# Accelerating Energy Efficiency in Indian Data Centers

DALE SARTOR | LBNL

JULY 2018

Version 24072018

# Project Background

- The energy intensity of data centers and the growth of data center infrastructure in India calls for increased energy efficiency.

**19.8 %**

The estimated compound annual growth rate (CAGR) of data centers (measured in square feet) in India between 2010 and 2018. *

*According to recent research by Cushman & Wakefield

# Project Background

- Public-Private partnership to increase efficiency in data centers through:
  - Market transformation
  - Capacity Building
  - Transfer of international best practices and benchmarks

Goal: Development of energy efficiency standards for Indian data centers

# Project Background - Participating Organizations


Lawrence Berkeley National Laboratory (LBNL) U.S. Department of Energy


Confederation of Indian Industry


Confederation of Indian Industry (CII) Indian Green Building Center (IGBC)


Indian Bureau of Energy Efficiency (BEE)

**And You!**

# Phase I Accomplishments

- Phase I Activities Included:
  - Review of energy efficiency (EE) policies in India
  - Review of global data center standards
  - Analysis of international standards relative to the  Indian context
  - Stakeholder engagement through an online survey and in-person workshop
  - Phase I Report

# Phase II Activities & Links

- Phase II built on Phase I findings related to international best practices and how EE standards in India could better address data centers.
- The Indian standards central to Phase II were:
  - the Energy Conservation Building Code (ECBC).
  - the Perform, Achieve & Trade (PAT) market-based scheme.
- Phase II Activities Included:
  - Development of recommendations for incorporating data center specific requirements into the 2016/2017 revision of the ECBC.
  - Evaluation of various Energy Performance Metrics for reporting data center energy efficiency under a PAT-type programme.
- Phase II report and Phase II white paper

# Progress

- The new version of the ECBC was launched in 2017
- Data centers are no longer excluded from the ECBC
- But few standards are specifically relevant to data centers
- The ECBC allows for three levels of performance
  - ECBC Code Compliance
  - ECBC+
  - SuperECBC
- Generally the higher levels were not developed for data center specific standards

# Phase III (Current Activities)

- Data Center specific User Guide on meeting ECBC standards as well as recommendations and resources to achieve best practices.
- Guide will include level 2 (stretch) and level 3 (superefficient) recommendations to augment ECBC Code Compliance requirements:
  - Recommended for adoption as ECBC+ and Super-ECBC requirements in the future.
  - Can be used as a guide to achieve international best practices.
  - Can be used in rating systems such as the IGBC Green Data Center Rating System.
  - Can be adopted as a corporate Standard.
- Identify and document case studies to highlight energy efficiency best practices in the Indian context
- Conduct workshops and other outreach activity

# Phase III (Current Activities)

- Tables developed to identify the ECBC 2017 standards relevant to data centers at each ECBC level (Code Compliance, ECBC+, and SuperECBC)
  - For certain measure categories where no ECBC+ or Super ECBC standards were outlined, or it was felt they could be enhanced, recommendations for "Level II" and "Level III" categories are added.
    - These recommended specifications are shaded in navy text in the tables and are denoted by a green asterisk (*).
- Values highlighted in RED would benefit from further industry input/discussion

# Example for UPS

| ECBC Compliant | ECBC+ & Level II | SuperECBC & Level III |
|---|---|---|
| ✓ UPS modules with kVA <20 shall have minimum efficiency of 90.2%<br>✓ UPS modules with 20 <= kVA <=100 shall have minimum efficiency of 91.9%<br>✓ UPS modules with kVA > 100 shall have minimum efficiency of 93.8%<br><br>ECBC Reference<br>ECBC 2017 Section 7.2.7 | **ECBC+**<br>✓ Same as ECBC Compliant<br><br>ECBC Reference<br>ECBC 2017 Section 7.2.7<br><br>**Recommended for Level II**<br>✓ UPS module efficiency shall be maintained for 25%, 50%, and 100% full load.* Values needed | **SuperECBC**<br>✓ Same as ECBC Compliant<br><br>ECBC Reference<br>ECBC 2017 Section 7.2.7<br><br>**Recommended for Level III**<br>✓ Eco-mode capability*<br>✓ UPS module efficiency shall be maintained for 25%, 50%, and 100% full load.* Values needed |

# Discussions

- Feedback on Tables of ECBC Data Centre Requirements
- Identification and participation in case studies
- Participation in capacity building programmes

# Data Centre Efficiency Code Requirements and Recommendations

# Data Centre Efficiency Code Requirements and Recommendations

| 1. **Data Center – Cooling** | 2. **Data Center - Electrical** | 3. **Chiller Plant** | 4. **IT Equipment** |
|---|---|---|---|
| a) Computer Room Air Conditioning (CRAC) Equipment Efficiency | a) Diesel Generators | a) Chillers | a) Star ratings |
| b) Air Management | b) Metering and Monitoring | b) Cooling Towers | b) Virtualization |
| c) Temperature and Humidity Control | c) Uninterrupted Power Supply (UPS | c) Pump Efficiency | c) Geo redundancy |
| d) Fan Control | | d) Economizers | |
| | | e) Chiller Plant (Performance Approach) | |

# CRAC EQUIPMENT EFFICIENCY

| ECBC Compliant | Level II | Level III |
|---|---|---|
| ✓ Minimum Net Sensible Coefficient of Performance (SCOP) value of 2.5 for both Downflow & Upflow.<br><br>ECBC Reference (Section 5.2.2.4) | **Recommendations for Level II**<br>✓ Minimum Net Sensible Coefficient of Performance (SCOP) value of 3.0 for both Downflow & Upflow.* | **Recommendations for Level III**<br>✓ Minimum Net Sensible Coefficient of Performance (SCOP) value of 3.5 for both Downflow & Upflow.* |

# AIR MANAGEMENT

| ECBC Compliant | Level II | Level III |
|---|---|---|
| --NONE- | **Level II Recommendations**<br>✓ Hot & Cold Aisles*<br>✓ Include air barriers such that there is no significant air path for hot IT discharge air to recirculate back to the IT inlets without passing through a cooling system*<br>✓ Target IT inlet temperature shall be no more than 6˚C higher than the cooling system supply temperature.*<br>✓ Provide variable fan speed to minimize excess airflow. No more than 30% extra supply air relative to IT airflow. * | **Level III Recommendations**<br>✓ Meet level II<br>✓ Target IT inlet temperature shall be no more than 3˚C higher than the cooling system supply temperature.*<br>✓ Provide variable fan speed to minimize excess air flow. No more than 15% extra supply air relative to IT airflow.* |

# TEMPERATURE & HUMIDITY CONTROL

| ECBC Compliant | ECBC+ & Level II | SuperECBC & Level III |
|---|---|---|
| ✓ Each floor or building block shall be installed with at least one control to manage the temperature.<br>✓ Where a unit provides both heating and cooling, controls shall be capable of providing a temperature dead band of 3.0°C within which the supply of heating and cooling energy to the zone is shut off or reduced to a minimum.<br>✓ Where separate heating and cooling equipment serve the same temperature zone, temperature controls shall be interlocked to prevent simultaneous heating and cooling.<br>✓ Separate thermostat control shall be in each computer room of educational.<br><br>ECBC Reference<br>ECBC 2017 Section 5.2.3.2) | **ECBC+**<br>In addition to ECBC Compliant:<br>✓ Centralized demand shed controls shall have capabilities to be disabled by facility operators and be manually controlled by a central point by facility operators to manage heating and cooling set points.<br>✓ Supply air temperature reset capabilities. Controls shall reset the supply air temperature to at least 25% of the difference between the design supply air temperature and the design room air temperature.<br>✓ Chilled water systems with a design capacity>350 kWr supplying chilled water to comfort conditioning systems shall have controls that automatically reset supply water temperatures by representative building loads (including return water temperature) or by outdoor air temperature.<br>✓ Exceptions : Controls to automatically reset chilled water temperature shall not be required where the supply temperature reset controls causes improper operation of equipment.<br><br>ECBC Reference<br>ECBC 2017, Sections 5.2.4.1 - 5.2.4.3 | **SuperECBC**<br>✓ Same as ECBC+<br><br>ECBC Reference<br>ECBC 2017, Sections 5.2.4.1 - 5.2.4.3 |

# TEMPERATURE & HUMIDITY CONTROL

| ECBC Compliant | ECBC+ & Level II | SuperECBC & Level III |
|---|---|---|
| See above | **Recommendations for Level II**<br>✓ The ability to operate at the upper limit of the ASHRAE recommended temperature & humidity range.*<br>✓ Controls to prevent simultaneous humidification & dehumidification. *<br>✓ Control on supply (not return) air temperature & humidity. * | **Recommendations for Level III**<br>✓ Meet Level II requirements<br>✓ Control on IT inlet air temperature.* |

# FAN CONTROL

| ECBC Compliant | Level II | SuperECBC |
|---|---|---|
| -NONE- | ✓ Provide variable fan speed to minimize excess airflow.*<br>✓ Fans in Variable Air Volume (VAV) systems shall have controls or devices that will result in fan motor demand of no more than 30% of their design wattage at 50% of design airflow based on manufacturer's certified fan data.<br>(as required by SuperESPC)* | ✓ Fans in Variable Air Volume (VAV) systems shall have controls or devices that will result in fan motor demand of no more than 20% of their design wattage at 50% of design airflow based on manufacturer's certified fan data.<br><br>ECBC Reference ECBC 2017, Section 5.2.5.1 |

# DIESEL GENERATORS

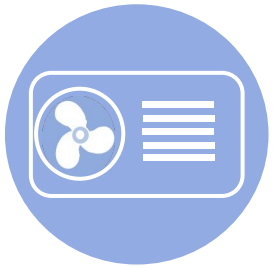
| ECBC Compliant | ECBC+ | SuperECBC |
|---|---|---|
| ✓ Minimum 3 stars rating<br><br>ECBC Reference<br>ECBC 2017 Section 7.2.3 | ✓ Minimum 4 stars rating<br><br>ECBC Reference<br>ECBC 2017 Section 7.2.3 | ✓ Minimum 5 stars rating<br><br>ECBC Reference<br>ECBC 2017 Section 7.2.3 |

# METERING & MONITORING

| ECBC Compliant | Level II | Level III |
|---|---|---|
| ✓ Buildings <65 kVA with data center shall have permanently installed electrical metering to record energy (kWh).<br>✓ Buildings >65 kVA with data center shall meter energy kWh, demand kVa, and total power factor.<br>✓ Building >120 kVA with data center present shall, in addition to requirements for buildings >65kVA (above), sub-meter HVAC system & components.<br>✓ Buildings >250 kVA with data centers shall, in addition to other requirements, sub-meter lighting, and plug loads.<br><br>ECBC Reference<br>ECBC 2017 Section 7.2.4 | ✓ 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). PUE to be measured as per the Green Grid Level 1 guidelines.*<br>✓ 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.*<br>✓ Minimum requirement for thermal (air) monitoring shall be at the inlet of the IT rack at the top of every 4th rack in the cold aisle.* | ✓ For Data Center services exceeding 100 kW of IT design load, sub-metering shall provide partial Power Usage Effectiveness (PPUE) for mechanical and electrical systems. Provide power measurement to each IT rack. PUE to be measured as per the Green Grid Level 2 or 3 guidelines.*<br>✓ All data shall be available in real time in an automated data center infrastructure management (DCIM) system / Feedback loop for performance assurance.*<br>✓ Minimum requirement for thermal (air) monitoring shall be in the top, middle, and bottom the inlet of the IT rack at the end and middle racks of each row, but no less frequent than every 4th rack in the cold aisle.* |

# Uninterrupted Power Supply (UPS)

| ECBC Compliant | ECBC+ & Level II | SuperECBC & Level III |
|---|---|---|
| ✓ UPS modules with kVA <20 shall have minimum efficiency of 90.2%<br>✓ UPS modules with 20 <= kVA <=100 shall have minimum efficiency of 91.9%<br>✓ UPS modules with kVA > 100 shall have minimum efficiency of 93.8%<br><br>ECBC Reference<br>ECBC 2017 Section 7.2.7 | **ECBC+**<br>✓ Same as ECBC Compliant<br><br>ECBC Reference<br>ECBC 2017 Section 7.2.7<br><br>**Recommended for Level II**<br>✓ UPS module efficiency shall be maintained for 25%, 50%, and 100% full load.* Values needed | **SuperECBC**<br>✓ Same as ECBC Compliant<br><br>ECBC Reference<br>ECBC 2017 Section 7.2.7<br><br>**Recommended for Level III**<br>✓ Eco-mode capability*<br>✓ UPS module efficiency shall be maintained for 25%, 50%, and 100% full load.* Values needed |



# Chillers

## ECBC Compliant

- ✓ Chillers shall meet or exceed the minimum efficiency requirements presented below under ANSI/ AHRI 550/ 590 conditions.
- ✓ Requirements of both COP and IPLV shall be met.

| Water Cooled Chillers | | |
|---|---|---|
| **Chiller Capacity (kWr)** | **COP** | **IPLV** |
| <260 | 4.7 | 5.8 |
| ≥ 260 & < 530 | 4.9 | 5.9 |
| ≥ 530 & < 1,050 | 5.4 | 6.5 |
| ≥ 1,050 & <1,580 | 5.8 | 6.8 |
| ≥ 1,580 | 6.3 | 7.0 |
| **Air Cooled Chillers** | | |
| **Chiller Capacity (kWr)** | **COP** | **IPLV** |
| <260 | 2.8 | 3.5 |
| ≥ 260 & < 530 | 3.0 | 3.7 |

ECBC Reference
ECBC 2017 Section 5.2.2.1

## ECBC+

- ✓ Chillers shall meet or exceed the minimum efficiency requirements presented below under ANSI/ AHRI 550/ 590 conditions.
- ✓ Requirements of both COP and IPLV shall be met.

| Water Cooled Chillers | | |
|---|---|---|
| **Chiller Capacity (kWr)** | **COP** | **IPLV** |
| <260 | 5.2 | 6.9 |
| ≥ 260 & < 530 | 5.8 | 7.1 |
| ≥ 530 & < 1,050 | 5.8 | 7.5 |
| ≥ 1,050 & <1,580 | 6.2 | 8.1 |
| ≥ 1,580 | 6.5 | 8.9 |
| **Air Cooled Chillers** | | |
| **Chiller Capacity (kWr)** | **COP** | **IPLV** |
| <260 | 3.0 | 4.0 |
| ≥ 260 & < 530 | 3.2 | 5.0 |

ECBC Reference
ECBC 2017 Section 5.2.2.1

## SuperECBC

- ✓ Chillers shall meet or exceed the minimum efficiency requirements presented below under ANSI/ AHRI 550/ 590 conditions.
- ✓ Requirements of both COP and IPLV shall be met.

| Water Cooled Chillers | | |
|---|---|---|
| **Chiller Capacity (kWr)** | **COP** | **IPLV** |
| <260 | 5.8 | 7.1 |
| ≥ 260 & < 530 | 6.0 | 7.9 |
| ≥ 530 & < 1,050 | 6.3 | 8.4 |
| ≥ 1,050 & <1,580 | 6.5 | 8.8 |
| ≥ 1,580 | 6.7 | 9.1 |
| **Air Cooled Chillers** | | |
| **Chiller Capacity (kWr)** | **COP** | **IPLV** |
| <260 | N/A | N/A |
| ≥ 260 & < 530 | N/A | N/A |

ECBC Reference
ECBC 2017 Section 5.2.2.1

# Chillers

| ECBC Compliant | ECBC+ | SuperECBC |
|---|---|---|
| ✓ The application of air-cooled chiller is allowed in all buildings with cooling load < 530 kW.<br>✓ For buildings with cooling load ≥ 530 kW, the number of air-cooled chiller is restricted to 33% of the total installed chilled water capacity unless the authority having jurisdiction mandates the application of air cooled chillers.<br>✓ Minimum efficiency requirements under BEE Standards and Labeling Program for chillers shall take precedence over requirements outlined above (see previous slide).<br><br>ECBC Reference<br>ECBC 2017 Section 5.2.2.1 | ✓ Same as ECBC Compliant | ✓ Same as ECBC Compliant |

# Cooling Towers

| ECBC Compliant | ECBC+ | SuperECBC |
|---|---|---|
| ✓ Equipment Type: Open circuit cooling tower Fans<br><br>✓ Rating Condition:<br>35°C entering water<br>29°C leaving water<br>24°C WB outdoor air<br><br>✓ Efficiency:<br>0.017 kW/kWr<br>0.31 kW/ L/s<br><br>ECBC Reference<br>ECBC 2017 Section 5.3.2 | Repeat ECBC Compliant and:<br>✓ Additional VFDs shall be installed in the cooling towers.<br><br>ECBC Reference<br>ECBC 2017 Section 5.3.2 | ✓ Same as ECBC+ |

# Pump Efficiency

| ECBC Compliant | ECBC+ | SuperECBC |
|---|---|---|
| ✓ Chilled Water Pump (Primary and Secondary): 18.2 W/ kWr with VFD on secondary pump<br>✓ Condenser Water Pump: 17.7 W/ kW<br>✓ Pump Efficiency (minimum): 70%<br><br>ECBC Reference<br>ECBC 2017 Section 5.3.1 | ✓ Chilled Water Pump (Primary and Secondary): 16.9 W/ kWr with VFD on secondary pump<br>✓ Condenser Water Pump: 16.5 W/ kWr<br>✓ Pump Efficiency (minimum): 75%<br><br>ECBC Reference<br>ECBC 2017 Section 5.3.1 | ✓ Chilled Water Pump (Primary and Secondary): 14.9 W/ kWr with VFD on secondary pump<br>✓ Condenser Water Pump: 14.6 W/ kWr<br>✓ Pump Efficiency (minimum): 85%<br><br>ECBC Reference<br>ECBC 2017 Section 5.3.1 |

# Economizers

| ECBC Compliant | ECBC+ | SuperECBC & Level III |
|---|---|---|
| ✓ Note while the ECBC requires economizers in all large buildings (as is written in the ECBC+ level) , it is not considered common practice in data centers and it will unlikely be followed. Therefore we recommend waiving the economizer requirement for data centers at the compliant level.<br>- | Each cooling system in data centers with an IT load > 100kW* shall include at least one of the following:<br>✓ An air economizer capable of modulating outside-air and return-air dampers to supply 50% of the design supply air quantity as outside-air.<br>✓ A water or pumped refrigerant economizer capable of providing 50% of the expected system cooling load at outside air temperatures of 10°C dry-bulb/7.2°C wet-bulb and below.<br><br>Exception:<br>✓ Projects in warm-humid climate zones are exempt.<br>✓ Projects with only daytime occupancy in the hot-dry are exempt.<br>✓ (c) Individual ceiling mounted fan systems is less than 3,200 liters per second exempt.<br><br>ECBC Reference<br>ECBC Section 2017 5.3.3.1 (not including red text) | **SuperECBC**<br>Same as ECBC+<br><br>**Recommendations for Level III**<br>Data centers in excess of 100kW shall utilize economizers. Each cooling system shall include at least one of the following:<br>✓ An air economizer capable of modulating outside-air and return-air dampers to supply 100% of the design supply air quantity as outside-air. *<br>✓ A water or pumped refrigerant economizer capable of providing 100% of the expected system cooling load at outside air temperatures of 10°C dry-bulb/7.2° C wet-bulb and below. *<br>No exceptions* |

7/22/2018

# Economizers

| ECBC Compliant | ECBC+ | SuperECBC |
|---|---|---|
| | ✓ Economizers shall be capable of providing partial cooling even when additional mechanical cooling is required to meet the cooling load.<br>Air economizer shall be equipped with controls:<br>✓ That allow dampers to be sequenced with the mechanical cooling equipment and not be controlled by only mixed air temperature.<br>✓ capable of automatically reducing outdoor air intake to the design minimum outdoor air quantity when outdoor air intake will no longer reduce cooling energy usage.<br>✓ Capable of high-limit shutoff at 24 °C dry bulb.<br>ECBC Reference<br>ECBC 2017 Sections 5.3.3.1-5.3.3.4 | |

# Chiller Plant- Performance Approach

Buildings may show compliance by optimizing the total system efficiency for the chiller plant instead of the individual equipment efficiencies listed under the prescriptive requirements. This alternate compliance approach is applicable for central chilled water plants in all building types. The total installed capacity per KW refrigeration load shall be less than or equal to maximum threshold requirements as specified below.

Equipment that can be included in central chilled water plant side system for this alternate approach are chillers, chilled water pumps, condenser water pumps, and cooling tower fan.

Compliance check will be based on annual hourly simulation.

| ECBC Compliant | ECBC+ | SuperECBC |
|---|---|---|
| ✓ Water Cooled Chill Plant Maximum Threshold (kW/kWr) of 0.26<br><br>ECBC Reference<br>ECBC 2017 Section 5.4 | ✓ Water Cooled Chill Plant Maximum Threshold (kW/kWr) of 0.23<br><br>ECBC Reference<br>ECBC 2017 Section 5.4 | ✓ Water Cooled Chill Plant Maximum Threshold (kW/kWr) of 0.20<br><br>ECBC Reference<br>ECBC 2017 Section 5.4 |

# Guide Overview

- Expand on the tables presented.
- Target Audience: Indian Data Center Owners, Developers, Designers, and Operators.
- Purpose:
  - Cross cut identification of ECBC17 requirements relavent to data centers .
  - Further guidelines and recommendations for higher levels of performance as well as operational best practices.
  - Highlight resources to help user achieve the target efficiency levels.

# Guide Format:

- Guide provides the high level table with *all* ECBC requirements as well as recommended requirements for standards at the following levels:
  - ECBC Compliant
  - ECBC + (or Level II if no requirements specified or changes recommended to requirements)
  - SuperECBC (or Level III if no requirements specified or changes recommended to requirements)
- Individual section for each of the measure categories
  - Description of measure and guidelines for applying it
  - Resources for further information/help
- Help needed for Indian context

# Nomination for Data Centers case studies

1. High Performance New Data Center
2. Existing Data Center that demonstrated significant improvements
3. Case studies will support the recommendations in the guide and provide the Indian context
4. Nominations being accepted now

# Thank you for your time !

# Contact Information

Dale Sartor, P.E.
Lawrence Berkeley National Laboratory
MS 90-3111
University of California
Berkeley, CA 94720

DASartor@LBL.gov
(510) 486-5988
http://datacenters.lbl.gov/