

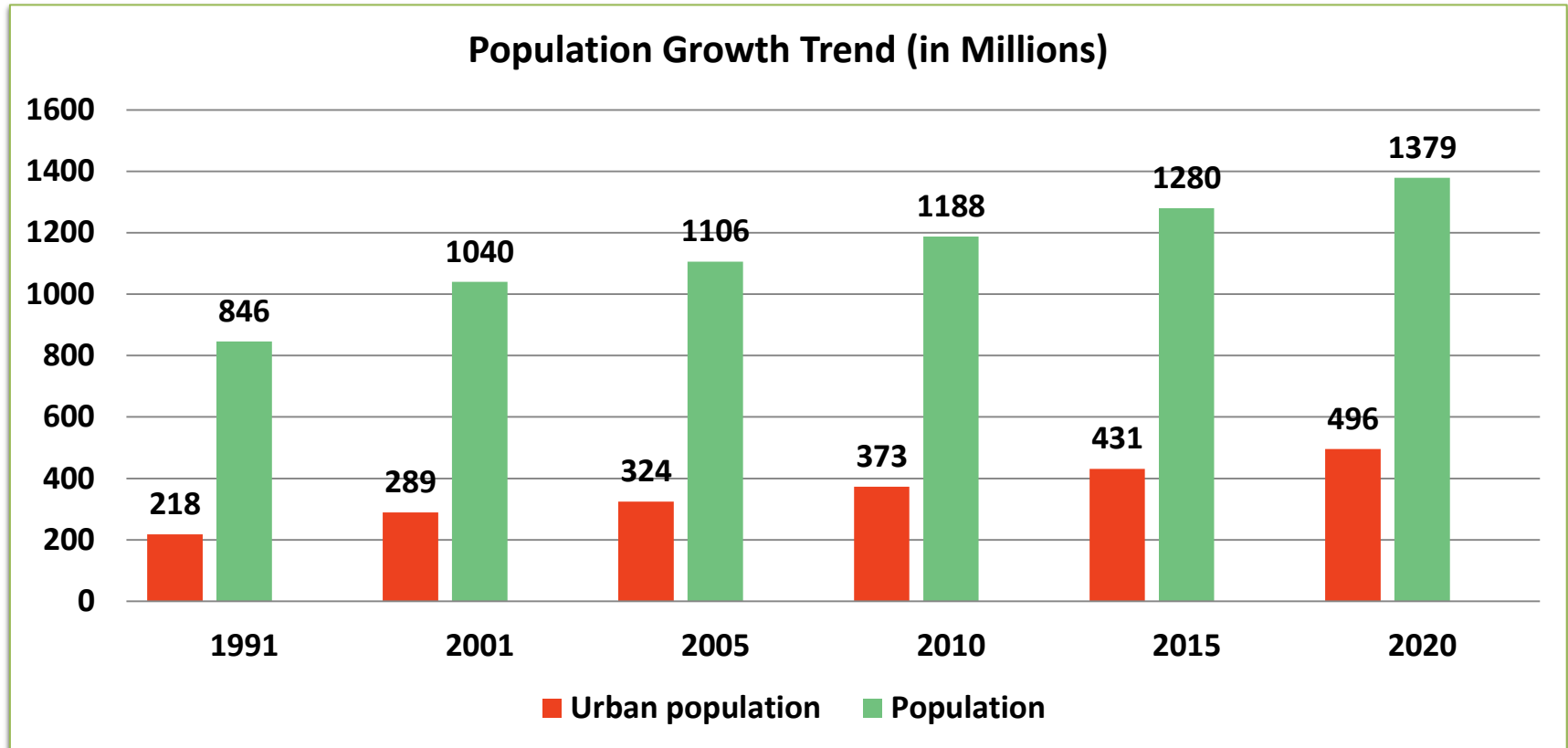
TERI-UTC Center of Excellence (CoE) on Energy Efficient Buildings in India

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TERI

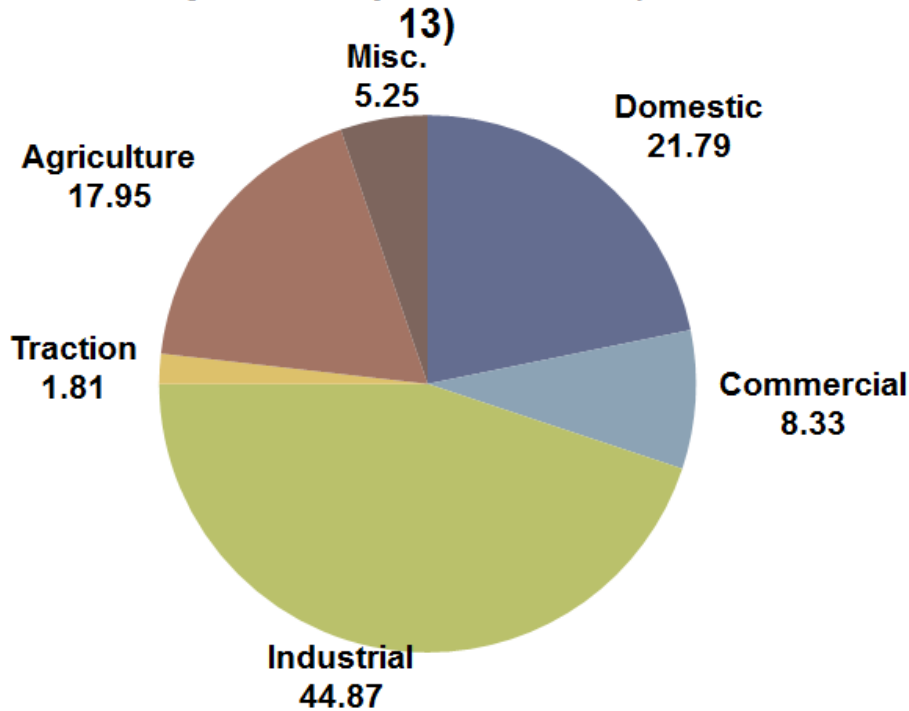
Urbanization in India



- Urbanization has increased from **26% in 1991 to 34% in 2015** and is expected to increase to **36% by 2020**
- By 2020 almost **500 Million** people will be living in Urban India

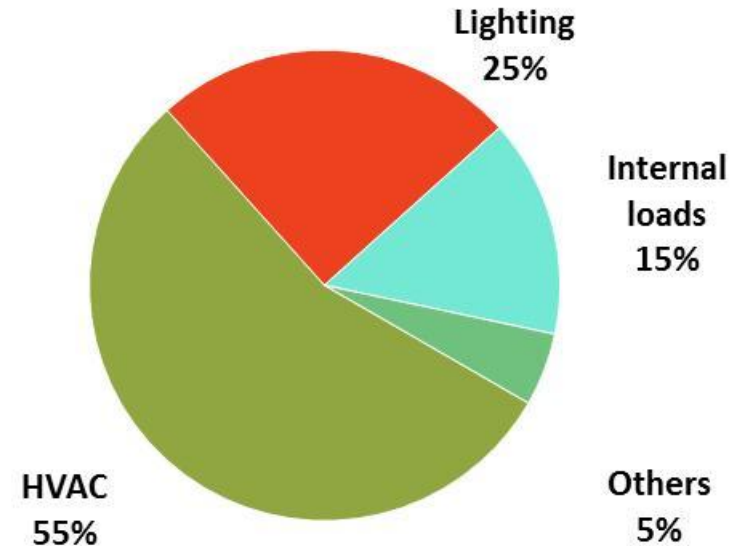
Sector wise electricity consumption in India

Electricity consumption in India (Year 2012-13)



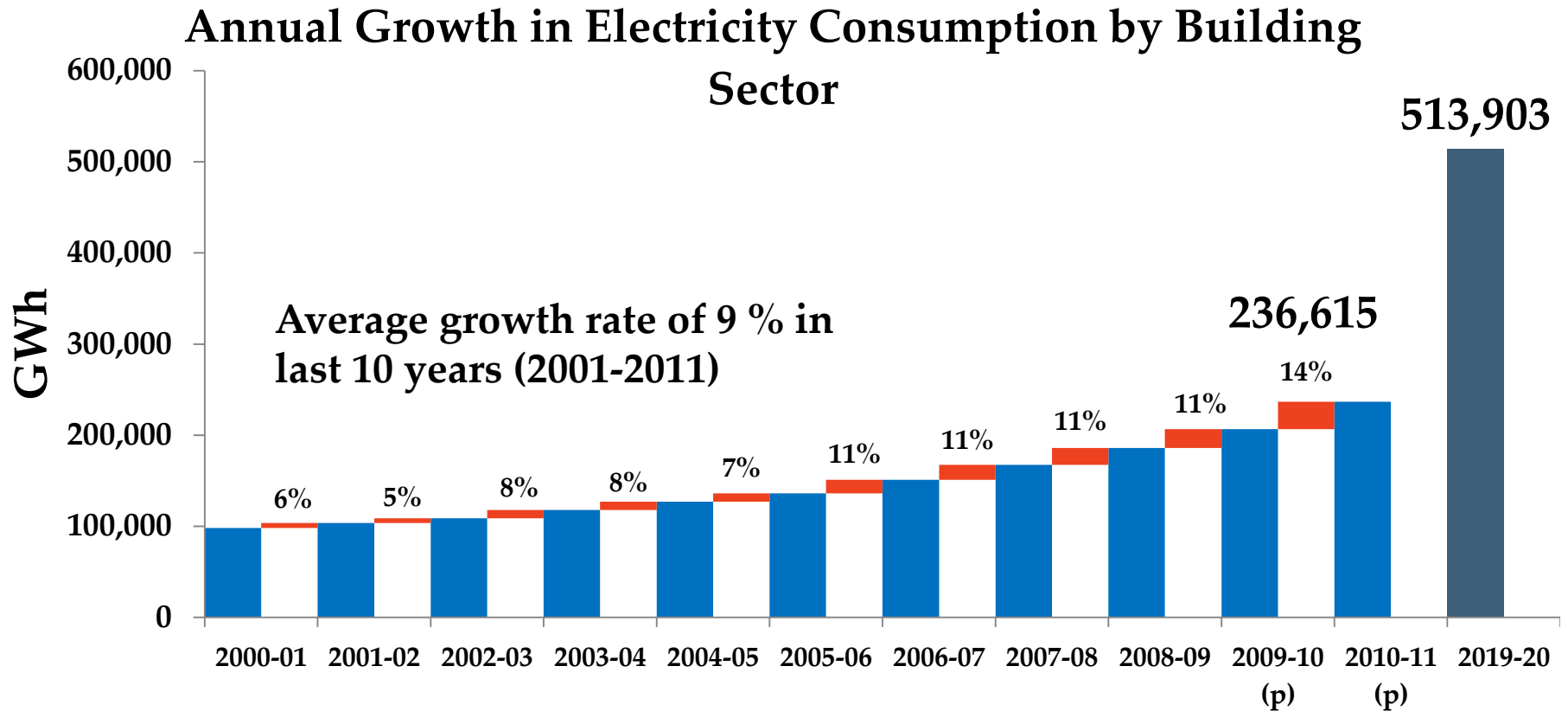
Residential & Commercial sector contributed to **30%** of total electricity consumption

Electricity Consumption Distribution in Commercial Buildings



55% of electricity consumption is due to HVAC
25% of electricity consumption is due to lighting

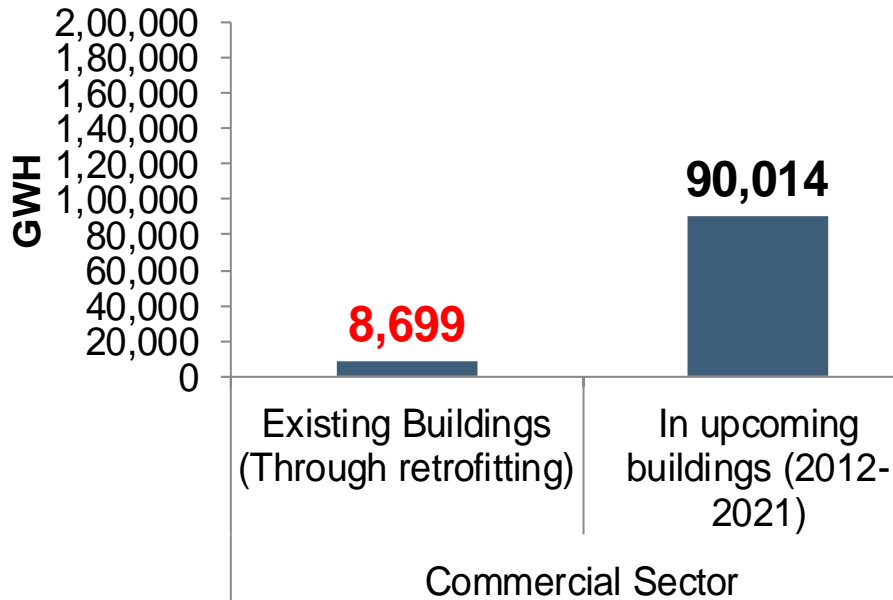
Electricity consumption growth in commercial buildings in India



At a conservative **9 %** growth rate, electricity consumption of building sector by 2020 will be more than **2 times to** the consumption in 2010-11

Energy Saving Potential

Estimated Electricity Saving Potential of Building Stock (2021)



Building Envelope



Lighting



Chillers



Automation

Saving potential in existing buildings- 8700 million kWh and 74 lakh tonnes of CO2

Enabling Mechanism for energy efficient buildings in India

Codes/standards and labeling

- Energy conservation building code (ECBC)
- National building code (NBC)
- Star rating of appliances

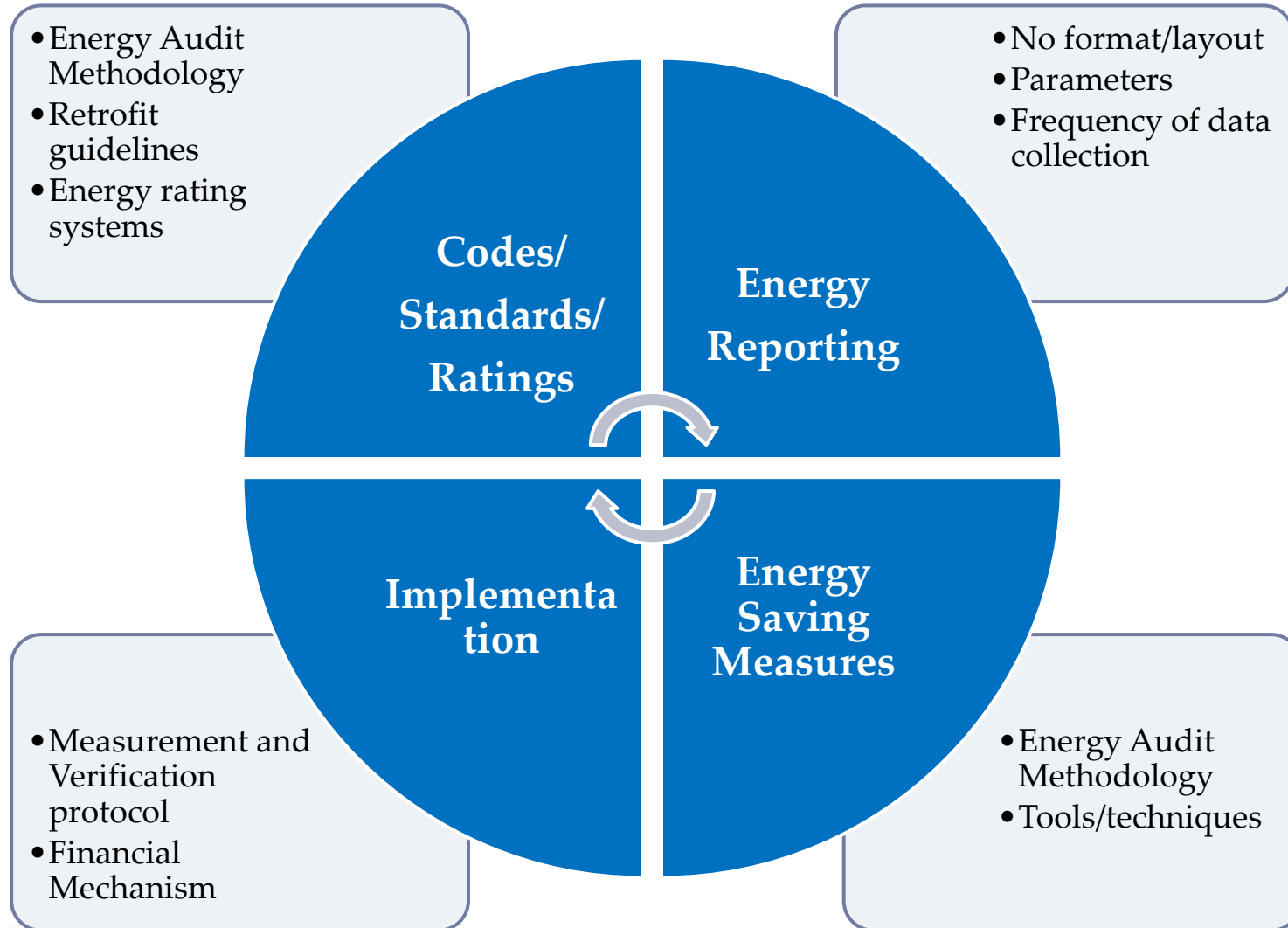
Rating systems

- BEE star rating for existing buildings
- GRIHA-National rating system for new buildings
- LEED and IGBC rating system for buildings

Smart city program

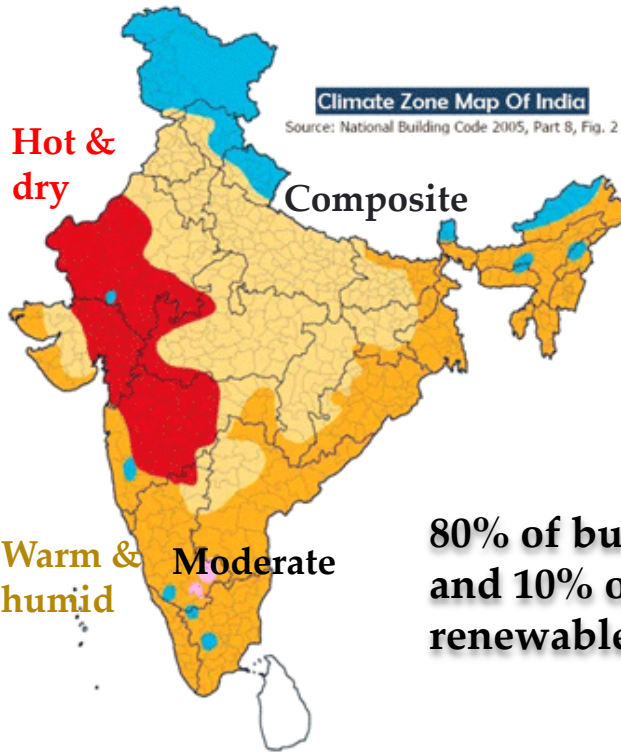
- 80% of buildings to be green and energy efficient
- 10% of power consumed should come through renewable energy source

Gaps and Barriers



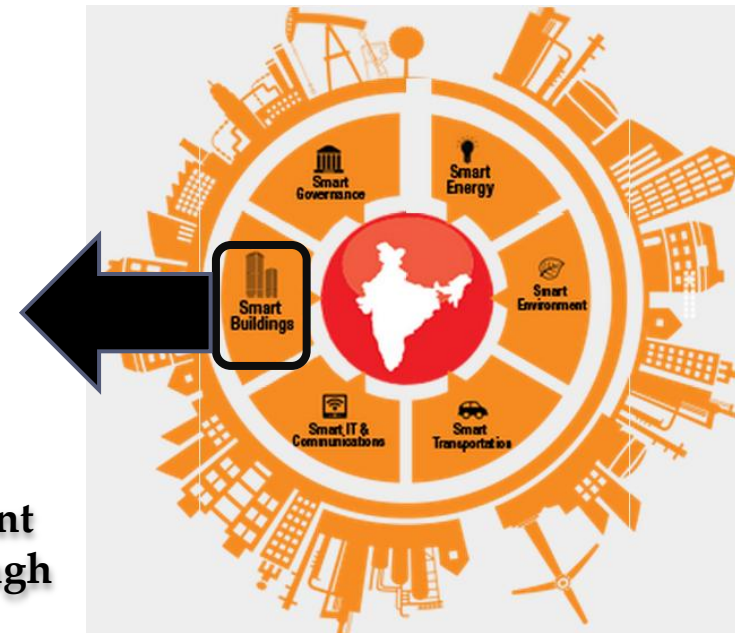
TERI-UTC Center of Excellence (CoE) for Energy Efficient Buildings in India

Energy performance assessment of **100 buildings** in Indian cities



Cities planned under **Smart Cities Program** launched by **Indian Government**

80% of buildings to be energy efficient and 10% of power should come through renewable source.



Stakeholders

BEE, MoUD, SDAs, Building owners/developers, EESL, CPWD, financial institutions/banks,

TERI-UTC CoE- Main outcomes

Energy Reporting

- Development of energy use **Reporting Framework** for the existing building sector

Tools and Techniques

- Derivation of tool and techniques for identification and cost benefit analysis of **Energy Conservation Measures**

Implementation

- Development of **Measurement and Verification (M&V) Protocol** for implementation of the various energy conservation measures

Financial Mechanisms

- Development of **Financial Mechanism** for facilitating retrofits

Communication Strategy

- Development of **communication strategy** between building owners, financial institutions, and energy services companies

Codes/standards/rating systems

- Evaluation of the existing **Building Energy Codes/Standards/Rating Systems**

Benefits and opportunities

Govt and ongoing programs on building EE

- Contribution to India's INDC targets
- Inputs to existing building rating system (BEE star rating, LEED EBOM)
- Integration with Smart cities program of India
- BEE chiller labelling program

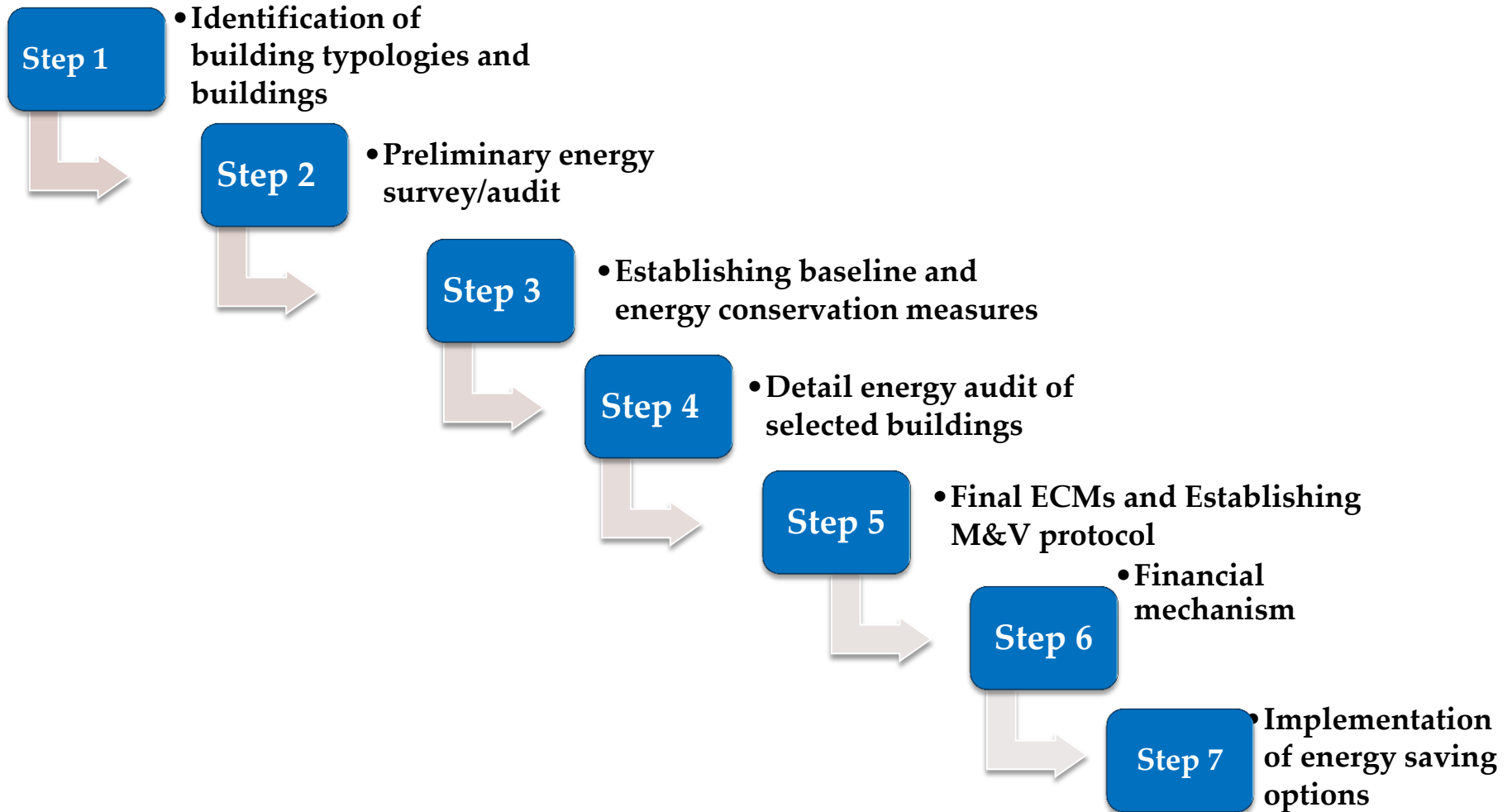
Building owners

- Energy assessment
- ECM identification and cost benefit analysis
- Energy report
- Retrofitting

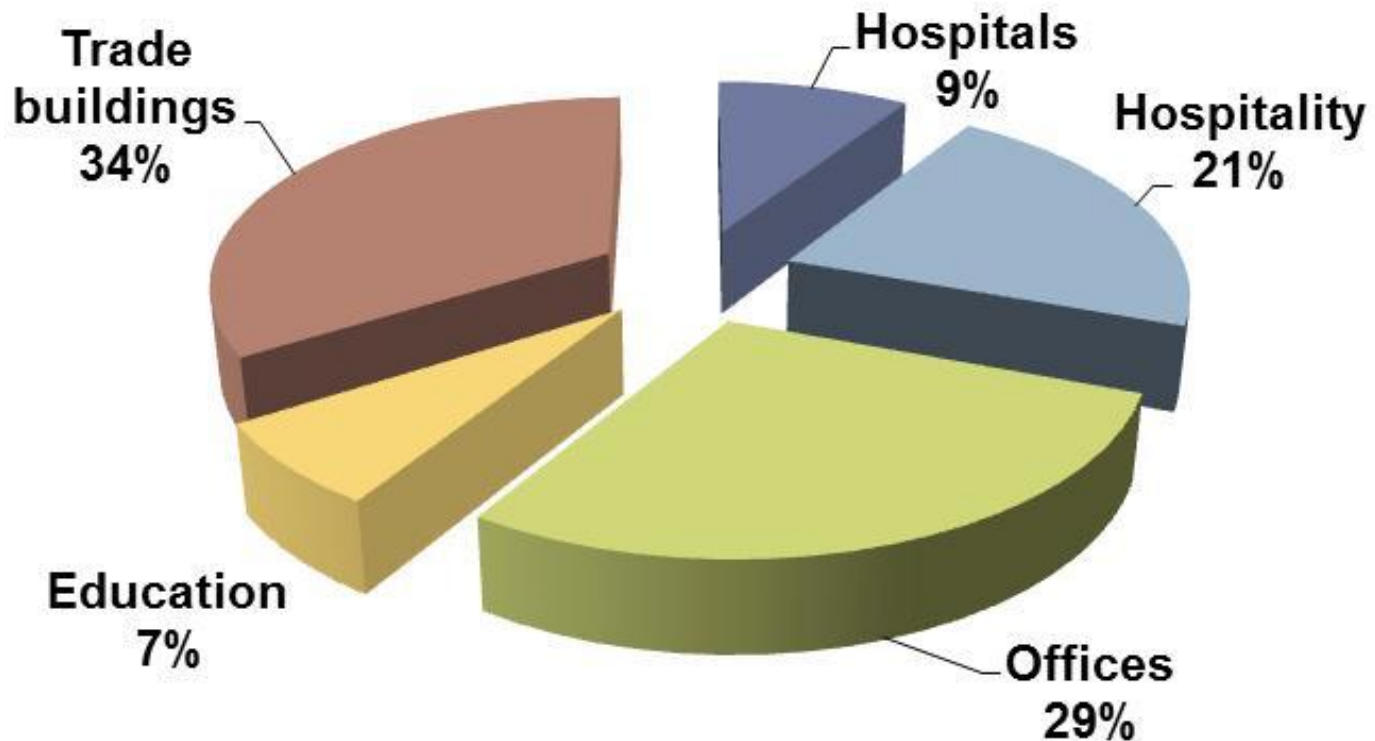
Industry

- Business opportunity for building industry including
 - Glass
 - Roof materials
 - Electrical systems
 - Lighting and controls
 - HVAC and controls

Methodology

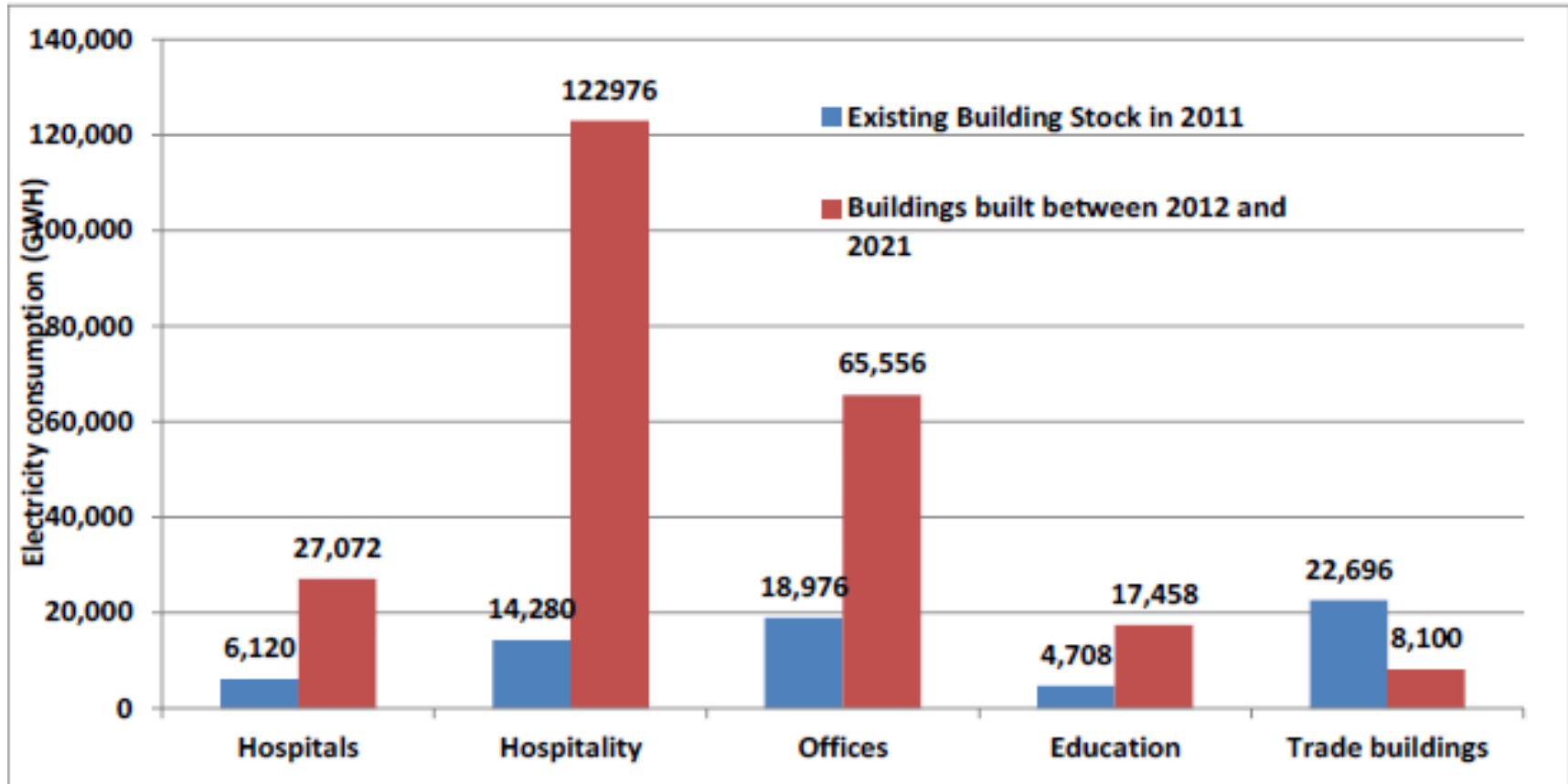


Energy consumption in commercial buildings in India



Offices , Hospitality and Hospital sector constitutes almost **60%** of **total energy consumption in commercial buildings**

Energy consumption growth rate in commercial buildings in India



Energy consumption growth rate in hospitals, hospitality and offices sector is around **300%, 700% and 250% by 2021, taking 2011 as reference**

Building typologies and number of buildings

▶ Offices (Daytime and 24 hours)	50
▶ Hospitals	25
▶ Hotels	25

Energy survey status

Energy survey status	
Offices	9
Hospitals	8
Hotels	3

Energy survey at 20 buildings have been completed

Energy Survey

Detail Energy (ASHRAE Level II)

Collection of design data

Collection of operating data using BMS/log books

Building energy systems/HVAC plant monitoring using appropriate instruments

Energy conservation measures

Energy bill

- ▶ Demand charges reduction
- ▶ Power factor improvement
- ▶ Harmonics improvement

Lighting system

- ▶ LEDs installation
- ▶ Daylight controls and occupancy sensors

HVAC

- ▶ Chillers resizing and replacement
- ▶ Unitary ACs replacement
- ▶ VFD installation on CSD chillers
- ▶ Chiller plant manager installation
- ▶ Chiller plant optimizer installation
- ▶ Replacement of inefficient pumps

Building envelope

- ▶ High reflective paints on roof
- ▶ High performance glass

Electrical

- ▶ Replacement of undersize and inefficient motors with efficient motors
- ▶ Smart energy meters

Building management system (BMS) installation

Outcomes-Energy saving measures

Efficient glass and roof



5% energy savings

Energy efficient lighting system



10% energy savings

Energy efficient chillers, pumps and fans

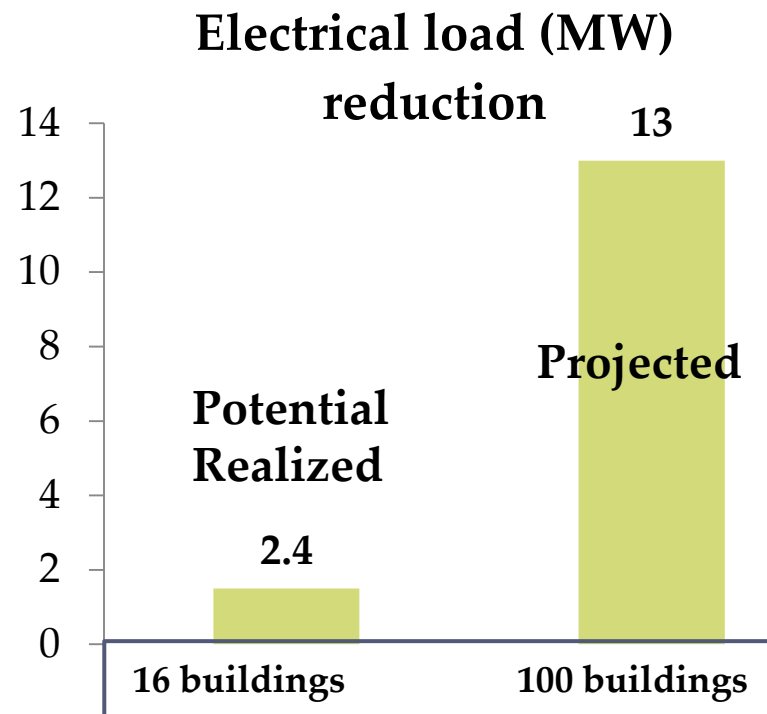
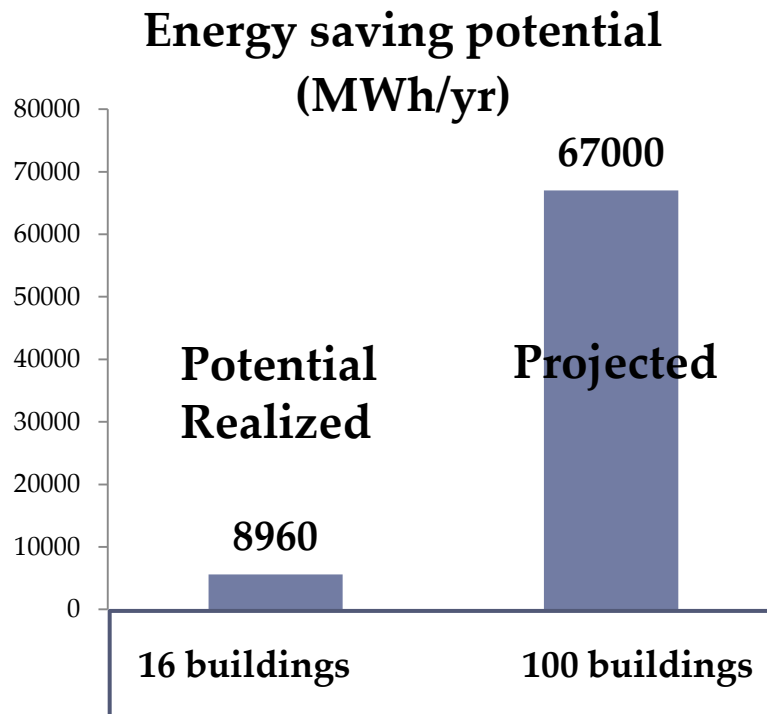


15-20% energy savings

Energy Saving potential-16 buildings

Energy saving potential (million kWh/yr)	8.9
% energy saving potential	18
Monetary savings (million USD/yr)	1.17
Investment (million USD)	2.38
Simple payback	2

CoE outcomes-Potential energy savings

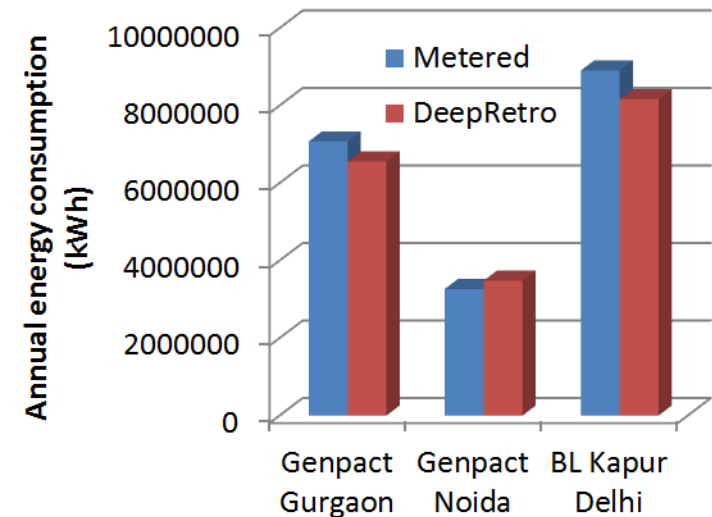


Energy saving achieved through 100 existing buildings is sufficient to power more than **2000 urban homes** or more than **12000 rural homes**

Tool for building energy analysis

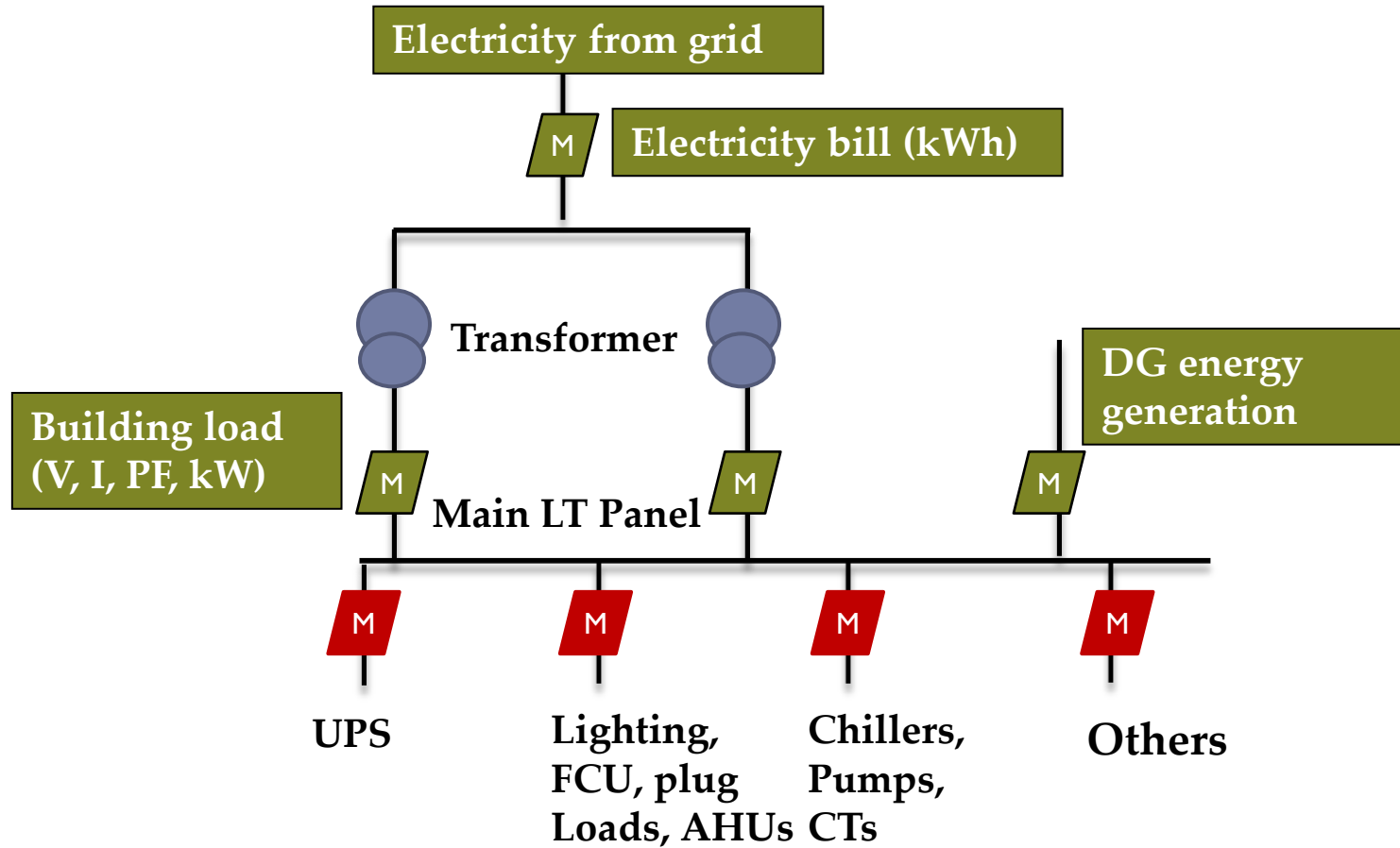
Simplified tool- Deep retro

- ▶ Indian climate data added to Deep Retro.
- ▶ 6 pilot buildings (4 offices and 2 hospital) have been evaluated
- ▶ Deep Retro model predictions for the 6 buildings within 10% of metered data

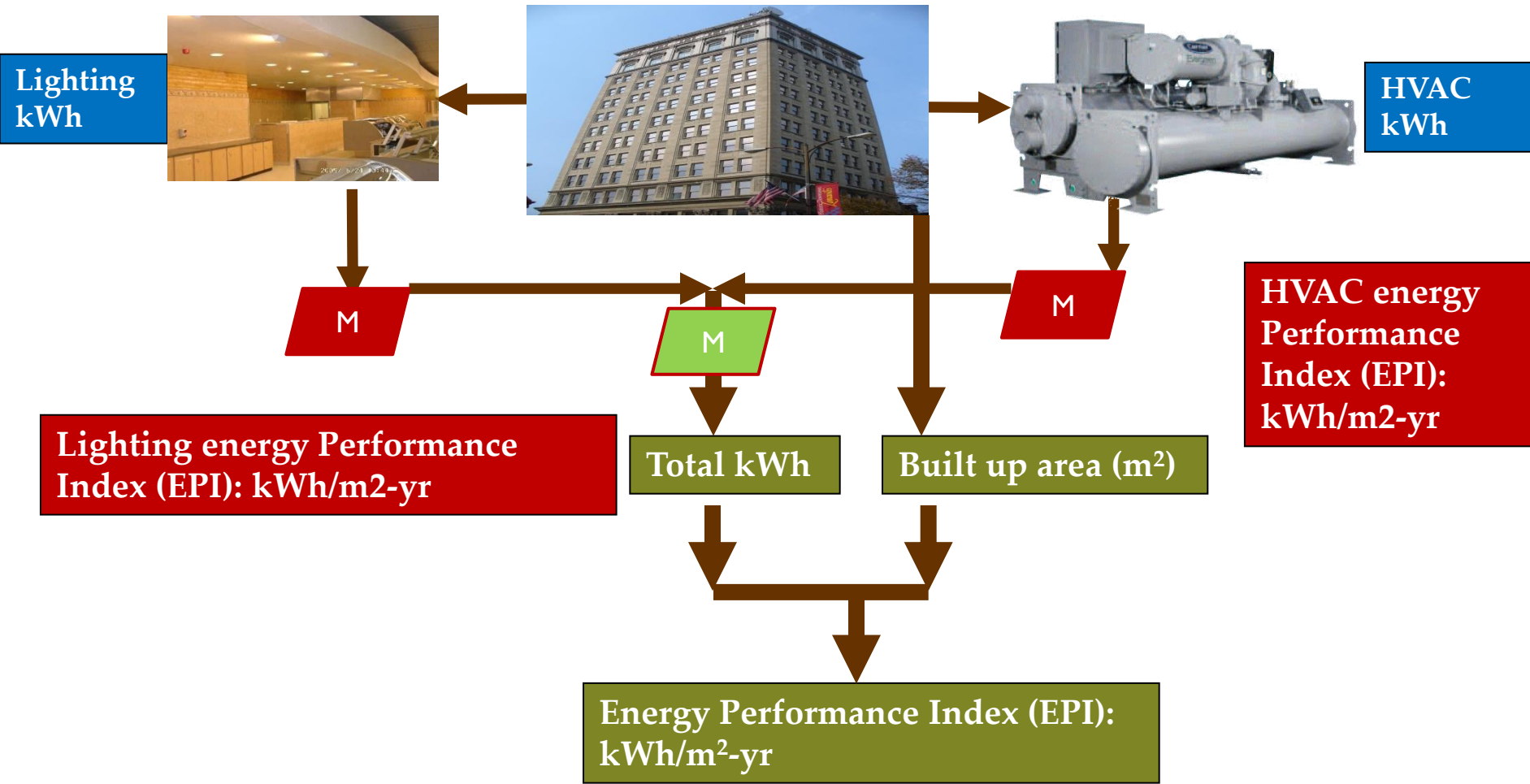


Energy Reporting and Measurement and Verification protocol

Electricity flow in a building



Energy performance Index



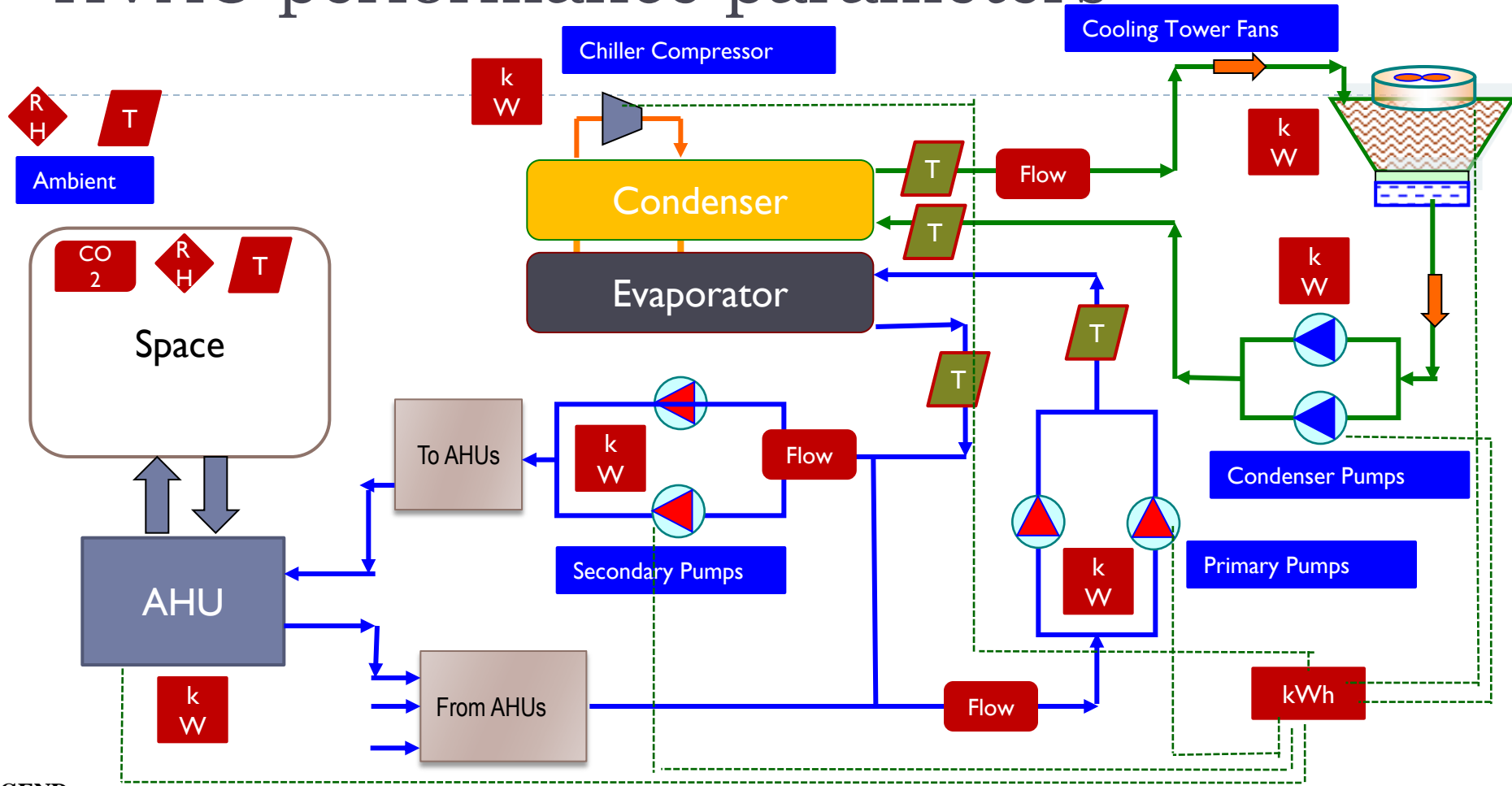
Other performance parameters

- ▶ Transformer losses (%)
- ▶ Load densities (W/m^2)
- ▶ Motor loading (%)
- ▶ Motor efficiency
- ▶ Power quality (Voltage, power factor, **harmonics**)











HVAC performance parameters

	ikW/TR
Chiller	
Primary chilled water pump	
Secondary chilled water pump	
Condenser water pump	
Cooling tower fans	
AC high side	
AHUs	
FCUs	
AC total	

HVAC performance parameters



LEGEND:

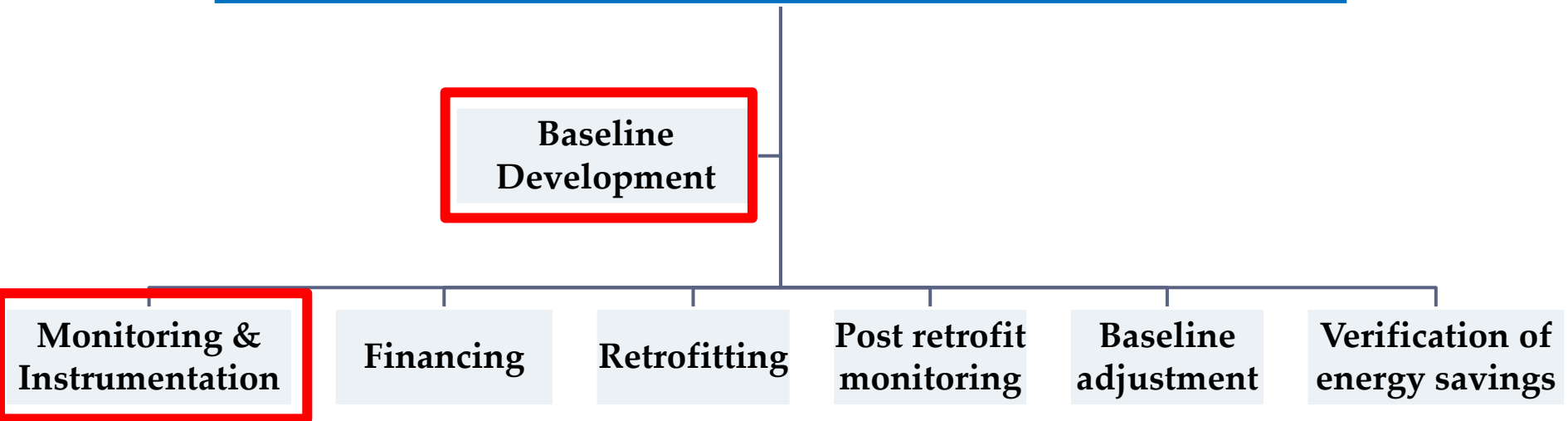
- | | | | | |
|---|--|--|--|--|
|  Chilled Water Line |  Condenser Water Pump |  Temperature Sensor |  Flow Meter |  Power Meter |
|  Condenser Water Line |  Chilled Water Pump |  Relative Humidity Sensor |  CO ₂ Sensor |  Energy Meter |

Log book- Chiller

	Meter	Record
V	Yes	No
I	Yes	Yes
PF	Yes	No
% ampere loading	Yes	Yes
kW	Yes	No
Chilled water supply temperature	Yes	Yes
Chilled water return temperature	Yes	Yes
Condenser water supply temperature	Yes	Yes
Condenser water return temperature	Yes	Yes
Chilled water flow	No	No

Measurement and Verification Protocol

Measurement and Verification Protocol



Outcomes till now-Key points

- ▶ **Developed energy reporting framework for buildings**
- ▶ **Established energy intensities of commercial buildings in India**
- ▶ **Developed contacts with building owners like Google, Genpact, JLL, CBRE etc**
- ▶ **Worked on the development of simplified tools for building energy performance evaluation**
- ▶ **Assessed the existing energy rating systems for buildings in India and in other countries**

Future activities

- ▶ **Industry partners (Lighting, glass, paints, controls) addition to the CoE**
- ▶ **Energy studies at Hotels (Marriott group, Taj group, ITC group), Hospitals and office buildings (Google, Microsoft, IBM, Genpact etc)**
- ▶ **Development of financial models for implementation**
- ▶ **Implementation of already audited buildings.**

Thank You

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