Accelerating Energy Efficiency in Indian Data Centers: Phase II

Confederation of Indian Industry (CII) and Lawrence Berkeley National Laboratory (LBNL)
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1. Background

The significant growth of the Indian IT Industry in recent years calls for a suitable policy that mandates Indian data centers to reduce their energy consumption. Though India has well-established energy efficiency standards in its commercial and industrial facilities, a dedicated standard for data centers does not exist.

To support the development of an energy efficiency policy framework for Indian data centers, the Confederation of Indian Industry (CII), in collaboration with Lawrence Berkeley National Laboratory (LBNL)-U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy and under the guidance of Bureau of Energy Efficiency (BEE), has taken the initiative on "Accelerating Energy Efficiency in Indian Data Centers." This initiative is also part of the larger Power and Energy Efficiency Working Group of the US-India Bilateral Energy Dialogue and consists of two phases: Phase-I (November 2014 – September 2015) and Phase-II (December 2015 – December 2016).

This report documents Phase II of the "Accelerating Energy Efficiency in Indian Data Centers" initiative, which built on Phase I findings related to international best practices and how existing energy efficiency standards in India could address data centers. The Indian standards central to Phase II were the Energy Conservation Building Code (ECBC), which is Prescriptive or Performance Based (Mandatory Code); and the Perform, Achieve & Trade (PAT) market-based scheme in which BEE sets sector-specific benchmarks and gives targets to Designated Consumers (DC).

Phase II consisted of two main activities: the development of recommendations for incorporating data center specific requirements into the 2016/2017 revision of ECBC and the evaluation of various Energy Performance Metrics for reporting data center energy efficiency under a PAT-type programme. Comprehensive policy review and stakeholder engagement were instrumental in both activities.

2. Energy Conservation Building Code (ECBC) for Data Centers

2.1 Policy Review

The Phase I study of over 20 international energy efficiency standards identified ASHRAE 90.1, 90.4 and California Title 24 as warranting further view to guide the integration of data centers into ECBC. The Phase II policy review focused on the standards' Electrical System and HVAC (Heating, Ventilation and Air-Conditioning) requirements to identify data center-specific technical specifications and test methods for incorporation into ECBC.

2.2 Stakeholder Engagement

CII formulated a Large Stakeholder Consultative Group consisting of 40 stakeholders and their involvement through periodic technical discussions and meetings helped CII and LBNL finalize data center specific recommendations for incorporation in the new ECBC version.

a) Bangalore Workshop (April 1st, 2016)

A focused group discussion was conducted to share the findings of the work done so far under this initiative and more importantly gather valuable inputs from industry stakeholders to finalize the data center-specific technical specifications and recommendations based on international standards (ASHRAE 90.1 and 90.4 and California Title 24).

b) Working Group Meeting (April 29th, 2016)

After extensive follow up discussions with our Advisory group members post-workshop, the recommendations were further revised and presented to the working groups (WGs) for HVAC and Electrical System.

c) National Stakeholder Consultation Meeting on ECBC (May 27th, 2016)

In order to make the ECBC update process transparent and inclusive, BEE and the PACE-D Team organized three stakeholder consultation workshops, one in each zone of the country – west, south, and east. The National Stakeholder Consultation on ECBC was organized to present the ECBC update process and recommendations for the new ECBC that will include data centers.

2.3 Final Recommendations for ECBC New Version

All commercial buildings that must comply with ECBC and have data center operations with an additional connected load of more than 100 kW of IT design load shall comply with the minimum energy efficiency requirements for HVAC and Electrical System presented in Table 1a and 1b.

Table 1a: ECBC Recommendations - HVAC System

Sections	Suggested Additions by CII & LBNL based on Stakeholder Consultations	Inclusion in ECBC 2016/2017
Minimum Equipment Efficiencies	As per ECBC 2016/2017 (draft version) Requirements, with the addition of: Air conditioners and condensing units in data centers (CRAC units) shall have a minimum Sensible Coefficient of Performance (SCOP) value of 2.5. ANSI/ASHRAE 127 standard to be followed as the test method for efficiency.	DC specific performance requirements for CRAC units incorporated.
Air Economizers and Water Economizers	Since economizers are not common in Indian data centers, this requirement is waived off.	No specific waiver for data center economizers provided.

ECBC Recommendations - HVAC System (Contd.)

Sections	Suggested Additions by CII & LBNL based on Stakeholder Consultations	Inclusion in ECBC 2016/2017
Data Center Air Management System	Data centers designed for air-cooled equipment and with an IT design load exceeding 100 kW/ room shall include air barriers such that there is no significant air path for computer discharge air to recirculate back to the computer inlets without passing through a cooling system. Target IT inlet temperature shall be no more than 3 ˚C higher than the cooling system supply temperature.	DC specific performance requirements not incorporated.
Temperature and Humidity Control	Air temperature controls must be able to control the inlet air temperature to the IT equipment in the range of 23˚C to 27 ˚C (with preference to the upper end). Controls must prevent humidification or dehumidification when within the range of -9 ˚C to 15 ˚C dew point and 60% RH. Also, if multiple units serving the same space have humidity control, prevent simultaneously humidifying and dehumidifying in the same room. No reheat should be allowed with dehumidification.	• Where a unit provides both heating and cooling, controls shall be capable of providing a temperature dead band of 3°C within which the supply of heating and cooling energy to the zone is shut off or reduced to a minimum • Where separate heating and cooling equipment serve the same temperature zone, thermostats shall be interlocked to prevent simultaneous heating and cooling • In warm and humid climates, thermostat controls shall also be programmed to maintain humidity at 60%
Fan Control	Each computer room air conditioner (CRAC) with mechanical cooling capacity exceeding 63,300kJ/hour (5 tons, 60,000 Btu/hour) and each air handler shall be designed to vary the airflow rate as a function of actual load and shall have controls and/or devices (such as variable speed control) that will result in fan motor demand of no more than 50 percent of design wattage at 66 percent of the design fan speed.	DC specific performance requirements not incorporated

Table 1b: ECBC Recommendations - Electrical System

Sections	Suggested Additions	Inclusion in ECBC 2016/2017
Diesel Generators	As per ECBC 2016/2017 (draft version) Requirements. Suggestion: Voluntary star labeling requirements shall be followed.	Provisions of this section shall comply with ECBC 2016/2017.
Metering and Monitoring	For Data Center services exceeding 100 KW of IT design load, sub metering at the data center shall be provided to allow the monitoring and calculation of Power Usage Effectiveness (PUE). Minimum metering includes IT equipment energy and total data center energy including cooling energy (e.g. compressors, fans and pumps), electrical distribution system losses (e.g. UPS), and lighting. PUE to be measured as per The Green Grid Level 1 guidelines. Minimum requirement for thermal (air) monitoring shall be at the IT equipment inlet at the top of every 5th rack (in the cold aisle).	DC specific electrical sub-metering requirements unclear. DC specific thermal monitoring not incorporated.
Uninterrupted Power Supply (UPS)	For Data Center services exceeding 100 KW of IT design load, each UPS module shall have a minimum efficiency of 94.0% at 100% load and 92.0% at 25% load. – BIS/IEC 62040-3 standard to be followed as the test method for UPS performance.	DC specific recommendation included in ECBC 2016/2017 as: UPS Size and Energy Efficiency Requirements at 100% Load kVA< 20 - 90.2% 20<=kVA <= 100 - 91.9% kVA > 100 - 93.8%

3. A PAT (Perform, Achieve & Trade)-type Programme for Data Centers

3.1 Policy Review

14 Energy Performance Metrics were reviewed and analyzed in regards to their applicability for benchmarking data center energy consumption in India. Table 2 below presents the metrics along with the formula for calculating the metric.

Table 2: Energy Performance Metrics

S.No.	Energy Performance Metrics	Metric Calculation
1	**Power Usage Effectiveness (PUE)**	**PUE** = Total Facility Energy/ IT Equipment Energy
2	**Data Center Infrastructure Efficiency (DCiE)**	**DCIE =** IT Equipment Energy/ Total Facility Energy
3	**IT Power Usage Effectiveness (ITUE)**	**ITUE =** IT Equipment Energy/ Total Energy into the Compute Components
4	**Total Power Usage Effectiveness (TUE)**	**TUE =** ITUE * PUE OR Total Facility Energy/ Total Energy into the Compute Components
5	**Compute Power Efficiency (CPE)**	**CPE =** Computer Equipment utilization rate / PUE OR Computer Equipment Utilization Rate * IT Equipment Energy/ Total Facility Energy
6	**Power to Performance Effectiveness (PPE)**	Performance of IT Equipment (Actual)/ Watt Consumed ——————————— Performance of IT Equipment (Optimal) / Watt Consumed
7	**Space, Watts & Performance (SWaP)**	**SWaP** = Performance/ (Space * Power Consumption)
8	**Compute Units Per Second (CUPS)**	**CUPS =** IT Productivity / Second
9	**Data Center Compute Efficiency (DCcE)**	**DCcE =** Summation (Σ) of all values of ScE taken from all server in a given time period/ Total Number of server (m)
10	**Server Compute Efficiency (ScE)**	**ScE =** Summation (Σ) of number of samples where the server is found to be providing primary services i.e (Parameter 1 + Parameter 2 + Parameter 3 + Parameter 4)/ The total number of samples taken over that time period. (Parameter 5) X 100
11	**Data Center Energy Efficiency and Productivity (DC-EEP)**	**DC-EEP** = IT Productivity / Total Facility Energy
12	**IT Productivity per Embedded Watt (IT-PEW)**	**IT-PEW** = IT Productivity / Embedded Watt
13	**Site Infrastructure Energy Efficiency Ratio (SI-EER)**	**SI-EER** = Total Facility Energy / IT Equipment Energy
14	**Server Utilisation Effectiveness (SUE)**	**SUE** = No of Servers / Summation (Σ) of Servers *0.707^age

3.2 Stakeholder Engagement

A Core IT Working Group comprising of 13 IT industry experts such as Dell, Intel, IBM, Oracle, and Cisco was also formulated by CII-LBNL in order to evaluate the identified 14 Energy Performance Metrics and arrive at a consensus on an appropriate metric to be considered for a PAT-type programme for data centers in India. Various periodic technical discussions were carried out with Core IT Working Group through a workshop and an online questionnaire.

a) Bangalore Workshop (April 1st, 2016)

As per the Core IT Working Group, the most important parameters for measuring the energy efficiency of data centers are listed below in order of their level of importance:

- Parameter 1 – IT Equipment Power
- Parameter 2 - Utilization of IT Equipment
- Parameter 3 – Total Facility Power
- Parameter 4 – Time (frequency of measurement and reporting time-frame)

b) PAT Pilot Study

To test the availability of data for the identified parameters mentioned above, CII-LBNL conducted an online questionnaire referred to as the "PAT Pilot Study." The structured questionnaire was primarily intended to capture the following information related to data centers selected for this study.

- Type, size, and tier level.
- Data on percentage contribution from various sources of power/electricity that include Grid, Diesel Generator and Renewables.
- Information on PUE calculation that include data on Total Energy Consumption, IT Energy Consumption and Level of metering of IT Energy.
- Utilization data for Average Annual CPU Utilization (%).
- Frequency of Measurement and Reporting Time for the selected parameters.

Results from the survey indicated the following:

- PUE is the metric measured by all the data centers which had participated in the study. Majority of the data centers measure their IT Energy at the PDU level on a shift-wise basis and reporting for the same is done on a monthly basis.
- Importance of measuring CPU Utilization is recognized by most of the data center owners/large users but measuring utilization at the data center level is not currently practiced in many data centers in India.

3.3 Overall Findings

Based on the discussions during the Pilot Study and after sharing the results of the study with our Core-IT Working Group members, the two metrics that have been identified as the most important and practical Energy Performance Metrics are:

a) PUE to measure and report infrastructure energy efficiency.
b) CPU Utilization metric for measuring IT equipment energy efficiency.

a) PUE is a well-established and matured Energy Performance Metric that is currently being used by many Indian data centers to report their infrastructure efficiency and operating efficiency to their management. This metric may be considered under a PAT-type programme for data centers, but it is recommended to take the following factors under consideration.

- The metric must be standardized. It may be measured as per the Green Grid Level 2 guidelines where:
  (i) Measurement of IT Energy Equipment is at PDU Outputs;
  (ii) Measurement of Total Facility Energy is at Utility Inputs;
  (iii) Measurement Interval is 15 minutes or less.

- Data centers may be categorized into:
  (i) New and Existing Data Centers; and
  (ii) Data Center Size (e.g., Large and Small Data Centers)
  Based on data center categorization PUE obligations may vary; for example, existing DCs may not have measuring facility at PDU output and therefore measuring at the UPS output would be appropriate. Considering the lack of instrumentation in existing data centers, only new data centers with the IT design load exceeding 100 KW may be mandated to follow The Green Grid Level 2 guidelines for PUE measurement and monitoring.

- One of the major issues with using only PUE as the Energy Performance Metric is that it does not take into consideration IT usage that includes server loads, underutilized servers/idle servers, utilization of storage and network devices etc.

b) CPU Utilization is a key Performance Metric as it tracks CPU performance regressions or improvements and is used to investigate performance problems. Also, CPU consumes approximately 50% of server power consumption. Even though the metric is considered important, there are various issues related to measuring and monitoring CPU Utilization:

- CPU Utilization values are highly variable and depend upon the nature of loads, application type, etc.
- Standardization of the metric is difficult for all data centers due to variation of categories of data centers, operation type etc.
- The metric is not suitable for colocation data center type as IT equipment in such data centers are controlled by the customers and not the data center owners.

Considering various challenges associated with collecting and reporting CPU utilization by the data centers, a mechanism may be introduced at this point to mandate data centers to at least monitor and document IT usage (i.e., number of underutilized/ idle servers).

4. New Delhi Workshop (December 06, 2016)

CII in collaboration with LBNL-US DoE, under the guidance of BEE, Ministry of Power, organized a workshop at India Habitat Center – Juniper Hall, Lodhi Road, New Delhi.

The objective of this workshop was to share the findings of the study and to provide participants with an opportunity to discuss the following topics important to the data center industry:

1. A "Composite Policy Framework" for Indian data centers, based on existing energy efficiency standards in India (i.e., PAT and ECBC).
2. Role of energy efficiency standards and technology interventions in accelerating the adoption of best practices in Indian data centers.

The workshop provided an important platform to data center industry experts to engage with each other. Workshop participants included data center owners/large users, technology providers, energy managers and consultants and policy makers who may help in accelerating the adoption of energy efficient technologies in Indian data centers. Various new technologies in IT and cooling were explored during the sessions and certain issues were identified related to their deployment in the Indian context.

5. Meeting with Bureau of Energy Efficiency (December 07, 2016)

CII and LBNL had an in-depth discussion with BEE, Ministry of Power on the findings of the CII-LBNL study, incorporation of our data center specific recommendations in ECBC 2016/2017 and inclusion of data centers under PAT-programme.

5.1 Inclusion of Data Centers under PAT-programme – Recommendations by BEE

In order to include data centers under an Indian PAT scheme, it is important to come up with an "appropriate Energy Performance Metric."

a) If PUE is the metric to be considered under the PAT scheme, further data collection is required that includes:

- List of all data centers that may be considered under the programme with details such as Name, Address, and Energy Consumption data, etc.
- Clearly defining the term 'Data Center' under the PAT programme including data center threshold (may be applicable to large data centers with IT load 500kW or higher and 1MW or higher).
- Factors that may influence the parameter(s) for measuring data center energy performance (i.e., Total Energy Consumption and IT Energy Consumption) must be identified.

b) PAT Process: Two Notifications will be issued by BEE.

- 1st Notification: Identification of all the buildings that will be considered under the Scheme.
- Format of data collection to be developed in order to capture all relevant information that has to be reported under the programme such as Total Energy Consumption, IT Energy Consumption, and Measurement Period etc. for Data Centers.
- 2nd Notification: PUE targets would be given to all the data centers under the scheme.
- Data centers are likely to be considered under PAT in the next cycle (2018).

5.2 Inclusion of Data Center Specific Recommendations in ECBC 2016/2017 – Recommendations by BEE

a) Schedule for ECBC 2016/2017

- Draft version already circulated for comments/suggestions.
- A meeting with Director General, BEE is scheduled in January for discussion on the code.
- A smaller committee meeting on HVAC and a bigger committee meeting for finalization of the code is also scheduled in January.
- The revised version of ECBC is scheduled to be launched by January 2017 and may be followed by the launch of a "User-Guide".

5. Conclusion and Recommended Next Steps

5.1 Conclusion

a) Inclusion of Data Center Specific Requirements in ECBC 2016/2017 Draft

- Data centers previously excluded from the Indian ECBC standard have been included in the draft code for ECBC 2016/2017.
- Though HVAC requirements specified in the code may be applicable to data centers, CII and LBNL have strongly recommended minimum SCOP of 2.5 for CRAC units in data centers.
- Based on stakeholder discussions, Economizer requirement to be waived-off for Indian data centers which has not been included in the ECBC 2016/2017 draft code.
- Data center-specific requirements for Air Management, Fan-Control, Temperature and Humidity Control as mentioned above have strongly been recommended by CII and LBNL for inclusion in the current code.
- Under Metering and Monitoring section in draft ECBC 2016/2017, CII and LBNL have recommended PUE calculation and requirement for thermal monitoring, which is not currently captured in the draft version.
- UPS system efficiency values as mentioned in draft ECBC 2016/2017 are applicable to data centers in India.

b) Reporting Energy Performance of Data Centers under a PAT-type Programme in India

- PUE may be used as a metric under a PAT-type mechanism for Indian data centers.
- PUE measurement and monitoring must be standardized. Measurement as per the Green Grid Level 2 guidelines is recommended.
- Categorization of Data centers into: (a) New and Existing Data Centers; and (b) Data Center Size (e.g., Large and Small Data Centers) depending upon which PUE obligations may vary.
- For BEE to successfully implement the PAT programme for data centers, 'Data Center' definition including data center threshold and normalization factors must be clearly defined.

4.2 Recommended Next Steps

- Development of a detailed ECBC User-Guide for Indian data centers that documents data center best-practices and implementation guidelines for data center specific requirements included in the new ECBC version.
- To successfully implement PAT programme for data centers under the next PAT cycle (2018), further data collection is required that includes identification of all data centers to be considered under the scheme, development of data collection format that includes total energy consumption and IT energy consumption used for measuring data center energy performance and identification of factors that may influence these parameters.
- In consultation with key stakeholders, organize workshops/awareness building sessions for data center owners/ large users.