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Accelerating Energy Efficiency in Indian Data Centers: Final Report for Phase I Activities

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Confederation of Indian Industry (CCI)

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Energy Technologies Area
January, 2016
Accelerating Energy Efficiency in Indian Data Centers: Final Report for Phase I Activities

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We are grateful to the Indian Bureau of Energy Efficiency’s (BEE) Director General, Dr. Ajay Mathur, and Energy Economist Mr. Sanjay Seth for providing extensive guidance and review throughout Phase I of this initiative.

On behalf of CII and LBNL, we extend our special thanks to all the stakeholders for their continued support and involvement during the survey and the workshop. The names of specific stakeholders we would like to recognize are listed under survey and workshop participants in Appendix E. 2, E. 4, and F.1.
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Executive Summary

Data centers are energy-intensive facilities that house computer systems, a dedicated cluster of computers and associated components, and support a diverse set of services such as web browsing, e-mail, social media, data storage, and processing. Growth in the data center industry is highly driven by sectors such as financial services, high-tech universities, media, telecommunication, government institutions, and retail (U.S. Environmental Protection Agency (EPA), 2007). According to reports, India will be the second largest market for data Centre infrastructure in Asia/Pacific in 2015. The Indian data center infrastructure market will total USD 2.03 billion in 2015, a 5.4 percent increase from 2014 revenue (Gartner, 2014). Additionally, Indian spending on data center storage, server, and network equipment reached USD 2.2 billion in 2012 and this market is expected to grow at the compound annual growth rate of 8.5% to reach USD 3 billion by 2016 (NASSCOM, 2012).

Energy is one of the most important components of the operating expenses of a data center (Data Center Knowledge, 2012) but increasing energy costs and corresponding operational costs pose challenges to business competitiveness. Thus, it is necessary to reduce the energy consumption in data centers and enhanced energy efficiency has been recognized as an appropriate instrument for this purpose. Around the world, initiatives to enhance energy efficiency in data centers are underway. According to a report released in 2012, there were 28 types of energy standards applicable to data centers in 12 EMEA (Europe, the Middle East and Africa) countries (Data Center Knowledge, 2012). India has several policies that encourage energy-efficient buildings (e.g., office, hospitals, homes) and industries (e.g., cement, textile), but a policy does not exist to regulate the energy consumption and environmental impact of data centers.

This report documents Phase 1 of the “Accelerating Energy Efficiency in Indian Data Centers” initiative to support the development of an energy efficiency policy framework for Indian data centers. The initiative is being led by 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). It is also part of the larger Power and Energy Efficiency Working Group of the US-India Bilateral Energy Dialogue. The initiative consists of two phases: Phase 1 (November 2014 – September 2015) and Phase 2 (October 2015 – September 2016).

Phase 1 consisted of three main activities: a comprehensive review of existing energy efficiency policy in India and data center standards from around the world; analysis of these international standards for energy efficiency, including metrics, to the Indian context; and stakeholder engagement through an online survey and in-person workshop.

The results of these activities are presented in this report and directly support the development of a tailored policy framework to reduce the energy consumption of data centers in India.

Policy Review

International standards were categorized into approaches based on common characteristics (Whole Building, Best Practices, Comparative Scale, and Prescriptive or Performance Based). There are many similar characteristics between the international standards and existing energy efficiency policies in India. The categorization into approaches and insight into potential metrics were utilized during the stakeholder engagement activities and resulted in more specific and actionable feedback.
### Approach and Examples

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<td><strong>International</strong>: No Comparable example in Data Center</td>
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### Stakeholder Engagement

Twenty-five key stakeholders, including data center owners and experts, responded to an online survey designed to capture industry's viewpoint on topics ranging from energy efficient technologies to different policy approaches to existing policy in India could be leveraged to cover data centers. Further stakeholder engagement was conducted through an in-person workshop with industry and the findings were presented to BEE. Each stage of engagement provided insight to guide the development of a standard for energy efficiency in data centers in India.

### Conclusion and Next Steps (Phase II)

Enhancing energy efficiency through a standard has been recognized as an appropriate strategy to reduce energy consumption in Indian data centers. Though India has well-established energy efficiency standards in its commercial and industrial facilities, a dedicated standard for data centers does not exist. This initiative established that existing energy efficiency policies in India share certain similarities with some of the international standards reviewed in this study and these existing standards can be leveraged for data center energy efficiency.

### Summary of Phase 1 Findings:

- An energy efficient data center in itself is an incentive or a reward for the data center industry. It not only improves the overall energy efficiency but also increases the business productivity of data centers.

- A “Composite Policy Framework” based on existing energy efficiency standards such as PAT, ECBC and S&L may be designed for Indian data centers to encompass all the components of a data center (e.g., IT, infrastructure), and should be applicable to both existing (brownfield) and new (greenfield) data centers.

- An Expert Stakeholder Group may be formulated to focus on the IT metric part and separately an Administrative Stakeholder Group will take care on the synchronization part with the existing ECBC, PAT, and S&L framework to make this standard easily adoptable by BEE.
Formulation of the new standard must consider the following factors: variation in size of data centers; variation in type of data centers (e.g., captive, colocation) and their implication on energy use; reliability; and air and environmental quality.

**Next Steps:**

- Development of short-term and long-term strategies to implement an energy efficiency standard for Indian data centers in the context of existing policy (e.g., ECBC, PAT). This process will follow in-depth consultation with a broad DC Stakeholder Consultative group.

- Formulation of a Core IT Stakeholder Consultative Group to come to a consensus on an IT Energy Performance Metric, taking PUE into consideration.

- Development of technical and administrative procedures the standard.

- Stakeholder discussions to define a specific methodology to design the standard.

- Facilitation of the implementation and notification aspects of the standard.

- National and international-level dissemination.
Introduction

Data centers are essential to the functioning of modern economy and are found nearly in every sector of the economy: financial services, high-tech universities, media, telecommunication, government institutions, and retail (U.S. Environmental Protection Agency (EPA), 2007). The overall data center workloads are expected to double from 2013 to 2018 (Upsite Technologies, 2014) and the approximately five exabytes (EB) of data online in 2002 rose to 750 EB in 2009; by 2021 it is expected to cross the 35 zettabytes (ZB) level (Cognizant, 2012). The growth of data centers is also driven by the evolution of cloud-based services and smart cities. By 2018, more than 78% of workloads will be processed by cloud data centers and almost 22% will be processed by traditional data centers (Upsite Technologies, 2014). Some of the world's biggest technology organizations (e.g., Microsoft, Google, IBM, Cisco) have taken on the development of smart cities (Franks, 2014) and experts have stated that data centers located in the same region of the smart city will be the backbone (Consorci de Serveis Universitaris de Catalunya (CSUC)). For example, data centers will be storing and processing the data received through sensors to detect excessive air pollution, integrated traffic controls, and education systems. Overall, the number of data centers is expected to increase dramatically in the near future.

Considering the growth expected in data center industry, interest is growing to reduce the energy consumption and make data centers more energy efficient. The interest is also necessary as data centers operate 24/7 and are highly energy intensive. The energy intensity of a data center may be 10 to 100 times of a typical commercial building (USAID ECO-III Project, 2009). Rising energy prices are also increasing the operating cost of data centers and it has been reported that global data center carbon emissions will grow 7% year-on-year through 2020 (National Resources Defence Council, 2014). These factors and increasing business competitiveness is driving the data center industry to become energy efficient.

It is estimated that achieving just half of the technologically feasible savings through adopting best practices could cut electric use by 40% in data centers (Whitney & Delforge, 2014). These practices cover everything from facility lighting to cooling system design, and have proven useful in helping some companies curb the trend of rising data center energy consumption (Emerson Network Power). However, most organizations still lack a cohesive, holistic approach for reducing data center energy use. It is not considered sufficient to simply recognize the need to save energy and improve efficiency; one must quantify key benefits associated with energy-efficient practices and prioritize actions to achieve them. To assist organizations measure the savings from adopting best practices, associations such as The Green Grid have developed metrics such as Power Usage Effectiveness (PUE) and Data Center Infrastructure Efficiency (DCiE).

Best practices include energy-efficient technologies such as: (i) The use of variable frequency drives (VFDs), the installation of air- or water-side economizers, and improved air flow management in the cooling system; (ii) The use of energy-efficient uninterruptible power supplies (UPSs), premium efficiency distribution transformers, and direct current power systems in the electrical system; and (iii) Server virtualization and consolidation, and energy-efficient storage technologies in the IT systems. See Appendix B for a detailed list of potential technologies, including existing barriers.

Improvements in the energy efficiency of a data center provide data center managers with a greater understanding of, and control over, energy consumption. Enhanced control enables more effective execution of equipment refresh rates, updates, and maintenance. It also provides superior visibility over the performance and efficiency of the entire network, facilitating the ability to pinpoint areas of opportunity. Energy efficiency leads to increased reliability and availability of data centers, enhanced efficiency in design and operations, reduced operating
costs, reduced greenhouse gas emissions, and enhanced grid support for the entire electric utility system (U.S. Environmental Protection Agency (EPA), 2013)

Many countries have developed standards to help design, rate, or certify data centers based on their environmental performance or energy consumption benchmarking to achieve the benefits of energy efficiency. Standards cover the whole range of energy efficiency-related issues in data centers rather than focusing on and solving a single issue and cover data centers of different sizes and characteristics. According to a report released in 2012, there were 28 types of standards applicable to data centers in 12 EMEA (Europe, the Middle East and Africa) countries (Data Center Knowledge, 2012). India has several policies that encourage energy-efficient buildings (e.g., office, hospitals, homes) and industries (e.g., cement, textile), but a policy does not exist to regulate the energy consumption and environmental impact of data centers in India.

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Data Centers and Energy Efficiency in India

Over the last decade, India has experienced an increased demand for data due to the explosive growth in smartphones and widespread use of social media apps, banking and e-commerce transactions, and multimedia storage needs. This increased demand for data has provided the impetus for the large growth in Indian data center markets. It has been predicted that India will become the world’s 5th largest data center market by 2050. The Indian government supports further growth in the data center industry through the inclusion of initiatives such as the provision of tax incentives for setting-up data centers and cloud services in its budget for 2015. Another project aims to provide 250,000 villages with broadband connectivity and enable Wi-Fi connectivity in schools by 2019 (Data Center Dynamics).

It has been estimated that the energy currently used by a 10 MW data center each year is equivalent to the energy consumed by 73,000 typical urban Indian houses or equivalent to energy consumed by 17,520 typical Indian cars (USAID ECO-III Project, 2009). In a country with a large and increasing energy demand, and an existing power-deficit, energy efficiency is key. With the introduction of the Energy Conservation Act 2001, the Government of India (GOI) began efforts to institutionalize and mainstream energy efficiency, which included the formation of the Bureau of Energy Efficiency (BEE) under the Ministry of Power.

Efforts to address energy efficiency in data centers officially began in 2009 when BEE launched an initiative to create a “Data Center Energy Efficiency Design Code” and a “Best practice
Manual” in partnership with Confederation of Indian Industry (CII) and industry members. In 2010, under the guidance of BEE, CII developed the “Energy Efficiency Guidelines and Best Practices in Indian Data Centers” report (Confederation of Indian Industry (CII) - Bureau of Energy Efficiency (BEE), 2010). Under this initiative, more than twenty data center-specific energy efficiency measures that offer high replication potential in the Indian data centers were identified. The early studies indicate that a focus on data center efficiency, reliability, and cost optimization has led to challenges in India such as: (i) lack of an integrated building design approach; (ii) lack of technical awareness, exposure to best practices, and energy-efficient solutions; (iii) the need for information technology (IT) infrastructure to keep up with evolving technologies; (iv) and lack of regulatory measures and an institutional framework to promote energy efficiency (USAID ECO-III Project, 2008).

Although a standard for data center energy efficiency does not exist in India, there are policies that cover the energy efficiency of buildings that could potentially be expanded to cover data centers. These policies include the Indian Green Building Council; Energy Conservation Building Code (ECBC); Star Rating for Buildings (Star Rating); Green Rating for Integrated Habitat Assessment (GRIHA); and the Standards and Labeling (S&L) program for appliances and equipment. See Appendix C for more information about the existing energy efficiency policies in India including assessment and award criteria.

**Policy Review and Analysis**

**Data center standards from around the world**

As part of the “Accelerating Energy Efficiency in Indian Data Centers” initiative, an extensive review of published journals, articles, white papers, and technical and strategic documents on existing energy efficiency standards for data centers was conducted. The review sought to unveil best practices and lessons learned from other data center standards already in place. National, regional, and international standards, both voluntary and mandatory, were reviewed.

The international energy efficiency standards reviewed include: Energy Star Rating (U.S.); Leadership in Energy and Environment Design, LEED (U.S); American Society of Heating, Refrigerating and Air-Conditioning Engineers, ASHRAE 90.1 (U.S); California Title 24 standards (U.S); National Australian Built Environment Rating System, NABERS (Australia); Green Mark (Singapore); Green Building Index, GBI (Malaysia); Certified Energy Efficient Datacenter Audit, CEEDA (U.K); Building Research Establishment Environmental Assessment Method, BREEAM (U.K); European Code of Conduct; Blue Angel Eco-Label (Germany); and International Standards Organization (ISO) 50001: 2011 (Europe). The standards exhibit varied approaches for improving data center energy efficiency. See Appendix D for more information and analysis on each standard including assessment and certification criteria.

**Based on common characteristics, the standards can be categorized under four broad approaches:**

- Whole-Building (point-based and voluntary)
- Best Practices (Guidelines)
- Comparative Scale (Benchmark)
- Prescriptive or Performance-Based (mandatory code based)
Whole-Building (point-based and voluntary)
Whole-Building (point-based and voluntary) standards usually address other aspects of sustainable design and operation (e.g., water use, energy and water sources, materials, indoor environment) in an attempt to achieve a holistic rating. Points are assigned to different section/criteria and rating is based on an overall score determined by summing the points achieved for each section/criteria. These awards are usually time bound and need reassessment after fixed time tenures. Standards that follow this approach are Leadership in Energy and Environmental Design (LEED), Certified Energy Efficient Datacenter Audit (CEEDA), Building Research Establishment Environmental Assessment Method (BREEAM), Green Building Index (GBI), and Green Mark.

Best Practices (Guidelines)
Best Practices (Guidelines) standards allow data centers to voluntarily set energy efficiency targets based on the type of data centers and/or services provided. A policy document provides the guidance needed to develop an action plan to meet targets. The successful achievement of targets leads to the certification of the data center as an “Energy Efficient Data Center.” Standards based on this approach are the European Code of Conduct, ISO 50001, and Blue Angel Eco-Label.

Comparative Scale (Benchmark)
Comparative Scale (Benchmark) standards evaluate an individual buildings’ actual energy use through metrics such as the Energy Performance Index (EPI) or Energy Efficiency Ratio (EER). The building’s performance is then compared to a peer group of buildings with similar characteristics and services. The rating is usually awarded based on a relative percentile. Standards based on approach rating are ENERGY STAR and the National Australian Built Environment Rating System (NABERS).

Prescriptive or Performance-Based (mandatory code based)
Prescriptive or Performance-Based standards focus on the energy efficiency of the building envelope, HVAC, service hot water and pumping, lighting, and electric power. Compliance is achieved through a Prescriptive, Trade-Off, or Whole-Building performance method that uses a simulation model to assess energy performance. Standards based on this approach include American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) 90.1 and California Title 24 standards. ASHRAE 90.4: Energy Standard for Data Centers and Telecommunication Buildings is also based on this approach, but is still in the review process; it has not been formally adopted.

Approaches in the Indian Context

The existing energy efficiency standards/policies in India can also be categorized across each of the four approaches to data center standards. The categorization shows that although India does not have a standard specifically for energy efficiency in Indian data centers, it does have energy efficiency policies that exhibit similar characteristics as the international standards and could potentially be expanded to cover data centers.

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| Prescriptive or Performance-Based (Mandatory Code) |  
|  Indian: ECBC  
|  International: ASHRAE 90.1, California Title 24  

| Energy Efficiency Obligations |  
|  Indian: Perform, Achieve and Trade (PAT)  
|  International: No Comparable example in Data Center  

**ECBC (Minimum Energy Performance Code)**

ECBC by BEE takes a prescriptive or performance-based approach (Mandatory Code). It follows the same structure as ASHRAE 90.1 and California Title 24, covers similar building components, and offers the Prescriptive, Trade-Off, or Whole-Building compliance options. It is likely that an energy-efficiency standard for data centers in India will focus on improving energy efficiency through a system approach or through a whole facility approach. However, considering that GOI/BEE has not issued a segment-specific energy code or application guide, it is unlikely that government will adopt this approach.

**Perform, Achieve, and Trade (PAT)**

The PAT scheme by BEE demonstrates similarities with the Best Practices (Guidelines) approach. PAT sets performance indicators for specific industry segments and assigns mandatory emission reduction targets for the most energy intensive industries (i.e., Designated Consumers). More specifically, energy saving targets and the grace period to achieve targets are based on actual energy consumption and validation is conducted by a third-party (authorized by BEE). A data center energy efficiency standard that uses a widely acceptable performance indicator (e.g., PUE) and benchmarks against India-specific data may fit very well with the existing PAT framework. This approach will not have the granularity or flexibility of achieving compliance by targeting individual systems. An accompanying policy document will also be needed to provide guidance to organizations that will come under the purview of the PAT scheme.

**Star Labeling of Buildings**

Star Labeling by the BEE demonstrates similarities with the Comparative Scale (Benchmark) approach and specifically the ENERGY STAR standard. Star Labeling is based on actual performance (metered data), uses the Energy Performance Index (EPI) to evaluate energy performance, and also provides a peer group comparison. It is currently applicable to offices, hotels, retail malls, IT parks, and hospitals, and accounts for operational characteristics of the building such as climatic zone and hours of operation.

**Data Center Performance Evaluation Metrics**

Evaluation metrics gauge the level of energy efficiency and environmental impacts of a data center or its components. Evaluation metrics can also be used to capture unique requirements for Indian data centers such as backup generation due to unreliable electricity supply. Many metrics have evolved over the years to simplify the evaluation process and increase the efficiency of data capture for calculations. Most metrics focus on the efficient use of individual resources during operation and the single most important resource is energy. Most of the short-listed energy efficiency data center standards have adopted Power Usage Effectiveness (PUE) or Data Center Infrastructure Efficiency (DCiE), introduced by The Green Grid as an evaluation metric or criteria to rate data center energy efficiency. PUE is the ratio of a facility's total power...
drawn to the amount of power used solely by the data center’s IT equipment and DCiE is its inverse. PUE and DCiE gauge the efficiency of a data center by focusing on the support infrastructure (e.g., cooling).

Evaluation can be grouped into two categories: Basic metrics define the level of “greenness” of a data center and Extended metrics are functions of basic metrics that provide an in-depth look at the data center.

**Basic Metrics**
- Cooling System Efficiency (CSE)
- Airflow Efficiency (AE)
- Cooling System Sizing (CSS)
- Air Econometer Utilization (AEU)
- Water Econometer Utilization (WEU)
- Data Center Infrastructure Efficiency (DCiE) (The Green Grid, 2009)
- HVAC Effectiveness
- Space, Watts and Performance (SWaP)
- Server Compute Efficiency (ScE)
- Data Center Compute Efficiency (DCcE)

**Extended Metrics**
- Storage Utilization (Storage-U)
- Network Utilization (Network-U)
- Server Utilization (Server-U) (Wang, 2011)

There are many other metrics used around the world, typically to characterize sub-systems. For example, on the infrastructure side, cooling plant overall and component efficiencies, power distribution efficiency, and fan specific power are used. On the IT side, utilization, virtualization, and power management are used. Others include: Data Center Energy Efficiency and Productivity (DC-EEP) (Brill, 2007); Carbon (The Green Grid, 2014) (The Green Grid, 2010); Water Usage Effectiveness (WUE) (The Green Grid, 2011); Electronics Disposal Efficiency (EDE) (The Green Grid). These evaluation metrics are Green Performance Indicators (GPIs), which assess overall environmental performance. GPIs are classified as Data Center Level GPIs, SI system Level GPIs, IT system Level GPIs, and IT Benchmarks (Schodwell, Zarnekow, & Erek, 2013).

Among the standards considered in this report, seven use PUE to provide scoring or rating. The Green Mark rating system has benchmarked PUE in the range of 2.2-1.5 for existing data centers and 2.0-1.4 for new construction. Malaysia’s Green Building Index rating system (Green Building Index (GBI), 2012) has benchmarked PUE in the range of 1.3-1.9. The PUE metric drives the need to minimize power used by anything other than IT. However, there are concerns that the metric does not consider the actual productivity or efficiency of the IT equipment (The Green Grid, 2009). Server Compute Efficiency (ScE) and Data Center Compute Efficiency (DCcE) consider the efficiency of the data center compute infrastructure, and also focus on operational efficiency, much like PUE. Other metrics that evaluate energy use with consideration of the energy source are Energy Reuse Effectiveness (ERE) and Green Energy Coefficient (GEC). The ERE (The Green Grid, 2010) quantifies the amount of energy reused outside of the data center and GEC looks at the amount of renewable energy used. SI-EER is similar to PUE. The DCEP is
the ratio of work produced in the data center to the energy used in producing it (The Green Grid, 2009).

It has been reported that when assessing the energy demand of IT services all metrics fall short. For example PUE only measures the efficiency of whole infrastructure and IT equipment; inefficiencies are not addressed properly by PUE. The shortcomings are mainly due to the difficulty in modeling real life conditions of a data center. The development of such a metric is a proven challenge because of the different types of data centers and the services they provide. It should also be noted that an improvement in a specific metric might affect the outcome of another metric. A holistic approach can help to understand multiple metrics for energy efficiency of data center and reveal the effects of one metric on others.

Stakeholder Engagement: Online Survey

As part of the initiative, key data center stakeholders in India were grouped into two categories: data center owners (also includes large users) and data center experts (technology providers, academia, and R&D experts). CII developed and conducted an online survey with a different set of questions for the two groups. Thirty stakeholders were asked to participate in the survey and twenty-five participated. See Appendix E for survey questionnaires and list of participants for both stakeholder groups.

The survey was designed to capture industry's viewpoint on the following:

- Awareness of international data center standards.

- Metrics and international standards currently used by Indian data centers to determine their efficiency and benchmark energy consumption.

- Development of a standard for data centers in India including which existing energy efficiency policy in India is best suited to cover data centers.

- Importance and level of applicability of various energy efficient technologies in the electrical, mechanical, and IT sections of data centers.

- Characterization of data centers in India including type of services provided, size, sources of electricity, and respective annual average energy consumption.

The three sections of the questionnaires are General Facility, Data Center Energy Efficient Technologies, and Energy Benchmarking. The inputs received from both stakeholder groups help define the appropriate approach to an energy efficiency standard for data centers in India and inform the various components such as categorization (e.g., size, services, energy consumption) and eligibility/compliance criteria.

Data Center General Facility Results

Tiers

Data center owners were asked at which tier their data operate. Tiers are based on the concept of redundancy in power distribution and components. Most data centers represented in this survey (66.7 %) operate at Tier 3. 22.2% operate at Tier 4, 11.1% operate at Tier 1, and 0% operate at Tier 2.
Level of IT Energy Metering

The highest existing level of IT energy metering in most data centers is at the PDU and UPS level. 44.4% of respondents selected PDU and 33.3% selected UPS. Most of the data center owners (66.7%) indicated that they use semi-automated (software based) and semi-manual method for record keeping and monitoring IT energy consumption.

PUE

77.8% of respondents determine PUE for their data centers. The average PUE for the majority (57.1%) of the data centers lies within the range of 1.5 – 2.0. 28.6% of owners surveyed reported an average PUE better than 1.5. Furthermore, 100% of the participants have specified that they measure both "IT Power" and "Total Power" to determine the PUE of their facility. 71.4% of data center owners calculate their PUE on a monthly basis and 28.6% calculate their PUE on a daily basis.
Energy Consumption Targets
77.8% of respondents have stated that they have set energy consumption reduction targets for their respective data center.

Energy Benchmarking (Rating/Certification/Labeling) Results
100% of both data center owners and data center experts agreed that a standard facilitating energy efficiency in data centers in India should be developed. Almost all (87.5% of data center owners and 92.9% of experts) agree that energy benchmarking (rating/certification/labeling) would help improve the overall efficiency and business productivity of their data centers.

Both owners and experts were asked which BEE energy efficiency policy (ECBC, PAT or Star Rating) could be extended to encompass all the components of a data center for the purpose of rating based on energy efficiency. Respondents were able to choose more than one policy. There were noteworthy differences between the responses for data center owners and experts. Over 50% of owners identified PAT as a policy that can be extended, 37.5% identified ECBC, and Star Rating was identified least frequently with only 12.5% of owners selecting this policy. Owners identified Star Rating the least, but experts identified this policy most frequently with 78.6% of data center experts selecting Star Rating.

One overarching approach to data center standards in India did not reveal itself in the survey. The majority of data center owners (57.1%) selected Best Practices (Guidelines), Whole-Building (point-based and voluntary), and Comparative Scale (Benchmark) as a suitable approach for developing an energy efficiency policy for Indian data centers. Data center experts (64.3%) preferred the Prescriptive or Performance-Based (mandatory code based) and the Whole-Building (point-based and voluntary) approach. See figure below for more details on this section.
### Question: Do you agree that Energy Benchmarking (Rating/Certification/Labeling) would help to improve the overall "Energy Efficiency" and "Business Productivity" of your Data Centers, and a policy/standard facilitating Energy Efficiency in Data Centers in India should be developed?

#### Data Center Owners

87.5% of the respondents agreed that Energy Benchmarking (Rating/Certification/Labeling) would help to improve the overall "Energy Efficiency" and "Business Productivity" of Data Centers. 12.5% of respondents did not agree. 100% of respondents agreed and affirmed that a policy/standard facilitating energy efficiency in data centers in India should be developed.

#### Experts

92.9% of the respondents agreed that Energy Benchmarking (Rating/Certification/Labeling) would help to improve the overall "Energy Efficiency" and "Business Productivity" of Data Centers. 7.1% of respondents did not agree. 100% agreed and affirmed that a policy/standard facilitating energy efficiency in data centers in India should be developed.

### Question: In Indian Scenario, Bureau of Energy Efficiency currently has three major programs to enhance the Energy Efficiency (ECBC, PAT and Star Rating of buildings). Which of these existing policies can be extended to encompass all the components of a Data Center for the purpose of rating based on Energy Efficiency? Do you agree that a “Composite Policy Framework” on Energy Efficiency in Data Centers may be designed focusing on ECBC, PAT and Star Rating of buildings?

#### Data Center Owners

50% selected PAT to be extended to encompass all components of a data center for the purpose of rating. 37.5% selected ECBC and the rest selected Star Rating. 100% affirmed that a “Composite Policy Framework” on Energy Efficiency in Data Centers might be designed focusing on ECBC, PAT and Star Rating of buildings.

---

[Diagram of responses for Respondents and Graphic and Inference]
Experts

78.6% of respondents selected Star Rating to be extended to encompass all components of a data center for the purpose of rating. 71.4% selected PAT and 50% of respondents selected ECBC.

85.7% respondents affirmed that a “Composite Policy Framework” may be designed focusing on ECBC, PAT and Star Rating of buildings.

Question: This ongoing study of CII-LBNL on Accelerating Energy Efficiency in Indian Data Centers, has categorized the worldwide existing standards for Energy Benchmarking (Rating/Certification/Labeling) methods in the area of Efficient & Sustainable operations into four categories. With this analytical context, according to you which one of the following methodologies (please refer table) would be more suitable for developing a policy on Energy Efficiency for Indian Data Centers?

Data Center Owners

57.1% of respondents selected Best Practices, Whole-Building, and Comparative Scale as a suitable methodology for developing a policy on energy efficiency for Indian Data Centers. 42.9% selected the Prescriptive or Performance-Based approach.

Experts

64.3% selected Prescriptive or Performance-Based and the Whole-Building approach. 42.9% of respondents selected Best Practices and 28.6% selected Comparative Scale.
Energy Saving Opportunities

Both stakeholder groups were asked to identify and prioritize specific sections within a data center in regards to their potential for energy savings opportunities. On a scale of 1 to 6, 1 signifies the least possibility of energy efficiency and Level 6 signifies the maximum possibility of energy efficiency.

Data Center Owners on Energy Saving Opportunities
The responses received from data center owners are diverse and informative in nature. 100% of respondents prioritized cooling distribution pattern and server utilization (Level 6), which signify the areas with the most energy saving opportunities. Power distribution architecture was the second highest priority area for energy saving opportunities as 42.9% of respondents selected Level 5. Only 28.6% of respondents selected Level 6 for networking architecture as an energy saving opportunity, most of the participants gave it a rating of 1, 2 and 3. A majority of stakeholders (57.1%) selected Level 3 for use of transformers and 42.9% selected Level 2 for power conversions (number of conversions from AC to DC).

Data Center Experts on Energy Saving Opportunities
Data center experts also prioritized power distribution pattern and server utilization. However, experts identified power distribution architecture as the section with the least opportunity to save energy whereas data center owners prioritized this section much higher (Level 5). Additionally, experts prioritized power conversions and the use of transformers much higher than data center owners.
Adoption of Energy Efficient Technologies

Both stakeholder groups were asked questions regarding energy efficient technologies. Data center owners were asked about the potential of these technologies and experts were asked about the current level of adoption in data centers.

Data Center Owners on Energy Efficient Technologies
Data center owners were asked to prioritize technologies according to their applicability and suitability in a data center. On a scale of 1-4, Level 1 signifies the most suitable technology and Level 4 signifies that the technology is not required at all. The figure below shows the responses of data center owners.

In the electrical system, prioritization has been given to high efficiency IT power supplies followed by energy efficient transformers. 66.7% participants selected Level 1 for IT power supplies and 50% of participants selected Level 1 for transformers. For
other technologies including variable module management system (VMMS) and K-rated transformers, Level 2 was selected by 50% of the participants. For power distribution unit (PDU), 100% of participants selected Level 2.

In the Cooling section, prioritization is given to CRAC/CRAH units with variable speed drives and rack cooling; 66.7% of participants selected Level 1 for both the technologies. 50% of participants selected Level 1 for in row cooling and free cooling with air and water economizers. Rack cooling with rear door heat exchanger was also selected as level 1 technology by 33.30% of participants. Solar cooling system and direct contact Cooling were selected as level 2 technologies by 66.70% and 50% of participants respectively.

In the IT Peripheral section, prioritization is given to server, storage and network virtualization followed by solid state drives. Level 1 was selected for the server virtualization by 83.30% participants, storage virtualization by 66.7% participants, and network virtualization by 40% participants. Solid state drives were designated at Level 1 by 33.3% of participants. 50% of participants selected Level 2 for fiber technology and RAID/Intelligent Disk Subsystem.

**Data Center Experts on Energy Efficient Technologies**

Data center experts were asked to identify and prioritize energy efficient technologies in regards to their level of adoption in data centers. On a scale of 1 to 5, Level 1 signifies low adoption and Level 5 very high adoption. The figure below represents the consolidated responses of the experts.

In the electrical Section, prioritization is given to K-rated transformers and high efficiency IT power supplies followed by PDU and energy efficient transformers, signifying a high level of adoption in data centers Level 4 was selected for K-rated Transformers and high efficiency IT power supplies by 36.40% of participants. 33% selected level 4 for PDU and 25% selected Level 4 for energy efficient transformers, still indicating a high level of adoption.

In the cooling section, high prioritization was given to direct contact cooling followed by free cooling with water side economizers, signifying a high level of adoption in data centers Level 4 was selected for both the technologies by 36.40% participants and 25% participants respectively.
In the IT peripheral section, prioritization was given to server virtualization and storage virtualization followed by RAID/Disk intelligent subsystem. Level 5 was selected by 41.7% participants for server virtualization and RAID/Disk intelligent subsystem and by 25.50% participants. Network virtualization received Level 3 by 63.30% participants. Further Fibre Channel Technology and solid state drives received Level 4 by 36.40% and 25% participants respectively.

Key Policy Findings from Stakeholder Surveys

- Energy benchmarking (Rating/Certification/Labeling) is the key to improve overall “Energy Efficiency” and “Business Productivity” of data centers. The Indian government may systematically formulate a standard facilitating energy efficiency in data centers in India.

- A data center is essentially a building with high-energy intensity. The large variation and associated refresh rate of IT technologies and infrastructure impacts its energy consumption as well. Thus, any single existing energy efficiency policy in India (e.g., PAT, ECBC, Star Rating) may not encompass all components of a data center.

- A “Composite Policy Framework” may be designed for existing (brownfield) and new (greenfield) data centers based on existing energy efficiency policies in India (e.g., PAT, ECBC, Star Rating). These policies can be extended to encompass all the components of a data center for the purpose of energy efficiency rating.

- While designing the composite policy framework for Indian data centers, appropriate inputs may be considered from the Best Practices (Guidelines) approach, Whole-Building (point-based and voluntary) approach, and Prescriptive or Performance-Based (mandatory code based) approach.

Stakeholder Engagement: Workshop

To gain further insight into the viewpoint of relevant stakeholders, an in-person stakeholder workshop took place in Bangalore on July 13th, 2015. See Appendix F for participants list and agenda.

Summary of Viewpoints from the Stakeholder Workshop:

- The Indian Government may initially come up with a voluntary standard that can later be made mandatory. Incentives may not be required in the new policy framework; comparative framework and public recognition leads to peer pressure, which is sufficient motivation.

- Considering the poor power infrastructure in India, the recognition through this new standard or rating by BEE may help in providing better quality and reliable electricity from distribution companies. This in itself will act as an incentive for the data center industry.

- Diversity in the types of data centers and related technologies, especially IT technologies may act as a barrier to policy formulation. The standard should be able to address the real time challenges and variations in technologies and operational
parameters for different types of data centers (e.g., captive and colocation data centers).

• It is necessary to have the proper ecosystem to support the new standard or policy framework for data centers. For example, qualified energy auditors with requisite level of understanding of data center technologies and operations should be made easily available to provide the certification/rating/expert advisory.

• Considering that PAT may be considered for this sector, an appropriate and feasible “Energy versus Output” reporting format should be developed for this standard. A standard where a metric such as Energy Performance Index (EPI) with a variant of PUE can be considered with IGBC/US GBC rating used for certification should also be considered.

• The new standard must set a benchmark and should encourage the reporting of information in form of the "Energy Vs. Output" reporting format. If PUE is the metric used then it must clearly define what PUE is considered good, average, and bad based on the size and type of data centers.

• A hybrid approach is appropriate where data center infrastructure related aspects of ECBC can be extended to new data center design, PAT may be applicable to large and existing data centers standards with S&L applied to IT equipment. This arrangement will allow continuous improvement in operation where targets can be changed over the time.

Presentation to BEE: Bangalore Consultative Meeting

The findings of the policy review and stakeholder engagement activities (online survey and workshop in Bangalore) were presented to BEE on July 21st 2015.

Key commentary from BEE:

• For ECBC integration into the new data center energy efficiency standard in India it is important to define a compliance path for data centers which is not currently addressed. International energy efficiency standards having similar characteristics as ECBC (e.g., Title 24, ASHRAE 90.1) that may be studied in detail.

• In regards to PAT for data centers, data centers being an energy intensive niche building market, PAT for commercial buildings may be initiated at this stage starting with voluntary notification. It is important to identify an appropriate performance metric for core IT Load and also define thresholds (e.g., 500 kW) for data centers.

• Standards & Labeling (S&L) may be applied to specific IT products (e.g., server, UPS) in data centers. Currently nineteen products are covered under S&L out of which three are mandatory and nine are in the process to become mandatory. S&L for data center equipment would be a major effort and may not fit within the BEE S&L.
Conclusion and Next Steps (Phase II)

Enhancing energy efficiency through a standard has been recognized as an appropriate strategy to reduce energy consumption in Indian data centers. Though India has well-established energy efficiency standards in its commercial and industrial facilities, a dedicated standard for data centers does not exist. The deeper understanding of existing energy efficiency policy in India and the review of standards and specific metrics used around the world provided a strong base for the development of a standard for data centers in India. The alignment of these standards to Indian data centers, the results from stakeholder engagement, and feedback from BEE have also provided valuable insight for the development of an effective policy framework for data center energy efficiency. Phase 1 of the “Accelerating Energy Efficiency in Indian Data Centers” initiative established that existing energy efficiency policies in India share certain similarities with some of the international standards reviewed in this study and these existing standards can be leveraged for data center energy efficiency.

Summary of Phase 1 Findings:

- An energy efficient data center in itself is an incentive or a reward for the data center industry. It not only improves the overall energy efficiency but also increases the business productivity of data centers.

- A “Composite Policy Framework” based on existing energy efficiency standards such as PAT, ECBC and S&L may be designed for Indian data centers to encompass all the components of a data center (e.g., IT and Infrastructure), and should be applicable to both existing (brownfield) and new (greenfield) data centers.

- An Expert Stakeholder Group may be formulated to focus on the IT metric part and separately an Administrative Stakeholder Group will take care on the synchronization part with the existing ECBC, PAT, and S&L framework to make this standard easily adoptable by BEE.

- Formulation of the new standard must consider the following factors: variation in size of data centers; variation in type of data centers (e.g., captive, colocation) and their implication on energy use; reliability; and air and environmental quality.

Next Steps:

- Development of short-term and long-term strategies to implement an energy efficiency standard for Indian data centers in the context of existing policy (e.g., ECBC, PAT). This process will follow in-depth consultation with a broad DC Stakeholder Consultative group.

- Formulation of a Core IT Stakeholder Consultative Group to come to a consensus on an IT Energy Performance Metric, taking PUE into consideration.

- Development of technical and administrative procedures the standard.

- Stakeholder discussions to define a specific methodology to design the standard.

- Facilitation of the implementation and notification aspects of the standard.

- National and international-level dissemination.
Appendix A: References


Appendix B: Efficient Technologies Matrix

<table>
<thead>
<tr>
<th>TABLE</th>
<th>TECHNOLOGY</th>
<th>DESCRIPTION OF TECHNOLOGY</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Integrated Power Supply (UPS) &amp; Batteries</strong></td>
<td><strong>Topologies</strong></td>
<td>Topologies depend on the intended application, availability and Power Quality Considerations. The primary requirements of load, which are driven by specific applications.</td>
</tr>
<tr>
<td><strong>Variable Module Management Systems (VMM)</strong></td>
<td><strong>Doc Mode</strong></td>
<td>The input is to be shared UPS. Parallel Mode: Parallel UPS Power Control is used, which means that the load is divided among the UPS in the VMM.</td>
</tr>
<tr>
<td><strong>Energy Storage System</strong></td>
<td><strong>Battery Efficiency</strong></td>
<td>Battery Efficiency is an important factor when the input is to the availability and Voltage and Frequency.</td>
</tr>
<tr>
<td><strong>Battery Energy Storage</strong></td>
<td><strong>Battery Energy Storage</strong></td>
<td>Battery Energy Storage is used to ensure constant performance and to maintain a load capacity as power needs change.</td>
</tr>
<tr>
<td><strong>Traction Systems</strong></td>
<td><strong>Battery Energy Storage</strong></td>
<td>Battery Energy Storage is used to ensure constant performance and to maintain a load capacity as power needs change.</td>
</tr>
<tr>
<td><strong>Battery Energy Storage</strong></td>
<td><strong>Battery Energy Storage</strong></td>
<td>Battery Energy Storage is used to ensure constant performance and to maintain a load capacity as power needs change.</td>
</tr>
<tr>
<td><strong>Fiber Ducts</strong></td>
<td><strong>Fiber Ducts</strong></td>
<td>Fiber Ducts are used for the management of optical fibers or cables, which can be used to transmit optical signals over long distances.</td>
</tr>
<tr>
<td><strong>Power Distribution Systems</strong></td>
<td><strong>Fiber Ducts</strong></td>
<td>Fiber Ducts are used for the management of optical fibers or cables, which can be used to transmit optical signals over long distances.</td>
</tr>
<tr>
<td><strong>Cable Ducting</strong></td>
<td><strong>Cable Ducting</strong></td>
<td>Cable Ducting is used to route cables and protect them from physical damage.</td>
</tr>
<tr>
<td><strong>Direct-Link Ducting</strong></td>
<td><strong>Direct-Link Ducting</strong></td>
<td>Direct-Link Ducting is used to deliver power and data directly to the data center.</td>
</tr>
<tr>
<td><strong>Piping/Conduit</strong></td>
<td><strong>Piping/Conduit</strong></td>
<td>Piping/Conduit is used to route fluids and protect them from physical damage.</td>
</tr>
<tr>
<td><strong>Solvent Resistant</strong></td>
<td><strong>Solvent Resistant</strong></td>
<td>Solvent Resistant is used to protect circuits and components from harsh environments.</td>
</tr>
<tr>
<td><strong>Storage</strong></td>
<td><strong>Storage</strong></td>
<td>Storage is used to hold data for long periods of time and is a critical component of any data center.</td>
</tr>
<tr>
<td><strong>Software Optimized Flash</strong></td>
<td><strong>Software Optimized Flash</strong></td>
<td>Software Optimized Flash is used to improve the performance of flash storage systems.</td>
</tr>
<tr>
<td><strong>Flash Technology</strong></td>
<td><strong>Flash Technology</strong></td>
<td>Flash Technology is used to store and retrieve data.</td>
</tr>
<tr>
<td><strong>Network Virtualization</strong></td>
<td><strong>Network Virtualization</strong></td>
<td>Network Virtualization is used to create virtual networks that can be managed and configured independently.</td>
</tr>
</tbody>
</table>

**SYSTEM COMPONENT**

- **Data Center**
- **UPS & Batteries**
- **Energy Storage System**
- **Traction Systems**
- **Fiber Ducts**
- **Power Distribution Systems**
- **Cable Ducting**
- **Direct-Link Ducting**
- **Piping/Conduit**
- **Solvent Resistant**
- **Storage**
- **Software Optimized Flash**
- **Flash Technology**
- **Network Virtualization**

**TECHNOLOGY**

- **Topologies**
- **Doc Mode**
- **Variable Module Management Systems (VMM)**
- **Battery Efficiency**
- **Battery Energy Storage**
- **Fiber Ducts**
- **Power Distribution Systems**
- **Cable Ducting**
- **Direct-Link Ducting**
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- **Solvent Resistant**
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**SYSTEM COMPONENT DESCRIPTION**

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**TECHNOLOGY DESCRIPTION**

- **Topologies**
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- **Direct-Link Ducting**
- **Piping/Conduit**
- **Solvent Resistant**
- **Storage**
- **Software Optimized Flash**
- **Flash Technology**
- **Network Virtualization**
Appendix C: Existing Energy Efficiency Standards in India

The following energy efficiency policy/standards currently exist in India: Indian Green Building Council; Energy Conservation Building Code (ECBC); Star Rating for Buildings; Green Rating for Integrated Habitat Assessment; and Standards and Labeling program for appliances and equipment.

Indian Green Building Council (IGBC) Green SEZ Rating System

The IGBC rating system enables the designer to apply green concepts and criteria, so as to reduce the environmental impacts, which are measurable. The certifications available are Certified (51-60), Silver (61-70), Gold (71-80), and Platinum (81-100). The assessment is carried out through certain credit points using a prescriptive approach and other credits on a performance-based approach. The credit points are awarded for the following components: Site Preservation & Restoration (4 Points); Site Surveys & Design (4 Points); Water Efficiency (3 Points); Energy Efficiency (2 Points); Materials & Resources (2 Points); Innovation & Design (2 Points).

Energy Conservation Building Code (ECBC) by Bureau of Energy Efficiency (BEE)

The ECBC by Bureau of Energy Efficiency aims to provide minimum requirements for energy efficient design and construction of buildings and their systems. ECBC encourages energy efficient design or retrofit of buildings so that it does not constrain the building function, comfort, health, or the productivity of the occupants and has appropriate regard for economic considerations. ECBC follows the same structure as ASHRAE 90.1 standard and covers the following areas: Building Envelope, HVAC, Service Hot Water and Pumping, Lighting, and Electric Power. It also provides both prescriptive and performance-based compliance framework for buildings with connected load of more than 100 kW or 120 kVA to achieve energy efficiency either at the component level or at the whole building level.

Green Rating for Integrated Habitat Assessment National Green Building Rating System (GRIHA)

GRIHA is a performance-oriented rating system where points are earned for meeting the design and performance intent of the criteria. GRIHA rating system consists of 34 criteria categorized under various sections such as Site Selection and Site Planning,
Conservation and Efficient Utilization of Resources, Building Operation and Maintenance, and Innovation points. All buildings (e.g., offices, retail spaces, institutional buildings, hotels, hospital buildings, healthcare facilities, residences, multi-family high-rise buildings) more than 2,500 square meters are eligible for certification under GRIHA. Industrial complexes are only eligible in the design stage. GRIHA measures and rates the building's environmental performance in the context of India's varied climate and building practices. Different levels of certification, on a scale from one star to five stars, are awarded based on the number of points earned. 1 star: 50-60 points; 2 star: 61-70 points; 3 star: 71-80 points; 4 star: 81-90 points; 5 star: 91-100 points.

**Perform, Achieve & Trade (PAT) by Bureau of Energy Efficiency (BEE)**

PAT is a market-based scheme launched in 2011 under The National Mission for Enhanced Energy Efficiency (NMEEE). NMEE is one of the eight missions under the National Action Plan on Climate Change (NAPCC). PAT aims to improve the energy efficiency in energy-intensive large industries and facilities by setting sector-specific benchmarks and giving targets to Designated Consumers (DC). The implementation of Phase 1 of the PAT scheme has laid a strong foundation that can now be extended to other energy-intensive sectors such as the sugar industry, commercial buildings, and chemicals.

The Ministry of Power (MoP) notified 478 Designated Consumers in eight energy-intensive sectors: Thermal Power Plants, Fertilizer, Cement, Pulp and Paper, Textiles, Chlor-Alkali, Iron & Steel, and Aluminum. The scheme imposes mandatory Specific Energy Consumption (SEC) targets on the covered facilities with less energy efficient facilities having a greater reduction target than the more energy efficient ones. Facilities making greater reductions than their targets receive “E-certs” or "energy saving certificates" which can be traded with facilities that are having trouble meeting their targets, or banked for future use. The PAT scheme establishes plant-specific targets rather than a sectoral target, with the average reduction target being 4.8% and a cumulative target of 6.68 Mtoe that was to be achieved by the end of the first phase in March 2015.

**Star Rating for Buildings by Bureau of Energy Efficiency**

Star Rating is based on the actual performance of a building in terms of its specific energy usage in kwh/m²/year. The standard rates office buildings on a 1-5 Star scale, with 5 Star labeled buildings being the most efficient. Only buildings with a connected load of 100kW and above are considered for assessment under this voluntary programme. This scheme provides public recognition to energy efficient buildings, to create a demand for such buildings. The major assessment criteria are as follows: Energy Performance Index (EPI) in kWh/m²/year. Buildings have been categorized into two categories, having air-conditioned area greater than 50% and less than 50% of built up area.
1. Review

International energy efficiency standards for data centers reviewed in this study are:
- Energy Star Rating (U.S. Environmental Protection Agency (EPA), 2013) (U.S.);
- Leadership in Energy and Environment Design (U.S) (U.S. Green Building Council, 2014);
- American Society of Heating, Refrigerating and Air-Conditioning Engineers (U.S) (American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), 2010);
- California Title 24 Standards (U.S) (California Energy Commission (CEC), 2013);
- National Australian Built Environment Rating System (Australia) (State of NSW and Office of Environment and Heritage, 2012);
- Green Mark (Singapore) (Building and Construction Authority (BCA) and Infocomm Development Authority (IDA));
- Green Building Index (Malaysia) (Green Building Index (GBI), 2012);
- Certified Energy Efficient Data Center Audit (U.K) (British Computing Society -The Chartered Institute for IT, 2011);
- Building Research Establishment Environmental Assessment Method (U.K) (Building Research Establishment (BRE) Global, 2010);
- European Code of Conduct (European Commission, 2008);
- Blue Angel Eco-Label (Germany) (The Blue Angel, 2012);

The following section describes these standards.

### Appendix D: Approaches to Energy Efficiency Standards

#### ENERGY STAR Rating by Environment Protection Agency (EPA)

ENERGY STAR selected Power Usage Effectiveness (PUE) as the metric to evaluate data center energy performance. To develop the rating, EPA extensively collected data on energy use and operating characteristics from a large number of existing data centers. Regression analysis was used to identify the operating characteristics (e.g., Heating Degree Days (HDD), Cooling Degree Day (CDD), Building Square Footage, Data Center...)

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**Country-Wise Data Center Energy-Efficiency Policy Consolidation Matrix**

<table>
<thead>
<tr>
<th>S.No</th>
<th>COUNTRY</th>
<th>STANDARDS</th>
<th>ASSESSMENT &amp; CERTIFICATION CRITERIA</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>USA</td>
<td>Data Center Efficiency (DCE)</td>
<td>The U.S. Environmental Protection Agency (EPA) uses the Data Center Efficiency (DCE) metric to evaluate the energy efficiency of data centers. A lower DCE score indicates a more energy-efficient data center.</td>
</tr>
<tr>
<td>2</td>
<td>Australia</td>
<td>National Australian Built Environment Rating System (NABERS)</td>
<td>The NABERS framework assesses the energy efficiency of buildings, including data centers, in terms of energy consumption, water consumption, and waste management.</td>
</tr>
<tr>
<td>3</td>
<td>Malaysia</td>
<td>Green Building Index (GBI)</td>
<td>The GBI is a national green building rating system that evaluates the energy efficiency and environmental performance of buildings, including data centers, in Malaysia.</td>
</tr>
<tr>
<td>4</td>
<td>Singapore</td>
<td>Green Mark</td>
<td>The Green Mark is a voluntary environmental assessment and certification program for buildings in Singapore, including data centers.</td>
</tr>
</tbody>
</table>

---

**Notes**

1. The Data Center Efficiency (DCE) score uses metrics such as energy consumption and total square footage to calculate a ratio that represents the energy efficiency of a data center.
2. The NABERS framework includes metrics such as energy consumption, water consumption, and waste management to evaluate the performance of buildings, including data centers, in Australia.
3. The GBI framework assesses the energy efficiency and environmental performance of buildings, including data centers, in Malaysia.
4. The Green Mark framework evaluates the environmental performance of buildings, including data centers, in Singapore using metrics such as energy consumption and water consumption.

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**Regression Analysis**

Regression analysis was used to identify the operating characteristics (e.g., Heating Degree Days (HDD), Cooling Degree Day (CDD), Building Square Footage, Data Center...)

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**Energy Efficiency Metrics**

- **Energy Star Rating**
- **Certified Energy Efficiency**
- **Building Research Establishment Environmental Assessment Method (BREEAM)**
- **European Code of Conduct**
- **Blue Angel Eco-Label**
- **ISO 50001 Standard**
Square Footage, Number of Racks, UPS Utilization, Annual IT Energy) that explain the variation in PUE among data centers. Out of the numerous variables analyzed, only the Annual IT energy consumption was found to be statistically significant in explaining the variation in energy use; data showed that facilities with higher IT energy consumption have lower PUE values, on average. For a given facility the actual measured PUE can be compared with this prediction. A facility whose actual PUE is lower than the predicted PUE is doing better than average. The Energy Efficiency Ratio (EER = Actual PUE/Predicted PUE) is mapped to a 1-100 scale such that one point represents one percent of the population.

**Leadership in Energy and Environmental Design (LEED)**
LEED certification recognizes a best-in-class data center based on the score achieved on a scale of 110 points. Areas of assessment & credits assigned pertaining to data centers are: (i) Sustainable Sites (10 Points): Site selection, building reuse, alternative transportation measures etc; (ii) Water Efficiency (9 Points): Water use reduction, landscaping, and wastewater technologies; (iii) Energy and Atmosphere (29 Points): Energy efficiency, renewable energy commissioning, refrigerant management, measurement and verification, and green power; (iv) Materials and Resources (9 Points): Building reuse, construction waste management, materials reuse, recycled content etc; (v) Indoor Environmental Quality (17 Points): Outdoor air delivery monitoring, ventilation, and indoor air quality management; (vi) Innovation (6 Points): Exceptional or innovative performance. Other categories include: Integrative Process (3 Points); Location & Transportation (14 Points); Performance (9 Points); and Regional Priority (4 Points). The section points are then added together to give the overall LEED score. The overall score is then compared to the threshold levels to determine the LEED rating, provided all pre-requisites have been met. There are four levels of certification - the number of points a project earns determines the level of LEED certification that the project will receive. Typical certification thresholds are: (i) CERTIFIED: 40-49 Points; (ii) SILVER: 50-59 Points; (iii) GOLD: 60-79 Points; and (iv) PLATINUM: 80+ Points.

**California Title 24 Standards**
California Title 24 focuses on key areas to improve the energy efficiency of new data centers, additions, and major alterations to existing data centers. Areas of assessment include HVAC, Power, Lighting systems etc. There are two methods for achieving Title 24 compliance in California: (i) Prescriptive Method: The simplest approach to Title 24 compliance where each individual component of the proposed building must meet a prescribed level for energy efficiency. An applicant need only show that a building meets each minimum or maximum level prescribed in the set of requirements contained in a package. The prescriptive method is not recommended for new constructions or larger additions, and can result in higher construction costs. (ii) Performance Method: The use of computer models provides the most flexibility and accuracy when seeking Title 24 compliance. Detailed accounting of energy trade-offs between measures is possible with this compliance approach. The computer program automatically calculates the energy budget for space conditioning. The budget is determined from the standard design, a version of the building which is upgraded or downgraded to achieve minimum compliance with the prescriptive package conservation features. To comply with the Standards, the predicted combined "Energy Use" of the Proposed Design cannot exceed the combined "Energy Budget" of the Standard Design. There are mandatory provisions (pre-requisites) under each area of assessment, which are required to demonstrate code compliance.
American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) 90.1
ASHRAE 90.1 establishes the minimum energy efficiency requirements of buildings, including Data Centers and Telecommunications Buildings, for design, construction, and a plan for operation and maintenance, as well as utilization of on- or off-site renewable energy resources. It is the reference standard for US Energy Policy Act and many state building energy codes in the United States; it has been adopted in many countries as a model for energy efficiency guidelines and codes. In terms of structure and compliance options, it is very similar to California Title 24.

National Australian Built Environment Rating System (NABERS)
The National Australian Built Environment Rating System (NABERS) is the industry standard for measuring and benchmarking the environmental performance and efficiency of existing Australian buildings. NABERS rating tools measure environmental performance on a scale of 1 to 6 stars. Three stars represent market median performance and a 6-star rating demonstrates market-leading performance. A 1-star rating represents below median market practice and indicates that there is considerable scope for improvement.

There are three types of rating:

- **IT Equipment rating:** benchmarks the greenhouse gas emissions associated with the energy consumed by the IT equipment within a data center over a one-month period (approximately). NABERS has developed two metrics: Processing capacity – measures the sum of the number of server cores multiplied by clock speed in gigahertz (GHz), and Storage capacity – measures the total unformatted storage capacity in terabytes (TB).

- **Infrastructure rating:** benchmarks the greenhouse gas emissions associated with the energy consumed in supplying infrastructure services to IT equipment within a data center over a 12-month period. The NABERS benchmark for an Infrastructure Rating measures the energy efficiency in delivering support services to IT equipment, using the widely accepted industry Power Usage Effectiveness (PUE) ratio.

- **Whole facility rating:** benchmarks the greenhouse gas emissions associated with the energy used by the IT equipment and infrastructure services within a data center over a 12 month period.

**Green Mark**
Green Mark is a Singaporean performance-based rating system that awards points for green features, energy efficiency, and best practices. Points are awarded across the following categories: (i) Energy Efficiency (88 points): Overall energy efficiency, systems energy efficiency (cooling, IT equipment), energy assessment and monitoring, energy policy/management, energy efficiency innovations; (ii) Water Efficiency (12 points): Water-use efficiency, alternate water use, water consumption of cooling tower; (iii) Sustainable Operation (7 points): Refrigerants and fire suppressors, sustainable policies; (iv) Indoor environmental quality (8 points): Thermal comfort, noise level, indoor air quality and ventilation, lighting quality and management; (v) Other Green Innovations (10 points): Green features and innovations. The assessment system is a performance-based rating system that awards points for green features, energy efficiency, and best practices adopted by the data centers. Based on the total number of points scored a final rating, from Certified to Platinum is given. Platinum (>=90); GoldPLUS (85 to <90); Gold (75 to <85); or Certified (50 to <75).
Green Building Index (GBI)
GBI is derived from existing rating tools, including Green Mark, but has been extensively modified for relevance to the Malaysian tropical weather, environmental context, and cultural and social needs. Points are awarded across 6 main categories: (i) Energy Efficiency (35 points): Design, commissioning, verification and maintenance; (ii) Indoor Environmental Quality (21 points): includes air quality, thermal comfort, lighting, visual, acoustic comfort, and verification; (iii) Sustainable Site Planning and Management (16 points): Site planning, construction management, transportation, design; (iv) Material and Resources (11 points): Reused and recycled materials, sustainable resources, waste management, and green products; (v) Water Efficiency (10 points): Water harvesting and recycling, and energy efficiency; and (vi) Innovation (7 points). Projects are scored on a 100-point scale, with four Green Mark ranking levels: certified (50-65 points); silver (66-75 points); gold (76-85 points); and platinum (86 points & above).

Certified Energy Efficient Datacenter Audit (CEEDA)
CEEDA is an U.K-based award that assesses the implementation of energy efficiency best practices within a data center. The CEEDA framework involves certifies data centers at three different levels: Bronze, Silver and Gold. The certification is received through the British Computing Society – The Chartered Institute for IT and is valid for 2 years. The assessment process is two years. In year one, the initial assessment provides a detailed analysis of the implementation of a set of energy efficiency best practices in M&E, IT, and operational management. In year two, a second assessment evaluates the energy efficiency impacts of the roadmap, new infrastructure deployment, and new services delivered. The assessment is based on a set of up to ninety best practices and metrics from ASHRAE, Energy Star, ETSI, EUCoC, and The Green Grid. The assessment covers the following key areas within the data center facility: Data center utilization, IT equipment and services, cooling, power equipment and data center building monitoring.

Building Research Establishment Environmental Assessment for Data Centers (BREEAM)
BREEAM sets the standard for best practice in sustainable design and has become the de facto measure used to describe a building's environmental performance. This U.K-based rating, also practiced in Hong Kong, is based on the total score achieved by a data center across ten categories: (i) Management (10 Points): Site commissioning, contractor issues, overall policy management; (ii) Health and Wellbeing (15 Points): Elements that impact building user comfort and health, such as fresh air ventilation and controls for lighting and temperature; (iii) Energy (28 Points): Power consumption and carbon emissions, heating and cooling efficiencies, metering; (iv) Transport (10 Points): Elements to reduce carbon emissions associated with transportation from the use of local building materials to the proximity to public transit to encourage employee usage; (v) Water (8 Points): Water consumption, efficiencies; (vi) Materials (15 Points): Building material; (vii) Waste (7 Points): Construction site waste management, recycled aggregates, recyclable waste storage; (viii) Land Use & Ecology (10 Points): Use of existing facilities rather than undeveloped land, or cleanup of previously contaminated property; (ix) Pollution (11 Points): air and water pollution; and (x) Innovation (additional 1%). The percentage of 'credits' achieved in each section is then multiplied by the corresponding section weighting. Section weightings for data centers depend on the type of data center, which are categorized into: Large Associated Function Area, Small Associated Function Area & No Associated Function Area. Credits are awarded in ten categories according to performance. These credits are then added together to produce a single overall score of Unclassified, Pass, Good, Very Good, Excellent and Outstanding.
European Code of Conduct by the European Commission

The European Code of Conduct promotes data center energy efficiency by setting targets, understanding energy demand, raising awareness, and recommending energy-efficient best practices. The energy saving focus of the European Code of Conduct covers two main areas: (i) IT Load: relates to the consumption of the IT equipment in the data center; (ii) Facilities Load: relates to the mechanical and electrical systems that support the IT electrical load. The Code of Conduct uses the ratio of IT Load to Facilities Load (DCiE), known as 'facility efficiency', as the key metric in assessing infrastructure efficiency. The Code of Conduct has both, an equipment and system-level scope: (i) Equipment Level: All energy using equipment within the data center, such as: IT equipment (e.g., rack optimized and non-rack optimized enterprise servers, blade servers, storage and networking equipment), cooling equipment (e.g., Computer room air-conditioner units) and power equipment (e.g., uninterruptible power supplies and power distributions units), and miscellaneous equipment (e.g., lighting). (ii) System Level: At system level, the Code of Conduct proposes actions which optimize equipment interaction and the system design (e.g., improved cooling design, correct sizing of cooling, correct air management and temperature settings, correct selection of power distribution), to minimize overall energy consumption. All Participants have the obligation to continuously monitor energy consumption and adopt energy management in order to look for continuous improvement in energy efficiency.

Blue Angel Eco-Label

Blue Angel Eco-Label in Germany may be awarded to any resource-conscious company committed to the implementation of a long-term strategy to improve the energy and resource efficiency of its data center. Label requires regular monitoring to optimize its data center operations. The Blue Angel eco-label is awarded to the entire data center building defined by a specific location and company name. If an organization runs several data centers located at different locations and/or independent data centers, each one shall be considered as an independent data center for which a separate application needs to be filled. This environmental label requires the implementation of an energy management system according to EN 16001. This includes a transparent energy efficiency strategy, a plan for concrete energy saving measures, a monitoring system, and clear definition of responsibilities in the data center. Applicants must provide a basic analysis of the data center according to specified guidelines. Analysis is required to include information on the Energy Usage Effectiveness (EUE) measured over a period of 12 months. Data provided must not be more than 3 months old. The applicant also needs to fulfill a number of requirements regarding procurement and management of the IT and infrastructure.


ISO 50001 is an international standard that specifies EMS requirements upon which data centers can develop and implement an energy policy, and establish objectives, targets, and action plans which take into account legal requirements and information related to significant energy use. ISO 50001 can be implemented individually or integrated with other management system standards. This international standard is based on the Plan-Do-Check-Act continual improvement framework and incorporates energy management into everyday organizational practices. (i) Plan: Conduct the energy review and establish the baseline, energy performance indicators (EnPIs), objectives, targets and action plans necessary to deliver results in accordance with opportunities to improve energy performance and the data center's energy policy; (ii) Do: Implement the energy management action plans; (iii) Check: Monitor and measure processes and the key characteristics of its operations that determine energy performance against the
energy policy and objectives and report the results; and (iv) Act to take actions to continually improve energy performance and the EnMS.

Additional energy efficiency standards reviewed were the Building Energy Rating (Ireland) (Sustainable Energy Authority of Ireland (SEAI)); Green Star Rating System (Australia) (Green Building Council of Australia); and German Sustainable Building Certificate (German Sustainable Building Council, 2008). Two other important mechanisms to determine resource availability are Uptime Institute (U.S) (Uptime Institute Professional Services, 2012) and Data Center Star Audit (Germany) (European Business Reliance Centre (EBRC), 2013). The Green Grid has also developed the Data Center Maturity Model (Singh, H., 2011).

2. International and Indian standards, categorized by approach

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### WHOLE BUILDING (point-based and voluntary)

<table>
<thead>
<tr>
<th>S.No</th>
<th>Country</th>
<th>Standard/Policy</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>USA</td>
<td>LEED (Leadership in Energy and Environmental Design) for Data Centers</td>
</tr>
<tr>
<td>3</td>
<td>UK</td>
<td>BREEAM (Building Research Establishment Environmental Assessment) for Data Centers</td>
</tr>
<tr>
<td>4</td>
<td>MALAYSIA</td>
<td>Green Building Index (GBI) for Data Centers</td>
</tr>
<tr>
<td>5</td>
<td>SINGAPORE</td>
<td>Green Mark for Data Centers</td>
</tr>
</tbody>
</table>

### KEY CHARACTERISTICS

- Point-based rating system usually considers Energy & Environmental Performance Criteria. It gives high emphasis on Energy Efficiency but also consider other factors such as Environment, Resiliency, Water Efficiency, etc.
- Each scoring scale consists of points for a set of Minimum Requirements which are mandatory. Each additional criteria applies to both new and existing data centers.
- The assessment identifies the specific energy efficient and environment friendly features and practices which have been incorporated in the project.
- Additional innovation points are awarded for incorporating environment friendly features which are beyond the above criteria. It is found that the environment criteria may not be reflected in the actual performance.
- It is a point-based rating system on an approval seeking or a certification in more concerned about scoring higher points to actually improving the performance of the building.

### IMPERATIVES IN INDIAN CONTEXT

- It typically gives more weightings to energy efficiency as it does not focus on specific technologies which are used.
- A high score is obtained by selecting the environmental aspects of the building and does not consider other aspects of operation/management of data centers.

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### BEST PRACTICES (guidelines)

<table>
<thead>
<tr>
<th>S.No</th>
<th>Country</th>
<th>Standard/Policy</th>
</tr>
</thead>
</table>
| 1    | USA    | ENERGY STAR,
| 2    | EUROPE | ENERGY STAR,
| 3    | SINGAPORE | ENERGY STAR |

### KEY CHARACTERISTICS

- Key performance parameters such as DOE, IT, Productivity, Total Data Center Energy Consumption are the basis on which energy efficiency is measured for any data center.
- It stresses on chiller efficiency and millennials are set depending on type & services of the data center.
- It is a voluntary Continuum Improvement Program through an Energy Management Program.
- It includes assessment and implementation of best practices and new technologies.
- It is derived as a result of Third Party Validation and Certification.
- An official methodology for data center owner/operators to remove their need for implementing energy efficiency.
- A voluntary standard which ensures the data centers are compliant with the requirements of the program at any time.

### IMPERATIVES IN INDIAN CONTEXT

- Perform, Achieve & Trade (PAT) Mechanism to initiate in BEE to improve Energy Efficiency of Existing India’s installed base data centers. The standard must be voluntary in nature and the energy consumption limitation is considered by third party authorized by BEE.
- Considering the Diversity in Productivity, Typical Output and Various Types of Technologies being adopted across Data Centers, a new standard may be prepared where a part of the mechanism may focus to “label” with the approach which can further be tagged with existing BEE scheme of BEE, with the processes for data center to be implemented.

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### COMPARATIVE SCALE (Benchmark)

<table>
<thead>
<tr>
<th>S.No</th>
<th>Country</th>
<th>Standard/Policy</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>USA</td>
<td>ENERGY STAR Rating for Data Centers by Environmental Protection Agency (EPA)</td>
</tr>
<tr>
<td>2</td>
<td>AUSTRALIA</td>
<td>NATIONAL AUSTRALIAN ENVIRONMENT RATING SYSTEM (NARES) for Data Centers</td>
</tr>
</tbody>
</table>

### KEY CHARACTERISTICS

- EPA star rating also allow users to compare the Energy Performance of one data center with others and also enables comparison with the national average group and for comparison to industry benchmarks.
- It takes the “actual metered” energy data.
- It measures “Total Energy Efficiency,” and improving energy consumption is a regular basis.
- It involves tracking, measurement, and improving energy consumption rates on a regular basis.
- It is a voluntary calculation of the data center’s energy efficiency. It ensures that all energy reductions in energy consumption and support systems but does not capture IT equipment efficiency.
- The certification process requires data for 12 months of continuous operation of the facility before the results can be evaluated.
- The EU’s Data Center Efficiency (DCi) Benchmark aims to use the results of the international comparison to improve the energy consumption and thermal efficiency of equipment in the data center.
- The EU’s Data Center Efficiency (DCi) Benchmark aims to use the results of the international comparison to improve the energy consumption and thermal efficiency of equipment in the data center.

### IMPERATIVES IN INDIAN CONTEXT

- The Labelling of buildings by BEE in India determines certain standards for the EPA Energy Star Rating scheme which would include:
- Evaluation of energy performance of building is based on Actual Energy Performance.
- The performance improvement Group Based Certification Mechanism applicable to Commercial, Sectors, Hotels, IT Parks and Data centers.
- The performance improvement Group Based Certification Mechanism applicable to Commercial, Sectors, Hotels, IT Parks and Data centers.
- The performance improvement Group Based Certification Mechanism applicable to Commercial, Sectors, Hotels, IT Parks and Data centers.

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### PRESCRIPTIVE OR PERFORMANCE-BASED (mandatory code based)

<table>
<thead>
<tr>
<th>S.No</th>
<th>Country</th>
<th>Standard/Policy</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>USA</td>
<td>ASHRAE 90.1-2013 for Data Centers</td>
</tr>
</tbody>
</table>

### KEY CHARACTERISTICS

- Popularity for its compliance in compliance method.
- Prescriptive, Trade Off, Energy Cost/Budgeting Method.
- It is based on the minimum requirements, to some extent (e.g. IT, Environment Design, etc.) the use of green products must be considered to achieve a score off to achieve maximum scores.
- It measures the total amount of energy consumed and compares it against a specified standard from a list of data centers with similar attributes.
- It requires 12 months of monitoring data before rating can be evaluated.

### IMPERATIVES IN INDIAN CONTEXT

Appendix E: Survey Questionnaires and Participants

1. Questionnaire for Data Center Owners/Large Users

Online Questionnaire on
Developing Energy Efficiency Policy/Code for Data Centers in India

Questionnaire for Data Center Owners/Hosting Providers

General Guidelines:
This Questionnaire have been specially formulated as a part of the study on “Accelerating Energy Efficiency in Indian Data Centers” consisting of 16 questions which are divided in following two sections:

a) Section 1: General Facility Related Questions
b) Section 2: Energy Benchmarking Related Questions
c) Section 3: Data Center Energy Efficient Technologies Questions

The information provided by you through this questionnaire may lead to the formulation of a conducive policy defining Energy Efficiency Standards for Indian Data Centers.

* Required

Name of the Person *


Designation *


Name of the Data Center and Contact Details *
Address/Phone no/Email

General Facility Related Questions

1. Please specify the following for your Data Center
a) Type of Service(s):
   - Hosting Services
   - Managed Services/Managed Hosting
   - Cloud Services
   - Outsourcing
   - Colocation Services
c) Total building area of your Data Center
   if your Data Center is a part of a big building then mention the areas of both the buildings separately

   %

   %

   %

d) Percentage wise contribution from various sources of power/electricity procured
   Grid %

   On-site %

   %

e) Sanctioned Load (kW) by Distribution Companies (DISCOMs) (Optional)
   (Note: ‘Sanctioned Load’ means the load which the Licensee has agreed to supply from time to time subject to the governing terms and conditions)

   Operational Load (kW) (Optional)

   %

   %

   %

   %

   %

f) Average Annual Energy Consumption (kWh) (Optional)

   Estimated

   Measured

g) Highest existing Level of “IT Energy Metering” and frequency of measurement & monitoring of the data in your Data Center
   Level of metering

   Frequency of Monitoring

Energy Benchmarking (Rating/Certification/ Labelling) Related Questions

2. Do you determine Power Usage Effectiveness (PUE) for your data center?
   - Yes
   - No

   If yes, what is the average PUE of your Data Center?

   Please specify the basis of values for both "IT Power" and "Total Power" to determine PUE.
   - Both values Measured
   - Both values Estimated
   - Measured IT Power value and Estimated Total Power
   - Measured Total Power and Estimated IT Power

   What is the frequency of calculating PUE in you data center?

   Please specify any other Energy Efficiency related "Performance Measuring Attribute".

3. Are there any energy consumption reduction targets for your Data Center (set by your Management)?
   - Yes
   - No

4. Do you agree that Energy Benchmarking (Rating/Certification/Labeling) would help to improve the overall "Energy Efficiency" and "Business Productivity" of your Data Centers?
   - Yes
   - No

   Please comment in support of your answer
5. Has your Data Center (Overall Building) achieved any Environmental Compliance/Sustainability Certification?

○ Yes
○ No

If yes, please specify the certification program and Level of Certification
For example: LEED Gold Certificate, Star Labelling - 3 Star

If No, are you planning or are in the process to get any certification?

6. a) In Indian Scenario, Bureau of Energy Efficiency currently has three major programs to enhance the Energy Efficiency (refer the table for description). Which of these existing policies can be extended to encompass all the components of a Data Center for the purpose of rating it based on Energy Efficiency?
(Note: PAT is a Mandatory Standard, BEE Star Rating & ECBC are Voluntary Standards)

○ Energy Conservation Building Code (ECBC)
○ Perform Achieve and Trade (PAT)
○ Star Rating for Buildings
<table>
<thead>
<tr>
<th>Programme</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy Conservation Building Code (ECBC) by Bureau of Energy Efficiency (BEE)</td>
<td>The ECBC by Bureau of Energy Efficiency aims to provide minimum requirements for energy efficient design and construction of buildings and their systems. ECBC encourage energy efficient design or retrofit of buildings so that it does not constrain the building function, comfort, health, or the productivity of the occupants and has appropriate regard for economic considerations.</td>
</tr>
<tr>
<td>Perform, Achieve &amp; Trade (PAT) by Bureau of Energy Efficiency (BEE)</td>
<td>PAT is a Market Based Mechanism to enhance cost effectiveness of improvements in energy efficiency in energy-intensive large industries and facilities, through certification of energy savings that could be traded. Facilities making greater reductions than their targets receive “EsCerts” or “energy saving certificates” which can be traded with facilities that are having trouble meeting their targets, or banked for future use.</td>
</tr>
<tr>
<td>Star Rating for Buildings by Bureau of Energy Efficiency (BEE)</td>
<td>This standard is based on the actual performance of a building in terms of its specific energy usage in kWh/ sqm/year. Buildings have been categorized into two categories, having air-conditioned area greater than 50% and less than 50% of built up area. This programme rates office buildings on a 1-5 Star scale, with 5 Star labelled buildings being the most efficient.</td>
</tr>
</tbody>
</table>

b) Standard & Labelling program evaluates the Energy Efficiency Performance of any equipment (eg. Refrigerator, AC etc.), on a scale of 1 star to 5 stars based on the annual energy consumption. This Energy Efficiency policy/tool extends an overall recognition to any set of equipment. Are you aware of the above stated mechanism?

- Yes
- No

e) Sustainable energy efficiency policy for Indian Data Centers may consider both the concepts of 'Specific Energy Consumption' improvement and the 'Building Energy Efficiency'. In this context, do you agree that a 'Composite Policy Framework' on Energy Efficiency in Data Centers may be designed on focusing both ECBC, PAT and Star Rating of buildings?

- Yes
- No

Please comment in support of your answer

7. This ongoing study of CII-LBNL on Accelerating Energy Efficiency in Indian Data Centers, has categorized the worldwide existing standards for Energy Benchmarking (Rating/Certification/Labeling) methods in the area of Efficient & Sustainable operations into four categories. With this analytical context, according to you which one of the following methodologies (please refer table) would be more suitable for developing a policy on Energy
Efficiency for Indian Data Centers?
You may select combination more than one
☐ Point - Based (Whole Building) Rating System
☐ Comparative Scale Rating System
☐ Best Practices/Guidelines Oriented Approach
☐ Performance-Based Relative Benchmarking

<table>
<thead>
<tr>
<th>S.NO</th>
<th>Rating/Certification Method</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Point - Based (Whole Building) Rating System</td>
<td>This process usually considers Energy &amp; Environmental Performance Criteria for a facility. Points are assigned to each of the sections criteria and rating is based on an overall score which is determined by adding the points achieved for different sections criteria.</td>
<td>LEED (USA), BREEAM (UK), GRIHA, IGBC (India)</td>
</tr>
<tr>
<td>2</td>
<td>Comparative Scale Rating System</td>
<td>Evaluation of energy performance of a building is based on Actual Performance in terms of specific energy use. It provides Peer Group Based Comparison Mechanism. It provides a simple metric to evaluate energy performance of the building such as Energy Performance Index (EPI), Energy efficiency Ratio, etc.</td>
<td>EPA Energy Star Rating (USA)</td>
</tr>
<tr>
<td>3</td>
<td>Best Practices/Guidelines</td>
<td>Annual targets for Energy Efficiency Improvements (voluntary in nature) are set by data centers depending on data center type, services etc. It involves a continual improvement process via an Energy Management Program. Includes assessment and implementation of best practices and new technology.</td>
<td>ISO 50001 (Global Standard), European Code of Conduct for DC, PAT (India)</td>
</tr>
<tr>
<td>4</td>
<td>Performance-Based Relative Benchmarking</td>
<td>These standards focus on energy efficiency related to Building HVAC, Lighting, water etc. Compliance via prescriptive, trade-off or whole building performance method which uses simulation model to assess energy performance of the building.</td>
<td>ASHRAE 90.1 for DC, California Title 24 for DC (USA), ECBC (India)</td>
</tr>
</tbody>
</table>

Please comment in support of your answer

Data Center Energy Efficient Technologies Related Questions

9. Please prioritize the following areas on basis of possibility of energy efficiency in a data center on a scale of 1 to 6.
1- Least possibility of energy efficiency, 6- Maximum possibility of energy efficiency

<table>
<thead>
<tr>
<th>Area</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Distribution Architecture (AC/DC based &amp; topology from source to load)</td>
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<tr>
<td>Power Conversions (number of</td>
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</tbody>
</table>
10. Please specify the area of highest energy savings in your data center

- Power Distribution Architecture (AC/DC based & topology from source to load)
- Power Conversions (number of conversions from AC to DC & DC to AC)
- Use of Transformers to reduce harmonics & losses
- Cooling Distribution Pattern (air management, the efficiency and control of the cooling equipment in the IT room, and the efficiency and control of the chiller plant)
- Networking Architecture
- Server Utilization (Virtualization & consolidation)

11. The global IT industry's drive towards Energy Efficiency has led to the commercialization of a variety of Energy Efficient technologies for Data Centers. Please prioritize the following technologies on the basis of suitability and applicability in a data center on a scale of 1 to 4.

<table>
<thead>
<tr>
<th>Technology</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable Module Management System for UPS</td>
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<tr>
<td>Load management</td>
<td></td>
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<tr>
<td>Eco Mode/Advanced Eco Mode for switching</td>
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<tr>
<td>Technology</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
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<tr>
<td>between different UPS topologies</td>
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<tr>
<td>K-Rated</td>
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<tr>
<td>Transformers for reducing Harmonics level</td>
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<tr>
<td>Energy Efficient Transformers with low rise operating temperatures</td>
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<tr>
<td>Power Distribution Units for distribution of power to IT equipment and infrastructure</td>
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<tr>
<td>High Efficiency IT Power Supplies</td>
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<tr>
<td>In Row Cooling to draw server warm air and cool it</td>
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<tr>
<td>Rack Cooling</td>
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<tr>
<td>Rack Cooling with Rear Door Heat Exchanger</td>
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<tr>
<td>CRAC/CRAH with variable speed drive</td>
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<tr>
<td>Direct Contact Cooling – heat is removed by conduction, i.e. by direct contact with hot IT equipment.</td>
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<tr>
<td>Free Cooling with Air Economizers</td>
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<tr>
<td>Free Cooling with Water Economizers</td>
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<tr>
<td>Solar System Cooling</td>
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<tr>
<td>Server Virtualization</td>
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<tr>
<td>Storage Virtualization</td>
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</tr>
<tr>
<td>Network Virtualization</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Solid State Drives</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RAID/Intelligent Disk Subsystem</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Fibre Channel Technology</td>
<td></td>
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</tr>
</tbody>
</table>
12. What are the different types of “Air Distribution” technology/arrangement(s) are being followed/adopted/operational at your Data Center?

- Hot Aisle Containment
- Cold Aisle Containment
- Under-floor Air Cooling Plenum
- Blanking Panels
- Air Supply through CRAC Unit
- Hot & Cold Air Separation

Please specify, if any other

13. What are the types of servers have you deployed in your Data Center?

- Blade Server
- Rack Optimized Server
- Universal or Tower Server

Please specify, if any other

14. What is the annual average level of server utilization your Data Center?

- 90 % to 100 %
- 70% to 90%
- 50% to 70%
- Below 50%
- Don’t Know

15. Virtualization may increase the effective utilization of any Server, Network or Storage equipment by manifolds and may significantly improve the PUE with rationalization of the infrastructure facilities. Have you implemented Virtualization technology in your Data Center?

- Yes
- No

If Yes, Please select which area (s) in the IT environment the virtualization/consolidation has been applied to?

- Server
- Storage
- Network
- All of the above

16. Do you agree that a policy/standard facilitating Energy Efficiency in Data Centers in India should be developed?

- Yes
- No

We appreciate your patience to complete the above questionnaire. We are also sincerely thankful for your valuable inputs and this will enable the appropriate authority of Government of India to formulate a conducive policy (design a Code) on Energy Efficiency for Data Centers in India.
### 2. Survey Participants: Data Center Owners

<table>
<thead>
<tr>
<th>Organization/Institution's Name</th>
<th>Designation</th>
<th>Sector (Govt. or Private)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NetDataVault</td>
<td>Managing Director</td>
<td>Private Sector</td>
</tr>
<tr>
<td>Centre for Railway Information Systems (CRIS)</td>
<td>General Manager – Data Center Infrastructure</td>
<td>Government Sector</td>
</tr>
<tr>
<td>Airport Authority of India</td>
<td>Executive Director</td>
<td>Government Sector</td>
</tr>
<tr>
<td>National Informatics Center</td>
<td>Senior Technical Director</td>
<td>Government Sector</td>
</tr>
<tr>
<td>Nxtra Data Ltd</td>
<td>GM-Infrastructure</td>
<td>Private Sector</td>
</tr>
<tr>
<td>Reliance Communication</td>
<td>Plant Engineering Head</td>
<td>Private Sector</td>
</tr>
<tr>
<td>CtrlS Datacenters Ltd</td>
<td>Vice President</td>
<td>Private Sector</td>
</tr>
<tr>
<td>Dell Inc</td>
<td>Director - Software Engineering</td>
<td>Private Sector</td>
</tr>
<tr>
<td>Oracle Corporation</td>
<td>Project Manager- Real Estate &amp; projects</td>
<td>Private Sector</td>
</tr>
<tr>
<td>NetMagic Solutions</td>
<td>Senior Vice President and Head DC Facilities</td>
<td>Private Sector</td>
</tr>
</tbody>
</table>
3. Questionnaire for Data Center Experts

General Guidelines:
This Questionnaire have been specially formulated as a part of the study on “Accelerating Energy Efficiency in Indian Data Centers” consisting of 9 questions which are divided in following two sections:

a) Section 1: Data Center Operation Related Questions
b) Section 2: Energy Benchmarking Related Questions

The information provided by you through this questionnaire may lead to the formulation of a conducive policy defining Energy Efficiency Standards for Indian Data Centers.

* Required

Name of the Person *

Designation *

Institution’s Name *

Data Center Operation Related Questions

1. Based on the concept of redundancy in power distribution and components, data centers can be classified as: Tier1/2/3/4. Please suggest any other criteria (eg. services) for classification of Data Centers.
2. Please prioritize the following areas of inefficiency in a Data Center on a scale of 1 to 6.
1- Least inefficient, 6- Most inefficient

<table>
<thead>
<tr>
<th>Area</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Distribution Architecture (AC/DC based &amp; topology from source to load)</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Power Conversions (number of conversions from AC to DC &amp; DC to AC)</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Use of Transformers to reduce harmonics &amp; losses</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Cooling Distribution Pattern (air management, the efficiency and control of the cooling equipment in the IT room, and the efficiency and control of the chiller plant)</td>
<td></td>
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<tr>
<td>Networking Architecture</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Server Utilization (Virtualization &amp; consolidation)</td>
<td></td>
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</tr>
</tbody>
</table>

Any other area of inefficiency:


3. The global IT industry's drive towards Energy Efficiency has led to the commercialization of a variety of Energy Efficient technologies for Data Centers. Please prioritize the following Energy Efficient technologies on the basis of their Level of Adoption in Indian Data Centers:
1 - Very Low, 2 - Low, 3 - Medium, 4 - High, 5 - Very High

<table>
<thead>
<tr>
<th>Technology</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable Module Management System for UPS load management</td>
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</tr>
<tr>
<td>Eco Mode/Advanced Eco-Mode for switching between</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Different UPS Topologies</td>
<td>K-Rated Transformers for Reducing Harmonics Level</td>
<td>Energy Efficient Transformers with Low Rise Operating Temperatures</td>
<td>Power Distribution Units for Distribution of Power to IT Equipment and Infrastructure</td>
<td>High Efficiency IT Power Supplies</td>
<td>In Row Cooling to Draw Server Warm Air and Cool IT</td>
</tr>
<tr>
<td>--------------------------</td>
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<td>0</td>
</tr>
</tbody>
</table>

4. Servers are commissioned to provide one or more specific services in a data center. Knowing whether servers are being well used for productive work and turning off those that are not (comatose servers), may help reduce redundant infrastructure and avoid unnecessary
spending and environmental impact. Do you agree?

- Yes
- No

What should be the frequency to check for in-activeness or percentage usage of the Comatose servers?

- Annually
- Semi-Annually
- Quarterly
- Monthly

5. According to you, what should be the level of “IT Energy Metering” and frequency of measurement & monitoring in a Data Center?

   Level of metering:
   
   Frequency of Monitoring:

   ▼

Energy Benchmarking (Rating/Certification/Labeling) Related Questions

6. Data Centers consume as much as 100 times the energy of a typical office building on a square-meter basis and Gartner predicts a 5.4 percent increase in Indian Data Center Infrastructure market.

   a. Considering this, do you think Energy Efficiency standards for Indian Data Center should be developed and implemented?

   - Yes
   - No

   b. Do you agree that Energy Benchmarking (Rating/Certification/Labeling) would help to improve the overall “Energy Efficiency” and “Business productivity” in Data Centers?

   - Yes
   - No

Please comment in support of your answer
7. This ongoing study of CII-LDNL on Accelerating Energy Efficiency in Indian Data Centers, has categorized the worldwide existing standards for Energy Benchmarking (Rating/Certification/Labeling) methods in the area of Efficient & Sustainable operations into four categories. With this analytical context, according to you which one of the following methodologies (please refer table) would be more suitable for developing a policy on Energy Efficiency for Indian Data Centers?

You may select combination more than one

- [ ] Point - Based System Rating System
- [ ] Comparative Scale Rating System
- [ ] Best Practices/Guidelines Oriented Approach
- [ ] Performance-Based Relative Benchmarking

<table>
<thead>
<tr>
<th>S.No</th>
<th>Rating/Certification Method</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Point - Based (Whole Building) Ratings</td>
<td>In this approach appropriate parameters are defined against all the crucial components and processes of a data center. Points are awarded against each of these parameters and the cumulative sum of these points is categorized to define the level of energy efficiency achieved.</td>
<td>LEED (USA), BREEAM (UK), GRIHA, IGBC (India)</td>
</tr>
<tr>
<td>2</td>
<td>Comparative Scale Ratings</td>
<td>This approach emphasizes a relative rating system, wherein a peer group of buildings with similar characteristics and services are defined and the rating is awarded based on relative percentile.</td>
<td>EPA Energy Star Rating (USA)</td>
</tr>
<tr>
<td>3</td>
<td>Best Practices/Guidelines</td>
<td>This approach is based on defining energy efficiency targets which must be achieved through a defined action plan, based on the guidelines defined in the standards. The successful achievements of these targets leads to the certification of the data center as an “Energy Efficient Data Center.”</td>
<td>ISO 50 001 (Global Standard), European Code of Conduct for DC, PAT (India)</td>
</tr>
<tr>
<td>4</td>
<td>Performance-Based Relative Benchmarking</td>
<td>This approach focuses on energy efficiency related to building envelopes, heating, ventilation, and air-conditioning (HVAC), lighting, water, gas etc. It offers compliance through Prescriptive, Trade-off or whole building performance method, which uses simulation model to assess energy performance of the building.</td>
<td>ASHRAE 90.1 for DC, California Title 24 for DC (USA), ECBC (India)</td>
</tr>
</tbody>
</table>

A brief comment in support of your answer

8. a) In Indian Scenario, Bureau of Energy Efficiency currently has three major programs to enhance the Energy Efficiency (refer the table for description). Which of these existing policies can be extended to encompass all the components of a Data Center for the purpose of rating it based on Energy Efficiency? You may select more than one.

- [ ] Energy Conservation Building Code
- [ ] Perform, Achieve & Trade
- [ ] Star Rating for Building

(Note: PAT is a Mandatory Standard, BEE Star Rating & ECBC are Voluntary Standards)
<table>
<thead>
<tr>
<th>Programme</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy Conservation Building Code (ECBC) by Bureau of Energy Efficiency (BEE)</td>
<td>The ECBC by Bureau of Energy Efficiency aims to provide minimum requirements for energy efficient design and construction of buildings and their systems. ECBC encourage energy efficient design or retrofit of buildings so that it does not constrain the building function, comfort, health, or the productivity of the occupants and has appropriate regard for economic considerations.</td>
</tr>
<tr>
<td>PAT by Bureau of Energy Efficiency (BEE)</td>
<td>PAT is a Market Based Mechanism to enhance cost effectiveness of improvements in energy efficiency in energy-intensive large industries and facilities. Through certification of energy savings that could be traded, facilities making greater reductions than their targets receive “EfCerts” or “energy saving certificates” which can be traded with facilities that are having trouble meeting their targets, or banked for future use.</td>
</tr>
<tr>
<td>Star Rating for Buildings by Bureau of Energy Efficiency (BEE)</td>
<td>This standard is based on the actual performance of a building in terms of its specific energy usage in kWh/m²/year. Buildings have been categorized into two categories, having air-conditioned area greater than 60% and less than 50% of built up area. This programme rates office buildings on a 1-5 Star scale, with 5 Star labelled buildings being the most efficient.</td>
</tr>
</tbody>
</table>

b) Standard & Labelling program evaluates the Energy Efficiency Performance of any equipment (e.g. Refrigerator, AC etc.), on a scale of 1 star to 5 stars based on the annual energy consumption. This Energy Efficiency policy/tool extends an overall recognition to any set of equipment. Are you aware of the above stated mechanism?

- Yes
- No

c) Sustainable energy efficiency policy for Indian Data Centers may consider the concepts of ‘Specific Energy Consumption’ Improvement and the ‘Building Energy Efficiency’. In this context, do you agree that a Composite Policy Framework on Energy Efficiency in Data Centers may be designed focusing on ECBC, PAT & Star Rating of buildings?

- Yes
- No

Please comment in support of your answer

---

9. Do you agree that a policy/standard facilitating Energy Efficiency in Data Centers in India should be developed?

- Yes
- No

We appreciate your patience to complete the above questionnaire. We are also sincerely thankful for your valuable inputs and this will enable the appropriate authority of Government of India to formulate a conducive policy (design a Code) on Energy Efficiency for Data Centers in India.
### 4. Survey Participants: Data Center Industry Experts, Academia, and Technology Providers

<table>
<thead>
<tr>
<th>Organization/Institution's Name</th>
<th>Designation</th>
<th>Sector (Govt. or Private)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cisco Systems, Inc</td>
<td>Distinguished IT Engineer</td>
<td>Private Sector</td>
</tr>
<tr>
<td>Nxtra Data Limited</td>
<td>Head - South Region; Infra &amp; projects</td>
<td>Private Sector</td>
</tr>
<tr>
<td>National Informatics Center</td>
<td>Senior Technical Director</td>
<td>Government Sector</td>
</tr>
<tr>
<td>Centre for Railway Information Systems (CRIS)</td>
<td>General Manager – Data Center Infrastructure</td>
<td>Government Sector</td>
</tr>
<tr>
<td>Airport Authority of India</td>
<td>Executive Director</td>
<td>Government Sector</td>
</tr>
<tr>
<td>Indian Institute of Technology, Madras</td>
<td>Professor</td>
<td>Government Sector</td>
</tr>
<tr>
<td>Indian Institute of Technology, Bombay</td>
<td>Professor</td>
<td>Government Sector</td>
</tr>
<tr>
<td>National Association of Software and Services Companies (NASSCOM)</td>
<td>Vice President</td>
<td>Private Sector</td>
</tr>
<tr>
<td>CtrlS Datacenters Ltd</td>
<td>Vice President</td>
<td>Private Sector</td>
</tr>
<tr>
<td>Tata Communications Limited</td>
<td>Vice President</td>
<td>Private Sector</td>
</tr>
<tr>
<td>AEON Consultants</td>
<td>Managing Director</td>
<td>Private Sector</td>
</tr>
<tr>
<td>ABB India Limited</td>
<td>Product Manager - INLPLS</td>
<td>Private Sector</td>
</tr>
<tr>
<td>Schneider Electric India Pvt. Ltd.</td>
<td>GM- Data Center Business Development</td>
<td>Private Sector</td>
</tr>
<tr>
<td>CtrlS Datacenters Ltd</td>
<td>Vice President</td>
<td>Private Sector</td>
</tr>
<tr>
<td>Tata Communications Limited</td>
<td>Vice President</td>
<td>Private Sector</td>
</tr>
<tr>
<td>AEON Consultants</td>
<td>Managing Director</td>
<td>Private Sector</td>
</tr>
<tr>
<td>SCHNABEL DC Consultants India</td>
<td>Managing Director</td>
<td>Private Sector</td>
</tr>
</tbody>
</table>
## Appendix F Stakeholder Workshop Participants and Agenda

### 1. Workshop Participants

<table>
<thead>
<tr>
<th>S.NO.</th>
<th>Organization/Institution's Name</th>
<th>Name of the Person</th>
<th>Designation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>National Information Center</td>
<td>Mr. S.M Shankar Raju</td>
<td>Senior Technical Director</td>
</tr>
<tr>
<td>2</td>
<td>Oracle India Private Limited</td>
<td>Mr. Krishna Rao</td>
<td>Senior Facilities Specialist</td>
</tr>
<tr>
<td>3</td>
<td>Intel Technology</td>
<td>Mr. Rajkumar Y Kambar</td>
<td>Data Center Manager</td>
</tr>
<tr>
<td>4</td>
<td>NetMagic Solutions</td>
<td>Mr. Mahesh Trivedi</td>
<td>Senior Vice President and Head DC Facilities</td>
</tr>
<tr>
<td>5</td>
<td>SCHNABEL DC Consultants India</td>
<td>Mr. Mallikarjun Patil</td>
<td>Project Manager</td>
</tr>
<tr>
<td>6</td>
<td>Intel Technology</td>
<td>Mr. M.D Ravindranath</td>
<td>Resource &amp; Capacity Manager</td>
</tr>
<tr>
<td>7</td>
<td>NxtGen Data Center &amp; Cloud Technologies Pvt. Ltd</td>
<td>Mr. Nakul O C</td>
<td>General Manager Projects</td>
</tr>
<tr>
<td>8</td>
<td>Tata Communications</td>
<td>Mr. Arun Kher</td>
<td>Vice President</td>
</tr>
<tr>
<td>9</td>
<td>Emerson Network Power</td>
<td>Mr. Baiju. B</td>
<td>Director, Data Center Design</td>
</tr>
<tr>
<td>10</td>
<td>SCHNABEL DC Consultants India</td>
<td>Ms. Shaheen Meeran</td>
<td>Managing Director</td>
</tr>
<tr>
<td>11</td>
<td>Emerson Network Power</td>
<td>Mr. Shrirang Deshpande</td>
<td>Head - Datacenter Business</td>
</tr>
<tr>
<td>12</td>
<td>IBM India Private Limited</td>
<td>Mr. Shankar KM</td>
<td>Manager- IT Infrastructure</td>
</tr>
<tr>
<td>13</td>
<td>Schneider Electric India</td>
<td>Mr. Amod Ranade</td>
<td>General Manager- Data Center Business Development</td>
</tr>
<tr>
<td>14</td>
<td>IBM India Private Limited</td>
<td>Mr Veerandra</td>
<td>Data Center Specialist</td>
</tr>
<tr>
<td>15</td>
<td>EMC 2</td>
<td>Mr. Pradeep KS</td>
<td>Lab Systems Engineer</td>
</tr>
<tr>
<td>16</td>
<td>NxtGen Data Center &amp; Cloud Technologies Pvt. Ltd</td>
<td>Mr. V Kannan</td>
<td>Director Operations</td>
</tr>
<tr>
<td>17</td>
<td>IBM Systems Lab Services</td>
<td>Mr Vaidyanathan Srinivasan</td>
<td>Server Design Architect</td>
</tr>
<tr>
<td></td>
<td>Company</td>
<td>Name</td>
<td>Position</td>
</tr>
<tr>
<td>---</td>
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<td>-------------------------------</td>
<td>-----------------------------------------------</td>
</tr>
<tr>
<td>18</td>
<td>Nxtra Data Ltd</td>
<td>Mr. John Bennet</td>
<td>Data Center Operation Manager - Bangalore</td>
</tr>
<tr>
<td>19</td>
<td>Dell India R&amp;D</td>
<td>Mr. Vivek Kumar Rajendran</td>
<td>Director - Software Engineering</td>
</tr>
<tr>
<td>20</td>
<td>EMC 2</td>
<td>Mr. Venkatesh Kuncham</td>
<td>Manager India Environment, Health &amp; Safety</td>
</tr>
<tr>
<td>21</td>
<td>IBM Systems Lab Services</td>
<td>Ms Vidhya Shankar</td>
<td>Senior Data Center Specialist</td>
</tr>
<tr>
<td>22</td>
<td>Nxtra Data Ltd</td>
<td>Mr. K Jeyabalan</td>
<td>Head - South Region; Infra &amp; projects</td>
</tr>
<tr>
<td>23</td>
<td>Emerson Network Power (India) Private Limited</td>
<td>Mr Arun Prasad</td>
<td>Senior Director</td>
</tr>
<tr>
<td>24</td>
<td>NetApp</td>
<td>Mr Mario Dias</td>
<td>Facilities, Operations Manager</td>
</tr>
<tr>
<td>25</td>
<td>IBM India Private Limited</td>
<td>Dr Rahul Rao</td>
<td>Senior Technical Staff Member</td>
</tr>
</tbody>
</table>

### 2. Bangalore Consultative Meeting Agenda

<table>
<thead>
<tr>
<th>Programme</th>
<th>Registration</th>
</tr>
</thead>
<tbody>
<tr>
<td>1030 – 1100 Hrs.</td>
<td><strong>Registration</strong></td>
</tr>
<tr>
<td>1100 - 1150 Hrs.</td>
<td><em>Overview of the Initiative on “Accelerating Data Center Energy Efficiency In India”</em></td>
</tr>
<tr>
<td>1100 - 1110 Hrs.</td>
<td><em>Introductory Short Video on “Energy Efficiency Guidelines &amp; Best Practices in Indian Data Centers”</em></td>
</tr>
<tr>
<td>1100 - 1135 Hrs.</td>
<td><em>Welcome Address</em></td>
</tr>
<tr>
<td>1135 – 1205 Hrs.</td>
<td><em>Presentation on “Accelerating Data Center Energy Efficiency In India”</em></td>
</tr>
<tr>
<td>1205 - 1245 Hrs.</td>
<td><em>Interactive/Q&amp;A session with the stakeholders on “Energy Efficiency Policy Framework” for Data Centers in India.</em></td>
</tr>
<tr>
<td>1245 -1300 Hrs.</td>
<td><em>Capturing the Inputs &amp; Conclusion</em></td>
</tr>
<tr>
<td>1300 – 1400 Hrs.</td>
<td><em>Lunch</em></td>
</tr>
</tbody>
</table>