yearbook*, which includes high level data on commercial and household energy consumption
Utilities	• Utilities collect energy consumption and TOD consumption for billing purposes, which is accessible online to consumers • Some utilities, such as Tata Power Delhi Distribution Limited, conduct surveys to collect energy, building and equipment data
ESCOs	• ESCOs collect detailed energy information when conducting audits and implementing EE projects for buildings
Green and NZEB Buildings	• Infosys and the CII-Godrej buildings have instituted extensive Enterprise Energy Management programs for which they collect and analyze building energy data

5.2 Legislation (Acts, Policies & Regulations)

Enabling state and city governments with the mandate and infrastructure to collect, analyze and publish building energy performance data is a critical step in institutionalizing the system. The Energy Conservation Act (2001) classifies buildings with connected loads of 500kW or more, or contract demand of 600 kVA or more as Designated Consumers (DC), and gives state governments the mandate to direct DCs to perform periodic energy audits. However, this does not cover most buildings, as the majority of buildings fall below the threshold connected load and contract demand.

Table 5.3 provides an overview of the existing legislation that pertain to data collection, analysis and dissemination relevant to building energy use.

Table 5.3 Legislation Supporting Data Collection and Dissemination

Act / Policy / Regulation	Data Collection & Analysis	Data Dissemination
Energy Conservation Act, 2001	• BEE & SDAs can recommend any energy user as a "designated consumer" (DC) • Gives BEE & SDAs the mandate to direct "designated consumers" to perform energy audits and furnish energy consumption data periodically	• No specific provisions mandating data dissemination

Act / Policy / Regulation	Data Collection & Analysis	Data Dissemination
Electricity Act, 2003	• Mandates CEA to collect electricity data • Mandates all entities involved in generation, transmission, distribution of electricity to provide data required by CEA	• Mandates CEA to publish electricity data
• CEA - Furnishing of Statistics, Returns and Information (Regulations, 2007, MoP)	• Mandates all entities involved in generation, transmission, distribution of electricity to provide data in a timely manner in a specified format	
• Energy Conservation – Form and Manner and Time for Furnishing Information With Regard to Energy Consumed and Action Taken on Recommendations of Accredited Energy Auditor (Rules, 2008, MoP)	• Every DC is expected to report on energy consumption every year, within 3 months of end of financial year • Reported data must be authenticated by energy manager appointed by DC and furnished to BEE	• No specific provisions mandating data dissemination
Census Act, 1948 amended 1994	• Mandatory for all citizens to participate • Includes some information on household electricity & fuel consumption, appliances	• Mandates publishing of census data
Collection of Statistics Act, 2008	• Grants central and state governments the power to collect statistics on economic, demographic, social, scientific and environmental aspects • Informants are bound to furnish the required data; refusing to furnish data is punishable • Authorizes statistics officer to access any record or document in the possession of the informant in order to collect the required data	• Mandates confidentiality when publishing data

Act / Policy / Regulation	Data Collection & Analysis	Data Dissemination
National Data Sharing and Accessibility Policy (NDSAP) (2012, Department of Science and Technology)	• Aims to set standards for data, metadata, data management and technology • Facilitates data access and sharing among the public and government departments to avoid duplication of data collection • Government ministries and departments required to upload high value data sets within 3 months of policy notification, and thereafter every quarter	• Applies to all data and information generated, collected and archived using public funds; • Recognizes that non-sensitive government data can be shared with civil society – "all shareable data to be made available on an as-is where-is basis" • Recommends a technology-based culture for data sharing and access, with standards for open access, restricted access and other levels of access

5.3 Recommendations

Mandate for Building Energy Performance Data Collection and Dissemination

Existing provisions within the Energy Conservation Act, 2001 and the Collection of Statistics Act, 2008 could be used to identify all commercial buildings as "Designated Consumers" and mandate the collection and reporting of all data related to building energy performance.

The National Data Sharing and Accessibility Policy (NDSAP), Department of Science and Technology, could be utilized to support the dissemination of building energy performance data in a timely manner to enable both the government and the public to access and use such data.

A "One-Stop" Information Portal for Energy Data Dissemination, Analysis and Modelling

Creating a single portal for all building energy performance data would be the first step in making it accessible to all branches of the government and the public. This would also enable the creation of standards and processes for metadata, data collection, validation, transfer and protection.

NITI Aayog could be the primary organization leading this effort, working with various ministries and government and non-government organizations. NITI Aayog already formulates the National Energy Policy and develops and manages the IESS energy modelling tool. NITI Aayog is also exploring the idea of Energy Data Management and has signed MoU's with IEA and US DOE EIA to help develop such a program.

MOSPI and the National Informatics Centre (NIC), Department of Science and Technology, both of which disseminate data to the public could pool their efforts and expertise in building a common Building Energy Performance Data System under the purview of NITI Aayog.

Standards for Technology, Systems and Processes
The National Data Sharing and Accessibility Policy (NDSAP 2012) (Department of Science and Technology) calls for the development and implementation of standards for metadata, data collection and transfer. Similar standards could be developed for data privacy & protection, data dissemination, interoperability and the use of technology in developing Building Energy Performance Data Systems and Processes.

Data Collection
Several organizations within government and outside government collect data for their own administrative or business purposes, for e.g. utilities, urban local bodies. These "administrative" data sources should be tapped first in collecting data for the Building Energy Performance Data System. Additional data can be collected through detailed field surveys.

Financing and Program Implementation
The Smart Cities Mission, which aims to create at least one smart city in each state, would be a good vehicle for institutionalizing the building energy performance data framework, given its focus on managing water and energy resources, providing a sustainable and healthy environment, as well as its focus on improving accountability and transparency in providing public services.

6 CONCLUSIONS & RECOMMENDATIONS

Enhancing the energy efficiency of the building stock is an important aspect of any national level energy or climate policy. This requires a thorough understanding of building energy consumption patterns. With India ratifying the Paris Agreement on climate change, and the need to track and report progress on actions taken through countries' nationally determined contributions (NDCs), the government will benefit tremendously from a reliable and robust energy data framework to quantify energy consumption and production. The building sector energy efficiency debate in India received a significant boost after the enactment of the Energy Conservation (EC) Act in 2001. The development of the Energy Conservation Building Code (ECBC) followed shortly after in 2007, targeting commercial buildings. Compared to the residential sector where no energy conservation code exits, the launch of ECBC for commercial buildings was a significant step. While the ECBC has been notified in a few states, a decade since its launch there still is no data driven policy framework for systematically targeting and tracking energy performance in both new construction and existing building stock. Additionally, there is no quantifiable mechanism currently in place to track the impact of code adoption through regular reporting/surveying of energy consumption in the commercial building stock – something that is essential for developing updates to the codes or for the purposes of enforcement. The lack of an institutional mechanism has inhibited the collection and/or analysis of empirical building performance data resulting in the absence of a reliable and credible baseline for the commercial buildings sector. Subsequently, it becomes challenging to create a coherent policy and regulatory framework that can quantify the benefits either in terms of reduced energy intensity of the entire commercial building sector or in terms of assessing the improvements in the building stock as a result of a policy measure.

The cross-country comparison covered in section 2 provides a detailed account of the process and value of the existing methods and formats for data collection, validation and reporting. Many of the programs reviewed therein are robust, have technical and statistical rigor, collect comprehensive data on parameters relevant to energy use in commercial buildings, and produce results in an effective, user-friendly format. This is a much needed approach to enhancing EE and enabling evidence based, effective building energy efficiency policy making in India.

Since data collection & disclosure laws are not stringent in India, they can handicap systematic and rigorous data collection efforts, processing and dissemination that is clearly critical in both the public and the private sector. The summary of efforts in India specifically illuminates the need as well as the importance of a comprehensive building energy data set. The review also points to an absence of a coherent strategy and continuity in the past data collection efforts. While the individual activities in India enumerated in this report have provided some understanding of the size, range, and diversity of the building stock and the nature of end-use consumption, however, these efforts, barring a few, have largely been ad-hoc – both in terms of data collection as well as analysis. There is not a single comprehensive data collection activity that has been able to provide a reasonable representation of the commercial building stock in India with adequate coverage of climate zone, building type, size and age, envelope and end-use detail, and demographics. The review of past efforts in India also highlighted the issue of non-existing mandates for data dissemination to the general public, which stymies the involvement of a larger pool of researchers and analysts who could otherwise have contributed to a better understanding of the building sector.

To capture building sector energy use, India needs to follow and adopt robust systems. Roles and responsibilities must be identified at city level, state level and national level and regular monitoring needs to be carried out. The U.S., Europe and Singapore data collection exercises are excellent examples of capturing national level building sector energy use. Apart from data collection efforts, which are carried out globally, other programs/systems have been launched to enhance awareness of building sector energy consumption at building and city levels. For example, the U.S. DOE developed BEDES, an online dictionary to support analysis of measured energy performance of commercial and residential buildings. The dictionary contains terms, definition and field formats to facilitate the exchange of information on building characteristics and energy use. Similarly, the recently launched IEA Annex 70 aids participating member countries in identifying, reviewing, evaluating and producing leading edge methods for studying and modeling the building stock. IEA Annex 70 helps member countries in the task of developing realistic transition pathways to dramatic reductions in energy use and carbon emissions associated with their buildings. Programs like C40- a network of the world's megacities (including six Indian cities) committed to addressing climate change, have outlined an Energy Initiative. The Energy Initiative is committed to address Private Building Efficiency, Municipal Building Efficiency and District Energy.

This study identifies four use cases which address the commercial buildings sector at large. Use cases are a pre-requisite to any data collection exercise. For any national or regional level data collection exercise, performing data collection before developing a framework and determining use cases will often lead to unsatisfactory results. The use cases as discussed in section 3 capture energy consumption ranging from building level to commercial sector level and to the sub-national or city level. KPIs were then developed and prioritized based on these use cases. Additionally, these inputs were discussed and analyzed for their usefulness at a round table that was attended by key stakeholders. A comprehensive data collection template, which organizes commercial buildings under three categories (climate zone, building activity and sub-activity; and age) has also been developed. Approximately 50 mandatory questions have been identified for each building activity type. The questions considered for the first release of the data collection template are based on the collection feasibility of the questions. Annexure 2 provides the detailed sample questionnaire.

The proposed institutional framework is a key contribution of the project. It is envisioned that this effort will help facilitate regular and coordinated data collection, analysis, creation of policies, and evaluation of policies followed by updates to the policies to achieve the desired impact. The institutional framework identifies the roles and responsibilities of the relevant ministries and organizations, lays down procedure for survey selection; and data collection and validation for data driven policies through ECBC, Smart Cities Mission, Green Building Rating tools and data Disclosure mandates. One to one meetings were conducted with relevant stakeholders like BEE, NITI Aayog, MOSPI, SDAs, Tata Power, CEPT, Prayas and CPR and following implications were drawn for the project:

- NITI Aayog is well positioned to form an inter-ministerial steering committee and can also request assistance from international organizations;
- MOSPI's statistical expertise in designing samples and conducting surveys and collaborative spirit could be tapped to help the leading organization with data collection;
- DISCOMs which are identified as DCs under PAT project could be strategically used to support data collection;
- SDAs and Chief Electrical Inspector office can prove key allies in states;
- SDAs, with support from carefully selected technical partner, can carry the pilot in one of the cities and can work on standardizing building data collection for DCs through mandatory energy audit;
- Utilities' role and contribution in this effort is very important; however; utilities lack "building area" information and a unique identifier may help in extracting information across ministries;
- Institutions like CEPT have significant knowledge and capability to be a key contributor in the effort and can provide high quality technical assistance and guidance to survey teams;
- Limited budgets and resource constraints impede the cause of building sector data collection and analysis to some degree.

The launch of India Smart Cities Mission, (in which the government targets 109 cities to institutionalize and employ a data framework), will help establish stringent EE building sector policies and their methodical implementation. India's NDCs to address climate change also outlines EE in the buildings sector as a mitigation strategy for climate change.

Data collection exercises must follow a data collection framework, which includes determination of use cases, identification of KPIs, data collection template and suitable institutional mechanism. Where the use cases identified in this project are applicable to the commercial buildings sector and are based on the scope of any given study, the KPIs and data collection templates can be modified with appropriate justification. To institutionalize the data framework following are key recommendations:

- Mandates for data dissemination: Under EC Act and Statistical Act, organizations like BEE, and MOSPI have been disseminating data; however, additional mandates could catalyze a more systematic data dissemination effort. Some examples include:
    - Through Indian Smart Cities Mission, energy consumption related data disclosure can be mandated. This could be initiated by MOUD at the central government level or through Urban Development departments at the state level;
    - Extending the existing mandate surrounding ECBC compliant buildings in various states should enable data collection and dissemination from these buildings as part of ECBC compliance process;
- Develop a robust strategy to collect existing data: No new legislation is required to collect existing data. DISCOMs already have building energy consumption data and ULBs have building category & structure data. However, how the independent data collection at the city or state level can be channeled in a national building data collection framework may require the involvement of a nodal agency at the national level. A government entity should take charge and execute this initiative. Following are some key steps for this entity:
    - Utilizing existing data with the DISCOMs and ULBs more effectively -- DISCOMs and ULBs have their unique identification numbers for each building, and they could be directed to have common identification numbers, which can enable database design and simplify data extraction and validation for use by different organizations;
    - Post collection of data from utilities and ULBs as a first step; a survey can be conducted for more detailed building energy consumption information on a subset of buildings. To simplify the data collation and compilation process, utilities and ULBs with data in an electronic format could be targeted first.
    - Large organizations like hotels/ hospitals chains, which have a presence across the country, can be requested to supply data under a voluntary/mandatory buildings data disclosure initiative.
- Allocate budget and technical resources for data collection: Before initiating a large scale data collection effort, develop budget estimates and find funding sources. Possible steps for this effort could include:
    - Authorizing a specific agency to set up the data collection framework using lump sum funding, then over the years, move to regular SDA/government funding;
    - Utilizing MOSPI's technical expertise to develop the survey - MOSPI has a wide reach across the country with about 2000 regional offices with total of 8000 employees. MOSPI's significant experience with conducting specific surveys could be utilized to provide technical guidance on instituting and implementing a survey. The concerned ministry/organization will, however, need to provide technical or content related expertise, in additional to aggregating the data.
    - Niti Aayog/ UD/ Smart cities/ BEE could potentially act as the aggregator. Another organization that may have some role to play is MoEF through the NATCOM process, which is tasked with creating emissions inventory for various sectors for communicating to the UNFCCC. It will be important to reconcile the approach they are taking to quantify emissions from the building sector. Further,

State Action Plans are developed as part of the climate change mandate to report on emissions. Organizations/entities with established domain expertise could contribute significantly to this effort through the creating of a technical task force;

- Two-tiered Approach to Data Collection - City and National level:
  - A national level effort could be implemented either through new commercial buildings survey, or through MOSPI's proposed Annual Survey of Services Sector (ASSS) encompassing comprehensive energy related data from buildings/building units. As a second tier, a more detailed but smaller survey can be conducted in select cities to obtain detailed energy consumption data from individual buildings.
  - City level efforts could begin with a few select cities in different regions/climate zone/ tier types, which can be scaled up to the national level through a bottom up approach;
  - 4-5 cities can be considered under the pilot phase depending on the budget available for initiating pilot studies. It may be useful to start with cities that have a reasonable track record for procedure and compliance, to enable easy data collection. Cities covered under the Smart Cities Mission or having electronic data collection capability could be potential candidates.

This study concludes with two major outcomes that may lead to city or national level data collection efforts. These are:

- Collecting and analyzing national level commercial building energy consumption information through MOSPI's upcoming "Annual Survey of Services Sector (ASSS)", as noted above. MOSPI requested assistance in developing a set of questions to be included in an "Energy Block." A list of questions has been shared with MOSPI to be included in the ASSS survey. Once the standing committee of the National Statistics Commission approves the updates in ASSS schedule, MOSPI can start collecting data annually.
- Conducting a pilot survey in 4-5 cities with a view to characterizing the building stock in greater detail. The 3rd and final round table panel constituted as part of the study made a proposal to understand data availability and roles and responsibilities of various organizations within the selected city, prior to launching the survey. The pilot survey as well as the developed data framework will compose part of phase 2 of this project.

Annexure 1: EE KPI Details

Table A.1. Common EE KPIs

EE KPI	Unit	Relevant Use Case & Granularity	Periodicity
Annual electrical energy consumed per unit area	MWh/km^2/year kWh/m^2/year	UC-1: Neighborhood, City, National UC-2, UC-3, UC-4: Building	Annual
Annual total energy consumed per unit area	Mtoe/km^2/year toe/m^2/year	UC-1: Neighborhood, City, National UC-2, UC-3, UC-4: Building	Annual
Annual electrical energy consumed per occupant[8]	kWh/person/year	UC-1: Neighborhood, City, National UC-2, UC-3, UC-4: Building	Annual
Annual total energy consumed per occupant	toe/person/year	UC-1: Neighborhood, City, National UC-2, UC-3, UC-4: Building	Annual
Annual CO_2 emissions per unit area	tons/KM^2/year kg/m^2/year	UC-1: Neighborhood, City, National UC-2: Building	Annual
Annual CO_2 emissions per occupant	kg/person/year	UC-1: Neighborhood, City, National UC-2: Building	Annual
Average demand density	MW/m^2 kW/m^2 or W/m^2	UC-1: Neighborhood, City UC-2, UC-3, UC-4: Building	Averaged over a year
Maximum demand density (at any TOD)	MW/m^2 kW/m^2 or W/m^2	UC-1: Neighborhood, City UC-2, UC-3, UC-4: Building	Highest during the year
Aggregate demand	MW	UC-1: Neighborhood, City	Over a year
Demand that can be curtailed / shed	MW, % of total demand	UC-1: Neighborhood, City	Over a year, based on seasons
Cool pavement	% of total pavement area	UC-1: Neighborhood, City, National	Annual
Buildings with cool / green roof	% of total roof area OR % of total buildings	UC-1: Neighborhood, City, National UC-2: Neighborhood, City	Annual
Buildings using insulation	% of total buildings	UC-2: Neighborhood, City	Annual
Building with single glazing windows	% of total buildings	UC-2: Neighborhood, City	Annual

[8] Occupant could be employee (office), bed (hospital), room (hotel), etc.

EE KPI	Unit	Relevant Use Case & Granularity	Periodicity
Building with double glazing windows	% of total buildings	UC-2: Neighborhood, City	Annual
Building with triple glazing windows	% of total buildings	UC-2: Neighborhood, City	Annual
ECBC compliance in the city	% of total buildings	UC-2: Neighborhood, City	Annual
Contracted demand	kW and kVA	UC-2, UC-3: Building	Annual
Contracted demand utilization	% OR kW	UC-2, UC-3: Building	Annual
Buildings with demand response control systems	% of total buildings	UC1, UC-2: Neighborhood, City	Annual
Buildings with Building Energy Management systems *(BEMS to be equipped with measuring, monitoring and controlling and must include sub-metering of building HVAC & lighting)*	% of total buildings	UC1, UC-2: Neighborhood, City	Annual
% of electricity sourced from grid	% of electricity	UC-1: Neighborhood, City UC-2, UC-3, UC-4: Building	Annual
% of electricity sourced from diesel generator	% of electricity	UC-1: Neighborhood, City UC-2, UC-3, UC-4: Building	Annual
% of electricity sourced from renewable energy	% of electricity	UC-1: Neighborhood, City UC-2, UC-3, UC-4: Building	Annual
Building Envelope: Window-Wall Ration (WWR)	%	UC-2, UC-3, UC-4: Building	One-time / retrofit
Building Envelope: Window glazing / film	Enumerated	UC-2, UC-3, UC-4: Building	One-time / retrofit
Building Envelope: Window shading (external)	Enumerated	UC-2, UC-3, UC-4: Building	One-time / retrofit

EE KPI	Unit	Relevant Use Case & Granularity	Periodicity
Plug power density (PPD)	W/m^2	UC-2, UC-3, UC-4: Building, System	Calculated dynamically, averaged for a year
Passive cooled area within building	% OR m^2	UC-2, UC-4: Building	One-time / change
Active Air-conditioned area within building	% OR m^2	UC-2, UC-4: Building	One-time / change
Types of HVAC system	Enumerated (technology, EE rating)	UC-2, UC-3, UC-4: Building, System	One-time / change
Use of HVAC controls	%	UC-2, UC-3, UC-4: Building, System	One-time / change
Space cooling efficiency	kW/ton OR m^2/ton	UC-2, UC-3, UC-4: Building, System	Calculated dynamically (kW/ton) or seasonally / yearly (m^2/ton)
% of total energy used for space cooling	%	UC-4: Building	Annual
Type of lighting systems	Enumerated (technology, EE rating)	UC-2, UC-3, UC-4: Building, System	One-time / change
Lighting power density	W/m^2	UC-2, UC-3, UC-4: Building, System	Calculated dynamically (W/m^2) and averaged for a year
% of total energy used for space lighting	%	UC-4: Building	Annual
Use of lighting sensor & control system	%	UC-2, UC-3, UC-4: Building, System	One-time / change
% of total energy use to economic output	%	UC-1: Neighborhood, City UC-2, UC-3, UC-4: Building	Annual
Naturally Ventilated buildings	%	UC-1, UC-2: Neighborhood, City	Annual
Mixed mode buildings	%	UC-1, UC-2: Neighborhood, City	Annual

EE KPI	Unit	Relevant Use Case & Granularity	Periodicity
Active cooled buildings	%	UC-1, UC-2: Neighborhood, City	Annual
Passive cooled buildings	%	UC-1, UC-2: Neighborhood, City	Annual

Table A.2. Building Category-Specific EE KPIs

EE KPI	Unit	Relevant Use Case & Granularity	Periodicity
UPS System Efficiency (at full charge)	%	UC-2, UC-4: Building, System	System rating or measured periodically?
% of total energy used for hot water & steam	%	UC-2, UC-4: Building (hotels, hospitals)	Annual
% of total energy used for cooking	%	UC-2, UC-4: Building (hotels, hospitals)	Annual
% of total energy used for laundry	%	UC-2, UC-4: Building (hotels, hospitals)	Annual
% of total energy used for refrigeration units (kitchen)	%	UC-2, UC-4: Building (hotels, hospitals)	Annual
Type, capacity & efficiency of hot water / steam systems	Enumerated (technology, EE rating)	UC-2, UC-4: Building (hotels, hospitals)	One-time / retrofit
Type, capacity & energy factor of laundry systems	Enumerated (technology, EE rating)	UC-2, UC-4: Building (hotels, hospitals)	One-time / retrofit
Type, capacity & efficiency of cooking systems	Enumerated (technology, EE rating)	UC-2, UC-4: Building (hotels, hospitals)	One-time / retrofit
Type, capacity & efficiency of refrigeration units	Enumerated (technology, EE rating)	UC-2, UC-4: Building (hotels, hospitals)	One-time / retrofit
% of total electrical energy consumption used for ICT equipment	%	UC-2, UC-4: Building (offices, hospitals)	Annual

Table A.3. Organizational Capacity KPIs

EE KPI	Unit	Relevant Use Case & Granularity	Periodicity
ECBC Compliance Check Method	Prescriptive or Performance or Trade-off	UC-2: City	Annual
Capacity at ULBs or SDAs to conduct compliance checks of building design and construction	Qualitative, through interviews & surveys	UC-2: City, State	Annual
ECBC compliance application for both prescriptive and performance path	Qualitative, through interviews & surveys	UC-2: City	Annual

Annexure 2: Commercial Building Energy Consumption Survey Questionnaire

Name of Surveyor:

Date of Survey:

BUILDING CATEGORY DATA (Select the relevant data from each column – Mandatory)							
Climate Zone	**Age of Building**	**Activity**	**Activity Sub-category**				
Hot and dry	0-5 years	Hotel	Heritage	Luxury	Budget	Resort	
Warm and Humid	6-10 years	Hospital	Single-Specialty	Multi-Specialty	Super-Specialty	Clinics	Diagnostic Labs
Composite	11-20 years	Educational establishment	Institutions of Higher Education		Schools		
Moderate	20+ years	Retail establishment	Shopping Malls	Large Retail Store *> 5000sqm*	Medium Retail Store *500-5000sqm*	Small Retail Store *50-499sqm*	
Cold		Office	IT	ITeS	Public	Non-IT	
		Restaurant					
Remarks for each category (if any)							

Questions in red and with an asterisk are mandatory					
S.NO.	**QUESTIONS**	**VALUE**	**DATA UNIT**	**PERMISSIBLE UNIT**	**GUIDANCE/ INSTRUCTIONS**
General Information					
1	Facility name*		-	-	
2	Contact person*		-	-	

3	Address*		-	-	
4	Contact number*		-	-	
5	Email ID*		-	-	
6	City/ Town*		-	-	
7	State/ UT*		-	-	
8	Building occupancy type*		-	Owner Occupied, Single Tenant, Multiple Tenants, Landlords + Multi Tenants	
9	Building daily occupancy hours*		-	-Number of hours daily(8/16/24/other)	
10	Building weekly occupancy days*			-Number of Days weekly(5/6/7)	
11	Number of daily shifts carried in the building*		-	One, Two or Three Shifts	
12	Total building occupancy per shift*		-	Number of people per shift (shift 1/ shift2/ shift 3)	
13	Building Management System (BMS) installed in building? * *BMS must include monitoring and measuring. (System controls is optional for BMS). Further, sub-metering must be provided for HVAC and lighting under BMS.*		-	Yes/ No	
Additional Information on OFFICES					
14	Number of organizations within the building complex		-	Single/ Multiple Organizations (Specify total number of multiple)	
15	Building structure owned/leased		-	Owned/ Leased	
16	Data center having connected load more than 100 kW*		-	Yes/ No (Specify connected load kW)	
17	Data center gross area			m^2 or ft^2	
18	Data center monthly energy consumption			kWh	
19	Data center peak demand			kW	

20	Data center power usage effectiveness (PUE)		-	PUE value	
Additional Information on HOSPITALS					
21	List specialities of hospital*		-	Name	
22	Total number of beds in hospital*		-	Number of beds	
23	Hospital ownership type*		-	Private/ Public	
24	Total full time hospital staff		-	Number	
25	Number of inpatients in an year		-	Number	
26	Number of outpatients in an year		-	Number	
Additional Information on HOTELS					
27	Hotel service class*		-	1/2/3/4/5 star	
28	Total number of rooms in hotel*		-	Number of rooms	
29	Average room occupancy		-	Percent	
30	Number of Banquets/ Conference guests per year		-	Number	
31	Number of swimming pools in the hotel		-	Number	
32	Provision of laundry service at the hotel		-	Yes/ No	
33	Average quantity of laundry handled per day		-	kg	
Additional Information on INSTITUTIONS					
34	Type of establishment*			Primary school/ Secondary school/ Senior secondary school, Institution for higher education (BA/MA/B.Tech/M.Tech etc.)	
35	Hostel facility provided on campus*		-	Yes/ No	
36	Total number of students*		-	Number of students per shift	
37	Total number of permanent faculty		-	Number of faculty per shift	

38	Data center having connected load more than 100 kW*		-	Yes/ No	
39	Data center gross area			m^2 or ft^2	
40	Data center monthly energy consumption			kWh	
41	Data center peak demand			kW	
42	Data center power usage effectiveness (PUE)		-	PUE value	
Additional Information on RETAIL ESTABLISHMENTS					
43	Operator type		-	Single/ Multiple operator (Specify number if multiple)	
44	Total number of restaurants (if any)		-	Number of restaurants	
45	Average type of meals served in the restaurants (shopping mall/ large retail store)		-	Breakfast/ Lunch/ Dinner/ Coffee/ Snack/ Dessert	
46	Average occupancy rate of the restaurants		-	Occupancy rate	
Additional Information on RESTAURANTS					
47	Average type of meals served in restaurant		-	Breakfast/ Lunch/ Dinner/ Coffee/ Snack/ Dessert	
48	Average occupancy rate		-	Occupancy rate	
Building Construction					
1	Building construction year*		-	Year	
2	In which year was the last major renovation done* *(if applicable)*		-	Year	
3	Building longer façade orientation*		-	North-South/ East-West/ NorthEast-SouthWest/ SouthEast-NorthWest	
4	Building window to wall ratio (WWR)*		-	WWR value (>50%/ <50%)	
5	Building roof type – Cool Roof/ Green Roof*		-	Yes/ No (Specify green/ cool roof)	Yes if only provided for more than 50% of roof area

6	Number of floors in building*		-	Number	
7	Number of basements in building*		-	Number	
8	Total site area*			m^2 or ft^2	
9	Total built-up area*			m^2 or ft^2	
10	Total built-up area excluding parking (includes parking in basement areas even if partially used for the purpose)			m^2 or ft^2	
11	Total parking area (includes parking in basement areas even if partially used for the purpose)			m^2 or ft^2	
12	Total area for service floors/areas (includes services in basement areas even if partially used for the purpose)			m^2 or ft^2	
13	Total carpet area			m^2 or ft^2	
14	Type of glazing on building north facade		-	SGU(clear/tint), DGU(clear/tint), TGU(clear/tint) - (Indicate the type installed more than 50% for each façade)	SGU – Single glazed unit, DGU – Double glazed unit, TGU – Triple glazed unit
15	Type of glazing on building south facade		-		
16	Type of glazing on building east facade		-		
17	Type of glazing on building west facade		-		
18	Wall insulation provided for all facades		-	Yes/ No	
19	'Green Building Certification' received by building		-	Yes/ No	
20	Specify the Green Building Certification rating authority		-	GRIHA, IGBC, LEED, EDGE (any other)	
21	Number of stars/points /grade achieved in Green Building Certification		-	Number of stars/ points/ grade/ other	
22	Year of award of the rating		-	Year	
23	Year of renewal of rating		-	Year	
Building Energy Consumption					
1	Sanctioned contract demand for building*			kVA	
2	Building total connected load*			kW	
3	Building monthly electricity consumption from the grid*			kWh or units (Specify for each month)	
4	Building monthly electricity consumption from RE installed on site (if any)*			kWh (Specify for each month)	

5	Building monthly electricity consumption from RE installed on offsite (if any)*			kWh (Specify for each month)	
6	Building monthly electricity consumption from DG or non-RE*			kWh or units (Specify for each month)	
7	Capacity of RE installed on site*			kW	
8	Capacity of DG set on site			kW	
9	Average number of hours DG is operational		-	Hours	
10	Electricity produced on site from RE per month (if any)			kWh	
11	Building peak demand			kW	
12	Types of fuel used on site for electricity generation, contributing to more than 5% in total electricity demand*		-	Gas/ Diesel/ Other (Specify name)	
13	Quantity of each fuel used per month on site*			kg or kl (specify quantity for each fuel type)	
14	Willing to participate in Demand Response (DR) programme		-	Yes/ No	
15	Building demand that can be curtailed			kW	
Building Energy Consumption for Cooling					
1	Building total cooling connected load*			kW	
2	Type of cooling system provided for building*		-	Passive Cooling System (design feature), Active Cooling/ Both/ None	
3	Number of months space cooling is operational*		-	Number of months	
4	Average number of hours space cooling is operational*		-	Number of hours	
5	Average cooling set point temperature*			Temperature	
6	Are cooling controls provided in the building*		-	Yes/ No/ Partly	
7	Building air conditioned gross area			m^2 or ft^2	
8	Building air conditioned carpet area			m^2 or ft^2	
9	Building monthly energy consumption for cooling			kWh	
10	Number of fans installed in building		-	Number of fans	
11	Number of fans installed in active cooled area		-	Number of fans	

12	Type of passive cooling system (design feature - if any)		-	Air cooling towers/Earth air tunnel/Solar chimneys/ Other(Specify type)	System installed for more than 30% conditioned area
13	Type of active cooling system – Refrigerant based or Non-refrigerant based (if any)		-	WRAC-mini splits, CUAC air cooled, Multi-splits/Cassette, Air-cooled chiller, Water-cooled chiller, Radiant cooling etc.	System installed for more than 30% conditioned area
14	How much area is passive cooled (if any)			m^2 or ft^2	
15	How much area is active cooled (if any)			m^2 or ft^2	
16	Cooling system capacity			kW or RT (Mention capacity of each cooling system)	
17	Energy efficiency rating of cooling system (BEE rating)		-	1/2/3/4/5 star (Mention rating for each cooling system)	
18	Energy efficiency ratio (EER) of cooling system		-	EER value	
19	Year of award of EER and rating		-	Year	
Building Energy Consumption for Heating					
1	Building total heating connected load*			kW	
2	Type of heating system installed in the building		-	forced-air or radiant (specify any other)	
3	Number of months space heating is operational*		-	Number of months	
4	Average number of hours space heating is operational daily*		-	Number of hours	
5	Average heating set point temperature*		-	Temperature	
6	Are heating controls provided in the building*		-	Yes/ No/ Partly	
7	Building gross heated area			m2 or ft2	
8	Building heated carpet area			m2 or ft2	
9	Building monthly energy consumption for heating			kWh	

10	Heating system capacity			kW	
Building Energy Consumption for Lighting					
1	Building total lighting connected load*			kW	
2	Type of lamps installed in building (Specify type of lamp along with wattage and total number)			Lamp type (Number & Wattage of each lamp) (Type of lamps – LED, CFl, GSFL, MH, HPSV, HPMV etc.)-	Mention types having total installed capacity more than 5% of the total installed capacity
3	Average number of daily operating hours of indoor lights*			Hours	
4	Average number of daily operating hours of outdoor lights*			Hours	
5	Building monthly energy consumption for lighting			kWh	
6	Building average Lighting power density (LPD)			W/m^2 or W/ft^2	
7	Specify whether lighting controls are installed in building			Yes/ No/ Partly	
Building Energy Consumption for Water Pumping					
1	Connected load for pumping ground/ municipal water*			kW	
2	Monthly energy consumption for pumping ground/ municipal water			kWh	
3	Pumps daily average operational hours		-	Hours	
4	Wastewater treatment system connected load*			kW	
5	Monthly energy consumption for treating waste water			kWh	
6	Building total hot water requirement per month			kl	
7	Type of building water heating system		-	Electricity/ Solar/ Gas	
8	Total connected load of water heating system (if electricity)*			kW	
9	Monthly energy consumption of water heating system (if electricity)			kWh	
10	Installed capacity of solar water heating system (if solar)			kW	
11	Monthly quantity of gas/other fuel used for water heating			Kg or kl	
Building Energy Consumption for Cooking					

1	Type of cooking fuel used in building		-	Electricity/ Gas	
2	Total connected load for cooking systems (if electrical)			kW	
3	Annual energy consumption for cooking systems			kWh/kBtu	
4	Quantity of gas/other fuel used for cooking			Kg or kl	
5	Number and type of refrigeration units used in kitchen			Mention all type and the number of units	
6	Installed capacity of each type of refrigeration unit			kW	
Building Energy Consumption by Service Equipment					
1	Number of Lifts/ Escalators/ Travelator used in building			Number	
2	Type of Lifts/ Escalators/ Travelator installed in building			Geared, Gearless, Regenerative lift, Sensor Based etc.	
3	Total connected load for each of the Lifts/ Escalators/ Travelator			kW	
4	Monthly energy consumption for Lifts/ Escalators/ Travelator			kWh	

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