Energy Benchmarking and Performance Based Rating for Hospital Buildings in India

Technical Report
30 September, 2014

An initiative supported by

SHAKTI
SUSTAINABLE ENERGY FOUNDATION

Prepared by
ps Collective
9/1, Sangathan Society
Opp Sunrise Park, Vastrapur
Ahmedabad – 380052. India
Ph. +91 (79) 40035860
ps@collective.in, www.ps.collective.in

ABOUT SHAKTI SUSTAINABLE ENERGY FOUNDATION

Shakti Sustainable Energy Foundation works to strengthen the energy security of India by aiding the design and implementation of policies that support energy efficiency and renewable energy.

Table of Contents

List of Figures

List of Tables

1. Background

The Ministry of Power, Government of India, set up the Bureau of Energy Efficiency (BEE) under the provisions of the Energy Conservation Act, 2001. As one of its primary objectives, BEE has focused on efforts to reduce energy intensity of the Indian economy by reducing the wasteful use of energy and bridging the power demand-supply gap.

It is with this in mind that BEE began an energy benchmarking initiative to evaluate building energy performance based on actual energy consumption. Initially, the United States Agency for International Development (USAID) supported this initiative under the Energy Conservation and Commercialization-Phase III (ECO-III) project by providing technical assistance. Subsequently, it is now being supported by the Shakti Sustainable Energy Foundation.

Under the guidance of BEE, an online tool called ECObench was conceived and developed to benchmark and rate the energy performance of the commercial buildings. The purpose of this document is to demonstrate the use of the tool and help in interpretation based on an illustrative example.

2. Performance Benchmarking

Buildings in India must continuously monitor and improve their performance in order to transit to an energy efficient economy. It is important to measure this performance against the established benchmarks. The aim is to improve the design, construction, maintenance, and operation of buildings by comparing the energy performance against established benchmarks, and recognize and reward exemplary buildings.

Energy benchmarking is a process of creating a whole building energy consumption profile of a group of buildings characterized by their primary use, construction, physical, geographic, and operating characteristics. The rating is derived by assigning a score to the performance differential between the building under consideration and a benchmarked building in relation to all other buildings in the stock.

3. Methodology

The BEE star rating program for commercial buildings started with office buildings including Information technology (IT) parks and BPOs. It used the 'fixed bandwidth method' for benchmarking to set up these performance based star labels.

It attempts to do so by making assumptions of linearity, non-interactive effects among various parameters and using multiple look up tables. These assumptions were required at that time given the granularity of available data and provided a good first step to arrive at benchmarks.

With continued data collection, we now have a larger and relatively detailed data about building's energy consumption. This allows to relax some of the assumption of the 'fixed bandwidth method' to effectively respond to multiple parameters that may affect building energy consumption like building size, number of beds, climate zone, area per bed, etc. as in the case of hospital buildings.

In an ideal situation, one could use simulation models to estimate benchmark values. However, they are not feasible due to expansive data requirements, need for large set of often unverified or non-standardized assumptions, need of well-trained technical expertise, and time required in arriving at benchmark values. Also, both methods discussed above do not provide peer based comparison.

The regression and distribution based method, as used by this tool, provides an intermediate solution between the relatively simple 'fixed bandwidth' method and more demanding 'simulation' based methods. It uses regression analysis to arrive at building specific standard values for comparison after simultaneously, interactively and non-linearly accounting for multiple parameters. It then uses distributional analysis to make comparisons among peers to arrive at performance rating of building's energy performance. Detailed comparison between 'fixed bandwidth' and 'regression and distribution based analysis' is presented in Appendix E.

The proposed method compares the whole-building energy consumption of the building under consideration with a benchmark building having similar characteristics. The energy consumption of benchmarked building is estimated using a regression model. The performance score is then computed by comparing the deviation in energy consumption of the proposed building from that of the benchmarked building and similar deviations of all other buildings from the survey. A three step statistical methodology originally developed for the USAID ECO-III project described below is followed.

1. **Estimate the energy consumption of the benchmark building:** The benchmark building is defined as a hypothetical building with similar use type, physical and operating characteristics and located in same climatic zone as the candidate building. The estimate is derived through regression technique applied to a large dataset of surveyed buildings.

2. **Compute performance index with respect to the benchmarked building:** The performance index is calculated as the ratio of actual electricity consumed by the candidate building to estimated electricity use by the benchmarked building. This ratio is termed as Building Performance Index (BPI). It indicates the relative efficiency of a building.

3. **Compute performance score based on the relative performance of other buildings in the sample:** The BPI of all buildings in the sample is used to create a distribution profile of relative performance. The distribution provides performance percentiles which can either directly be transformed into a 1-100 rating scale or be further grouped into star based rating method.

The original methodology has been improved to address econometric issues pertaining to multicollinearity and has undergone more rigorous model diagnostics.

4. Rating scheme

The tool can be used to rate hospital building with following characteristics

	Lower Value	Upper Value
Built up area excluding parking (m^2)	500	50,000
Area per bed (m^2)	15	200
Number of beds	30	1,000
Percent conditioned space	50%	-

Table 1: Criteria for eligible hospital buildings

The Hospital building rating scheme is based on data collected from various sources. The data was carefully scrutinized for errors, missing values and inconsistencies to ensure that only reliable data goes into the model estimation. The final scheme was based on key parameters that directly or indirectly affect the energy performance of hospital buildings. Some seemingly important parameters such as number of meals served, volume of laundry, etc. which might have also served as a proxy for occupancy rates were not included due to lack of reliable data, their statistically insignificant contribution to energy consumption and validity claims on ground level. We hope that better quality data in future will allow us to address these untested grounds more rigorously. The rating estimation model is packaged in an online tool which provides performance ranks to individual hospital buildings. These ranks are converted into star labels based on the table below

Rating	Rank (from)	Rank (to)	% of buildings	Remarks
5 stars	0	<= 4	4%	Exceptional / Outstanding performance
4 stars	> 4	<= 12	8%	Excellent performance, Best practice
3 stars	> 12	<= 24	12%	Very good performance
2 stars	> 24	<= 40	16%	Good performance
1 star	> 40	<= 60	20%	Average performance
No star	> 60	<= 100	40%	Below average performance

Table 2: Performance percentiles for star rating

5. Online Tool

ECObench is a web based tool (http://www.ecobench.eetools.in) used to evaluate performance benchmarks and assign star labels to buildings. The tool gathers inputs from the user to compare the performance of a building against its peers. It displays the benchmarking result in a graphic as well as tabular fashion for the convenience of the user. The tool also generates a report that may be submitted to BEE to apply for a performance star label.

The tool is a web based Rich Internet Application (RIA) that is similar to a desktop application software. It runs on a standard web browser and communicates with a web server. No special software needs to be installed on a computer to use this tool.

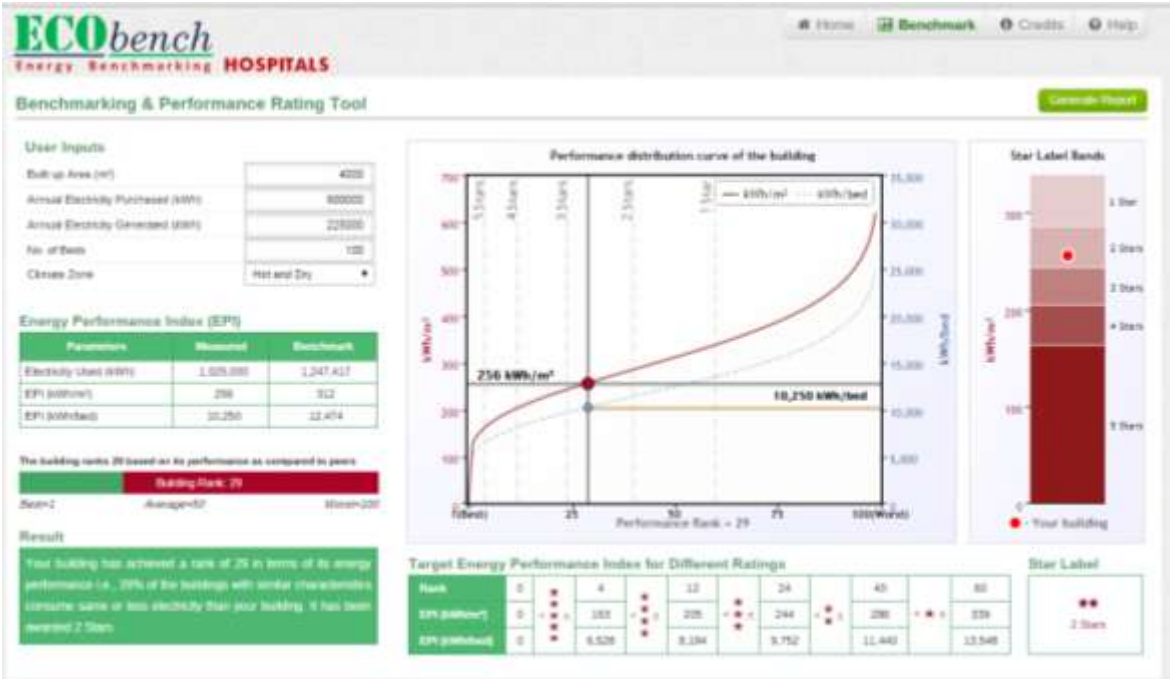


Figure 1: Screenshot of the ECObench tool

6. Illustrative Example

Data entry

Consider the following example:-

An applicant wants to evaluate the performance of a 100 bed hospital building located in the Hot and Dry climatic zone with a built-up area of 4,000 m^2 excluding parking. The hospital consumed 800,000 kWh of electricity in the preceding 12 months based on the bills provided from the utility company. In addition, it used an on-site diesel generator to produce 225,000 kWh of electricity during the same period. Table 3 provides a snapshot view of these parameters as should be entered in the online tool.

User Inputs

Built up Area (m²)	4000
Annual Electricity Purchased (kWh)	800000
Annual Electricity Generated (kWh)	225000
No. of Beds	100
Climate Zone	Hot and Dry ▼

Table 3: User input parameters for a hospital building

Benchmarking

The tool evaluates the performance of the building in comparison with other similar buildings and assigns a performance rank and a corresponding star label. To do so, it first computes the Energy Performance Index or EPI which is defined as the total electricity consumed in a year divided by the built up area of the building. This is measured in kWh/m^2. Next, it computes a benchmark value for a building with similar geographic, physical and operational characteristics. The benchmark value provides an average level of electricity consumption by similar buildings and is specific to the building characteristics as entered by the user. The EPI for the applicant's building and the benchmark values are also reported in terms of electricity consumed per bed in addition to electricity consumed per unit area (Table 4).

Energy Performance Index (EPI)

Parameters	Measured	Benchmark
Electricity Used (kWh)	1,025,000	1,247,417
EPI (kWh/m²)	256	312
EPI (kWh/bed)	10,250	12,474

Table 4: EPI of the applicant's building and corresponding benchmark values

The tool reports an EPI of 256 kWh/m^2 or 10,250 kWh/bed. The corresponding average EPI for similar buildings is 312 kWh/m^2 or 12,474 kWh/bed. This shows that the applicant's building consumes less energy than other similar buildings.

Star Rating

The tool compares the performance of the applicant's building with the benchmark values and assigns it a performance rank. A rank of 1 is awarded to the top performing building, while a rank of 100 is awarded to the worst performing building. For the building in the example, the tool evaluates a performance rank of 29 percentile for the building (Figure 2). This implies that 29% of the buildings with similar characteristics like the built-up area, number of beds and climatic zone consume less energy than the applicant's building.

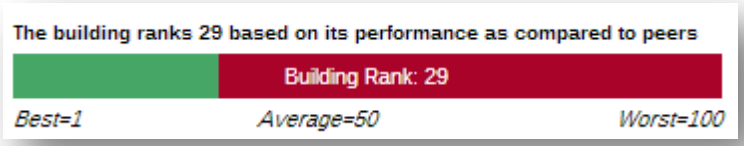


Figure 2: Performance rank information

The performance based rank is converted into Star labels.. If all the eligible hospitals in the national stock were to be rated, only the top 4% of the buildings will be awarded a label of '5 stars', next 8% '4 stars', next 12% '3 stars', next 16% '2 stars' and the next 20% '1 star'. All building with performance below 60% will not be awarded any star label. For the building given in the example, the conversion from performance rank to star labels is summarized in Table 5

Target Energy Performance Index for Different Ratings

Rank	0	< ★★★★★ ≤	4	< ★★★★ ≤	12	< ★★★ ≤	24	< ★★ ≤	40	< ★ ≤	60
EPI (kWh/m²)	0		163		205		244		286		339
EPI (kWh/bed)	0		6528		8194		9752		11440		13548

Table 5: Energy use intensity targets for different star labels

According to Table 5, the building is awarded a performance label of 2 stars (Figure 3).

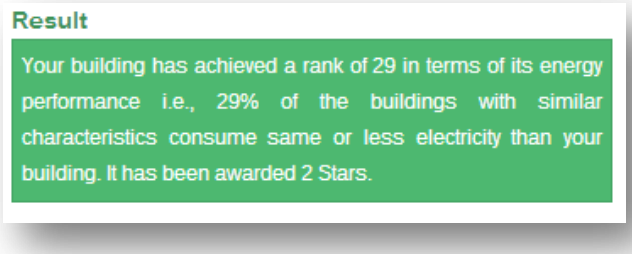


Figure 3: Benchmarking tool results along with the performance rank

Performance bands

The tool further computes dynamic performance bands specific to the building. Table *5* suggests energy consumption intensity threshold for the building to qualify for different star labels. The building will have to reduce its EPI below 244 kWh/m^2 (9,752 kWh/bed) to qualify for a performance label of 3 stars and below 163 kWh/m^2 (6,528 kWh/bed) to qualify for a 5 star label. It is important to note that these thresholds are specific to this building and will be different for other buildings. These thresholds can be used as performance targets for facility managers, owners and developers to manage large portfolios.

Graphical representation

This information is represented graphically with additional details in Figure 4. The red marker on the performance distribution curve (red curve) shows its EPI measured on the left Y-axis and performance rank measured on the X-axis. The red curve is unique to every building. Energy conservation measures in terms of building systems will enhance its performance, and the building will slide up and down its own unique curve. The blue curve and the blue marker show the same information, but normalized by the use intensity or the number of beds in this example rather than the built-up area. The histogram shows different EPI bands corresponding to different star rating levels. The range of these bands is specific to the building for which information is entered by the user.

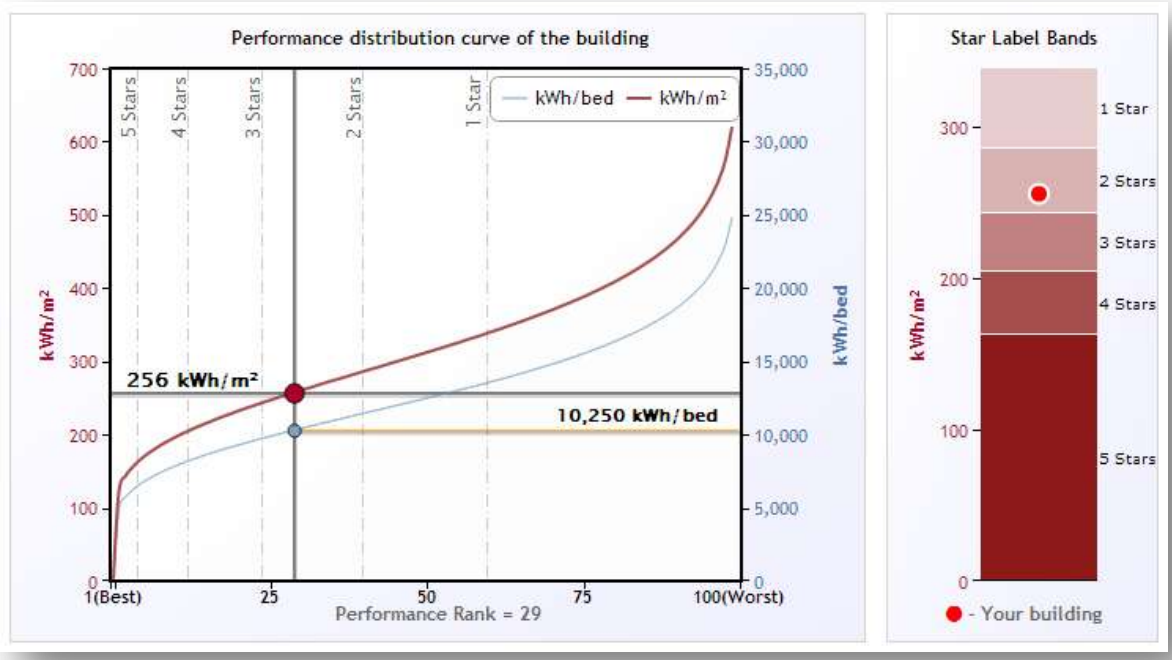


Figure 4: Graphical representation of the Performance distribution curve, EPI, performance rank and Star rating

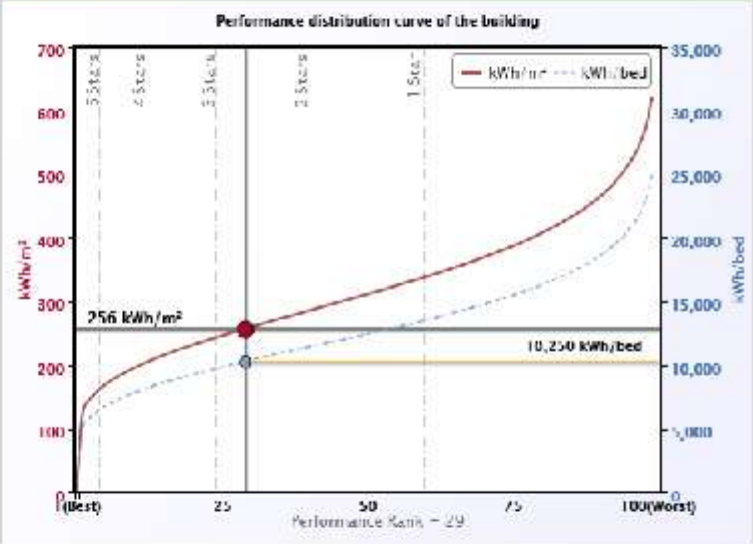
Benchmarking & Performance Based Labeling Report

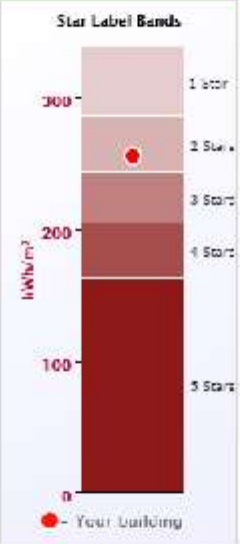
Building Name	ABC Hospital	Date of Reporting	17 September 2014
Address	12 Third Street NCR, Performabad	One year data period ending on	30 June 2014
PIN Code	110011	Rating Valid up to	30 June 2019

1. Input Summary

Building Detail		Annual Energy Use Summary	
Type	Hospital	Purchased from Utility	800,000 kWh
Sub-type	Multi-Speciality	Generated from DG/GG	225,000 kWh
Built up Area (m²)	4,000	Total Energy Consumed	1,025,000 kWh
Climate Zone	Hot and Dry		
No. of Beds	100		

2. Comparison with National Benchmark





Parameters	Measured	Benchmark
Electricity Used (kWh)	1,025,000	1,247,417
EPI (kWh/m²)	256	312
EPI (kWh/bed)	10,250	12,474

Building Performance Rank: 29

This building is eligible for 2 Stars

[0 Star] Below average performance ★ Average performance ★ ★ Good Performance
★ ★ ★ Very Good Performance ★ ★ ★ ★ Excellent performance ★ ★ ★ ★ ★ Exceptional performance

3. Evaluation

Energy Performance Intensity of this building is 256 kWh/m² or 10,250 kWh/bed. The average Energy Performance Index of similar hospitals in the national stock is 312 kWh/m². It consumes 18% less energy than the national average and is ranked among the top 29 percentile of hospitals buildings. It is eligible for 2 Stars.

4. Targets

This table sets energy performance targets to achieve different Star ratings for this building. For example, in order to achieve a 4 Star rating, this building's EPI should be between 163 kWh/m² and 205 kWh/m², and should rank among the top 12 percent in terms of energy performance. Note that these targets are specific to this building based on the input parameters and will be different for other buildings.

	Rank	EPI (kWh/m²)
0 Star	> 60	> 339
1 Star	> 40 & <= 60	> 286 & <= 339
2 Stars	> 24 & <= 40	> 244 & <= 286
3 Stars	> 12 & <= 24	> 205 & <= 244
4 Stars	> 4 & <= 12	> 163 & <= 205
5 Stars	<=4	<=163

5. Remarks

Please note that this is a preliminary / general assessment tool for determining building energy performance. Lower energy consumption does not necessarily mean that this building is efficient and higher energy consumption does not always mean that it is inefficient. Many related factors need to be taken into account for an accurate evaluation such as number of appliances / electrical equipment, operating hours, presence of special building uses and higher energy use areas, tenants, as well as internal operational and environmental settings. If your building's rank is less than 15 or greater than 85, you must verify your input data. If your EPI is twice that of the national average and you are sure of data accuracy, and this building does not have process load or some other factor that would cause energy consumption to be dramatically higher, you are probably using twice as much energy as your peers.

6. Certification

Based on the conditions observed at the time of my visit to the building and supporting documents, I certify that the building input data contained in this statement is accurate.

The building should to be awarded 2 Stars based on the official benchmarking tool.

Signature of Certifying Professional
Name:

Stamp and Certification Details
Date:

7. Disclaimer

The benchmarking result as indicated above is subject to the data quality input by the user. BEE or the developers of the tool do not warrant or represent that any outcome produced as a result of the use of the tool is accurate, or will be the same as, or is indicative of the outcome of any official rating by BEE. In no event will BEE or the developers of the tool be liable for any direct or indirect, special, incidental, tort, economical or consequential damage for negligence or any loss of profit, whether arising out of the use or inability to use the tool, any outcome produced by the tool or any reliance there on, or otherwise. You must not make any representation to third parties based on any outcome produced as a result of the use of the tool, and no license is granted to the use or reproduction of any BEE trade mark or otherwise.

7. Frequently Asked Questions

1. **Which building types can be rated by this tool?**

   The current version of the tool is designed to rate performance of hospital buildings only.

2. **What are the eligibility criteria for a building to be rated using this tool?**

   The tool can be applied to hospital buildings where at least 80% of the built-up area excluding parking is used for treatment and support facilities. The rating does not cover medical college and associated residential facilities within the hospital. The tool can be used to rate hospital buildings with at least of 30 beds, 500 m^2 of built-up area excluding parking, and having 50% air-conditioned area. Further, the building should be operable in full capacity for a period of one year prior to be considered eligible.

3. **What if a particular building type is not covered under this tool or does not meet the eligibility criteria?**

   BEE is working towards expanding the types of buildings covered under the rating scheme. You may send a request to BEE to expand the scope to cover more building types in the next update.

4. **Can the performance of a multi-use building be evaluated using this tool?**

   A multi-use building cannot be rated using the current version of the tool.

5. **Can the performance of a multi-tenant building be evaluated using this tool?**

   A multi-tenant building can be rated given that at least 80% of the floor space is used for the same primary function. Use aggregated information from all tenants in the building as input data.

6. **Can this tool be used to rate new buildings?**

   No. The tool is designed to evaluate and rate a building's energy performance based on its actual energy consumption. The building must be operational for at least one year prior to applying for rating. However, it can be used for setting efficiency targets for the design of new buildings.

7. **How is the energy consumed from different fuel types accounted for?**

   The star rating is currently based on electrical energy purchased from utilities and on-site generators only. It does not account for energy consumed from other fuels that are not converted to electricity.

8. **What about renewable energy generated on site?**

   Electricity generated through on-site renewable measures should be included under the field "Annual Electricity Generated". The rating evaluates the performance of the

building based on the total energy consumed by the building. It is not affected by the source of the energy.

9. What is the validity of the certificate?

The certificate is issued by BEE for a period of five years.

10. How much does it cost to rate a building?

Information regarding the cost of the rating is provided in the Star Rating Scheme Document available with BEE.

11. What is the procedure to apply for the rating?

The rating application can be made by filling the rating scheme document along with the report generated from the benchmarking tool. Detailed procedure and submission formats are available on BEE's website

12. What data was used to develop this tool?

A nationwide survey of over 1000 commercial buildings was used to develop this tool, of which more than 200 were Hospitals. This dataset is continuously being expanded to cover a larger diversity of buildings in terms of their use, physical location and operational characteristics.

13. How does the tool relate to other ratings like GRIHA, LEED&IGBC Green buildings?

GRIHA, LEED and IGBC are intent based rating systems. ECObench is a performance based rating system. ECObench may be used to establish context specific baselines for different buildings by intent based rating systems.

14. How can I improve my current rating?

The rating can be improved by increasing the overall efficiency of your building. Retrofit measures involving building systems like envelope, lighting, HVAC, use of controls etc. and maintenance can improve the operational performance. This will help reduce your energy consumption and improve efficiency. An investment grade audit is helpful to identify areas of improvements and associated costs.

15. Whom should I contact for additional information?

Please contact BEE for questions related to the Building Star Rating scheme.

8. Appendix

Glossary

Annual Electricity Purchased (kWh)
Total units of electricity consumed from the grid based on the utility bill and renewable sources such as solar photovoltaic in last one year

Annual Electricity Generated (kWh)
Total units of electricity generated on-site from fossil fuel based generators or renewable sources

Built-up Area
Total built-up area of the hospital building excluding parking area.

Number of Beds
Total number of census beds in the hospital

Climate zone
The climatic zone in which the building is located as per the National Building Code, 2011.

9. Acknowledgements

Bureau of Energy Efficiency (BEE)
Dr. Ajay Mathur, Sanjay Seth, Girja Shankar, Shammi Noor

Shakti Sustainable Energy Foundation
Smita Chandiwala, Kunal Gupta

ps Collective
Dr. Saket Sarraf, Shilpi Ananad Saboo

Moinee Systems
Arvind Thanvi, Vinay Bissa

Reviewers
Dr. Satish Kumar and Aalok Deshmukh (Schneider Electric India Pvt. Ltd), Rajan Rawal and Yash Shukla (CEPT University), Dr. Paul Mathew (LBNL)

USAID ECO-III project (For the previous version of the model)
Dr. Archana Walia, Dr. Satish Kumar, Aalok Deshmukh, Bibhash Das, Madhav Kamath, Vikas Arora