Aalborg Universitet

CLIMA 2016 - proceedings of the 12th REHVA World Congress

volume 1

Heiselberg, Per Kvols

Publication date:
2016

Document Version
Publisher's PDF, also known as Version of record

Link to publication from Aalborg University

Citation for published version (APA):
Heiselberg, P. K. (Ed.) (2016). *CLIMA 2016 - proceedings of the 12th REHVA World Congress: volume 1*. Department of Civil Engineering, Aalborg University.

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Energy Performance Monitoring Initiative to Evaluate and Handhold Energy Efficiency in Information Technology Enabled Serices (ITES) Companines of India: A Case Study

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Abstract

Buildings contribute 40% energy of the total energy consumed worldwide and this number is almost same of India as well. Commercial building in India consume more than 8% energy of the country and it is expected to grow in near future as well due to huge development in IT infrastructure. Information Technology Enabled Services (ITES) are major energy intensive in Hyderabad, India. Being a warm climate, all the buildings operate air-conditioning throughout the year to maintain indoor environment comfortable. Indian Green Building Council (IGBC), certifying agency for Green Buildings initiated Energy Performance Monitoring (EPM) service to evaluate and handhold ITES projects to achieve energy efficiency.

Under this initiative, large seized ITES are being to be measured and monitored. Total 10 EPM projects are taken, nevertheless tow projects are started. Energy simulation and field study is conducted for the case study building. Calibration is performed to predict accuracy of simulation model and also to get accurate prediction in energy savings. More than 10 efficiency measures are run on simulation and then economic analysis is carried out to recommend efficiency measure to particular ITES. Preliminary results show more than 10% energy savings in the project and due to huge energy consumption, therefore this will result in energy efficiency and offer tremendous environmental benefits.

Keywords: *Energy savings Potential in ITES; Energy Performance Monitoring; Energy simualtion; Calibration; Energy efficiency measures*

1. Introduction

Climate change has become a serious threat in the recent years. Buildings being the primary energy consumers, they contribute to the climate change in a menacing way [1]. World studies have acknowledged, buildings were responsible for 7.85Gt, or 33% of all energy-related CO2 emissions worldwide and these emissions are expected to grow to 11Gt (B2 scenario) or 15.6Gt (A1B scenario) by 2030 [2]. India ranks fifth in the world in terms of primary energy consumption and accounting 3.5% of the world commercial energy demand [3]. Nevertheless, buildings account for more than 30% of electricity consumption in India. It is estimated that the total built space in the country would increase five-fold from 2005 to 2030, and by then more than 60% of the commercial built space would have conditioned built environment [4]. A statistic report reveals that commercial buildings contribute to 8.72% of total energy of the country and predicts further increase energy in the years to come [5]. More importantly, since most of the 2040 building stock has yet to be constructed, there is a tremendous opportunity for India to expand and tighten energy efficiency standards and ensure that future demand for energy services mainly for cooling is met without putting undue strain on energy supply. Successful initiatives include a huge and cost-effective programme to replace old, inefficient light bulbs with LEDs, but the scope of other efficiency measures for buildings and appliances, while expanding, is still far from comprehensive [6].

In recent years, buildings have been given more focus in saving energy and resources. Green building movement has offered tremendous opportunities to save energy, water, material resources and it has led improved Indoor Environment Quality (IEQ), reduction in building carbon footprint and also offered enormous environmental benefits [7]. Various studies conducted worldwide on residential and commercial building sector have presented significant energy saving opportunities. A study carried out on existing residential buildings in Sweden has presented methods to save energy demand [8]. The study suggested two methods for retrofitting energy savings namely light retrofitting and further extend advanced retrofitting that resulted in saving up to 36-54%. Similar studies conducted in Abu Dhabi and Italy in residential sector demonstrated significant energy savings [9] & [10].

Energy consumption in commercial buildings is growing significantly and Energy Efficiency Measures (ECMs) are proposed to save energy in various built environment of this sector. A study conducted on hotel building in China proposed Energy Performance Contracting (EPC) similar to EU countries, ESCO for Building Energy Efficiency Retrofit (BEER) [11]. A review on energy efficiency in existing building presented several models and methods to save improve energy efficiency in commercial buildings [12]. The study proposed that efficiency and result in cost savings are created from the interaction among the behavioural, organizational and technological changes as presented in Fig 1.

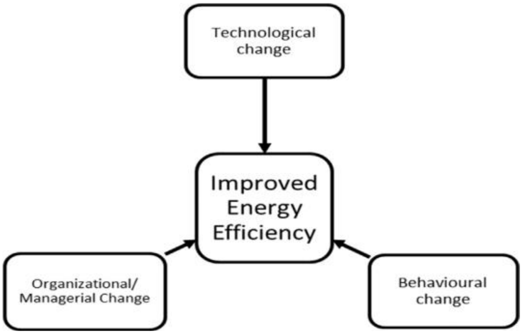


Fig. 1. Paradigms for energy performance improvement in existing buildings.

It is evident that commercial building consumes significant energy and expected to grow many fold. Bureau of Energy Efficiency (BEE), an organization working under Ministry of Power to conserve energy. BEE is playing vital role in implementation of building codes and policies to reduce energy consumption that will lead to reduce energy demand and load in setting up new power plants [13]. Studies conducted on implementation of Energy Conservation Building Code (ECBC) in upcoming or major renovations commercial buildings can result in energy savings between 17% and 42% [14] & ECBC user guide [15].

2. Information Technology Enabled Services (ITES) buildings

It is found that Information Technology (IT) buildings or IT Enabled Services (ITES) companies consume huge energy as these buildings operate throughout the year (24x7 operation). Intensive energy consumption is due to high occupancy, equipment, lighting and auxiliary loads. In these buildings, major energy is consumed by Heating, Ventilating and Air-Conditioning (HVAC) equipment, which is essential to maintain indoor conditions comfortable. India's IT industry amounts to 12.3% of the global market, largely due to exports [16]. Indian IT/ITES industry revenue is estimated at USD 119.1 billion in 2014-15 as compare to USD 106.3 billion in 2013-14, registering an increase of around 12% [17].

Hyderabad is one of the biggest IT hubs in India, only beyond Bangalore. The local government's ambition to make Hyderabad the biggest IT hub in India and other favorable conditions are setting up the platform for more ITES companies in Hyderabad in the near future. All these circumstances, coupled with shortage in the availability of electricity in the state are calling out for improving the energy efficiency in both the coming and existing ITES buildings. Government organization called Telangana State Industrial Infrastructure Corporation

(TSIIC) has come up with incentives to reward the existing buildings in improving energy [18]. ITES are very large infrastructure companies and it is very challenging to track energy performance and to handhold significant energy efficiency.

Being an energy guzzlers, present study is an initiative by Indian Green Building Council (IGBC) to

- evaluate energy performance of existing ITES
- compare project energy performance with ECBC energy benchmark
- propose energy efficiency measures results in energy efficiency on the basis of economic analysis
- handhold energy efficiency in ITES
- look-back energy performance of the projects

located in Hyderabad, composite climate of India.

3. Methodology

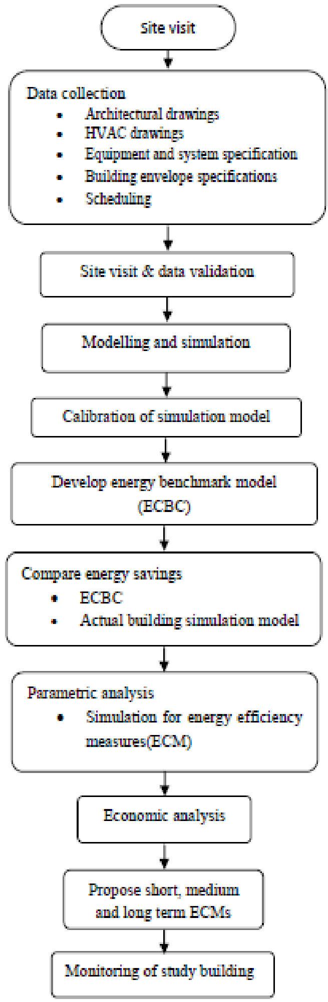
A. Green buildings in India

A green building is one which uses less water, optimizes energy efficiency, conserves natural resources, generates less waste and provides healthier spaces for occupants, as compared to a conventional building, campus [19]. The green building movement in India has been laid on the foundation of prestigious first and platinum rated building, CII-Sohrabji Godrej green business centre. Since then, Indian Green Building Council has driven the movement forward by certifying 758 buildings of various types with around 2700 more in-line to get certified. When compared to a conventional building, a green building reduces energy consumption & water consumption by around 30% & 40%, respectively [20]. As the market is facing a daunting task to show energy efficiency in existing buildings, IGBC has started Energy Performance Monitoring (EPM) services to achieve energy efficiency in especially in ITES. EPM has described in the next section.

B. Energy Performance Monitoring (EPM) services

To achieve envisaged energy savings and to track energy performance, a new service 'Energy Performance Monitoring (EPM)' was initiated by the IGBC for energy intensive commercial buildings. More than 10 large seized ITES located in Hyderabad are going for EPM study. The study opted methodology that includes conducting feasibility study, collect component level equipment details, perform energy simulation & calibration, propose Energy Conservation Measures (ECMs) specific to the project. Further, economic analysis was carry out to evaluate the visibility of the particular measure. Methodology for EPM is described in Table 1 along with specifications of three large seized ITES projects.

Table 1. Work flowchart for Energy Performance Monitoring (EPM) and project descriptions



EPM project-1

- Built-up area 1.28 M sq ft
- 5 buildings
- 5-16 storeyed
- Non insulated wall
- Overdeck roof insulation
- Single/double glazed window glasses
- LED & CFL lightings
- Air-cooled & water cooled chiller
- AHUs – CAV control
- VFD & non VFD pumps

EPM project-2

- Built-up area 1.1 M sq ft
- 2 buildings
- 10 & 16 storeyed
- Non insulated wall
- Roof overdeck insulation
- Double glazed window glasses
- LED & CFL lightings
- Water cooled chiller
- AHUs – VAV & VFD control
- HRW, VFD & non VFD pumps & Fans

EPM project-3

- Built-up area 2.2 M sq ft
- 3 buildings
- 6-10 storeyed
- Non insulated wall
- Roof overdeck insulation
- Single/double glazed window glasses
- LED & CFL lightings
- Air-cooled
- HRW, VFD & non VFD pumps & Fans

Questionnaire (Annexure A1.1) used to collected specifications of every equipment used in the ITES. At this stage, feasibility study is conducted for four IT Parks (built-up area 0.46-2.2 Million sq feet) and three IT Parks have undergone EPM study. The study shows that mostly IT Parks are similar in terms of building envelope, equipment load, interior & exterior lighting but air-conditioning equipment varies from one project to another. Air-cooled chiller, water-cooled chiller and mixed are the commonly used air-conditioning equipment. The energy consummation in these projects found to vary between 19,664 MWh and 27,805 MWh.

Site visits show that most of the projects have installed ECMs as per the market technology trends. Preliminary results of EPM study results that for about 6-8% energy can be saved in the existing IT Parks with less investment (payback within 2 years). Energy savings can be extended to maximum 10% with slight higher investment, payback within 4 years.

C. Case study building

Case study ITES building has two building, one is of 10 storey (0.65 mission sq ft) and other one is of Ground + 16 storey (0.063 million sq ft). Total 14000 occupant works in the study building (2 building blocks) and total built up are is 1.26 Million square feet. Building envelope specification are presented in the Table 2 and also in Annexure A1.3. Table 3-5 shows details of internal heat gain and AHU fan power for both the building block.

Table 2. Building envelope specifications (Annexure A1.3 & A1.4)

Component		Design case	Base Case (ECBC)
Wall		0.11 Btu/hr.ft2.ºF	0.11 Btu/Hr-Ft^{2o}C
Roof		0.066 Btu/hr.ft2.ºF, Roof reflectivity 0.46	0.063 Btu/Hr-Ft^{2o}C
Fenestration	Material	DGU	NA
	U-value	0.31 Btu/hr.ft2.ºF,	3.3 W/m^2 K
	SHGC	0.23	0.25
	VLT (%)	24	24
Shading devices		No	No

Table 3. Interior & exterior lighting, equipment and lift load

		Design case	ECBC case
Interior lighting power density (W/sft)		0.65	1.0
Day lighting control		Yes (Parking areas - No)	NA
Occupancy sensor		Yes (Facility area)	NA
Exterior	Bldg block 1	9.702 kW	19 kW

lighting power (kW)	Bldg block 2	4.39 kW	
	Total (kW)	14.092 kW	
Equipment power density (W/sq ft)		1.2	as design case
Lift load (kW)	Bldg block1	278 kW	as design case
	Bldg. block 2	446.9 kW	
	Total (kW)	724.9 kW	
	Bldg block 2		

Table 4. Fan power consumption for Bldg block 1

Floor	AHU No & Location	AHU Capacity (CFM)	TR	HP	kW	kW/CFM
G	1 to 4 & 6	100,500	163	60	44.76	0.000445
1	5,7,8,9,10	74,500	123	50	37.3	0.000501
2	11 to 14	70,000	116	40	29.84	0.000426
3	15 to 18	70,000	116	40	29.84	0.000426
4	19 to 22	66,000	108	40	29.84	0.000452
5	23 to 26	70,000	116	40	29.84	0.000426
6	27 to 30	70,000	116	40	29.84	0.000426
7	31 to 34	70,000	116	40	29.84	0.000426
8	35 to 38	66,000	108	40	29.84	0.000452
9	39 to 42	80,000	128	50	37.3	0.000466
	Total	737,000	1,210	440	328.24	0.000445

Table 5. Fan power consumption for Bldg block-2

Floor	AHU No.	CFM	TR	kW	kW/CFM
Entry	1 & 2	25000	50	14.8	0.000592
Mezzanine	3, 4 & 5	52500	105	27.9	0.000531
1	6 to 9	55000	110	35.4	0.000644
2	10 to 13	60000	120	37.2	0.00062
3	14 to 17	60000	120	37.2	0.00062
4	18 to 21	60000	120	37.2	0.00062
5	22 to 25	60000	120	37.2	0.00062
6	26 to 29	60000	120	37.2	0.00062
7	30 to 33	60000	120	37.2	0.00062
8	34 to 36	45000	90	27.9	0.00062
9	37 to 39	45000	90	27.9	0.00062
10	40 to 42	45000	90	27.9	0.00062
11	43 to 45	45000	90	27.9	0.00062

12	46 to 48	45000	90	27.9	0.00062
13	49 to 51	45000	90	27.9	0.00062
14	52 to 54	47500	100	27.9	0.000587
15	55 to 57	50000	100	27.9	0.000558
Total		860000	1725	524.5	

D. Energy simulation and calibration

Simulation model developed with the help of architectural & HVAC drawings and project specification extracted from the questionnaire. eQUEST dynamic thermal simulation tool was used for modelling and energy simulation. Simulation model was also calibrated as per the guideline proposed by IPMVP and ASHRAE guidelines on the basis of annual building energy consumption [21] & [22]. Figure 2 shows the 2D view of study building.

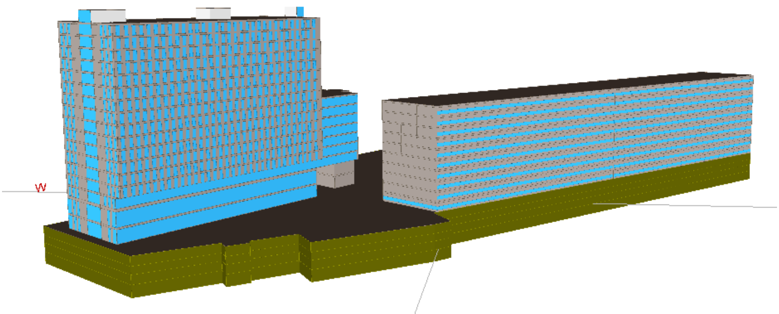


Figure 2. Simulation model of case study building (3 basement and 10 & 17 Storey)

Further, an ECBC model was developed from calibrated simulation model (a reference energy benchmark model) to compare the energy performance of existing ITES with ECBC, a national code to compare energy performance of actual or design model [13].

Furthermore, parametric analysis was carried out taking more than 10 ECMs to estimate energy efficiency potential in case study building and then economic analysis for considered ECMs. Only, ECMs those offered small payback period (within 2 yrs) were recommended to project team.

E. Monitoring and verification

Under EPM initiative, IGBC is offering building performance monitoring even after implementation of ECMs. Each EPM project will be visited again after one year and performance is to be compared to the performance of previous year.

4. Results and discussion

A. Climatic variations

Hyderabad experiences high solar radiation in all the seasons except monsoon. The mean monthly outdoor dry bulb temperature varies from 20 to 35 ºC. Therefore, ITES use air-conditioning throughout the year.

B. Case study ITES project

The study has observed that maximum energy savings comes from the chiller, pumps & cooling tower and then from the air distribution (variable frequency drive & variable air volume control, integration of heat recovery & demand control ventilation). The study also recommends projects to use adiabatic or mist cooling for air-cooled chillers to improve chiller performance, which has resulted energy efficiency with maximum ROI (in present case, building one has air-cooled chiller). EPM has observed that projects has implemented some ECMs after recommendation of study (building one). The study has observed that most of facility mangers have first choice to retrofit common area lighting (mostly common area vary from 30-40% of the total area) and then retrofitting of exterior lighting or also integration with Solar Photo-voltaic system. Table 6 shows the energy consumption, contact demand and recorded contract demand for two ITES projects.

Table 6. Energy performance of tow ITES projects

	B1 _MWh	B1 _C_MD	B1 _A_CD	B2 _MWh	B2 _C_MD	B2 _A_CD
2002	Not occupied/ operation			4509	1823	1400.5
2003				8676	2382	1979.2
2004				13833	3378	2900
2005				21090	4500	4476.6
2006				26607	6000	5738.3
2007				29274	8500	6922.5
2008				34413	9750	7279.3
2009	64	1600	437	33863	11000	7570.9
2010	5587	2183	1358	33504	11000	7117.8
2011	12542	3017	2637	33624	11000	6867.5
2012	12924	4475	2929	30032	11000	6547.3
2013	13842	5100	2972	29387	11000	6299.3
2014	16278	5100	3510	29728	11000	6487.9
2015	19664	6329	4185	27805	11000	5980.5

Note: B1 – ITES Building one, B2 – ITES building 2, C_MD – Contract maximum demand (kVA), A_CD – Recorded Contract Demand

Table 7 presents energy consumption for the case study building. It shows that building started operation in 2009 and since then built-up area has increase year on year and it has resulted increase in significant energy consumption.

Table 7. Building energy consumption for case study building

	B1_MWh	B1_C_MD	B1_A_D
2009	64	1600	437
2010	5587	2183	1358
2011	12542	3017	2637
2012	12924	4475	2929
2013	13842	5100	2972
2014	16278	5100	3510
2015	19664	6329	4185

Figure 3 and Figure 4 shows energy consumption and contract demand for both the ITES and separately for case study building. The gap in contract demand and recorded demand shows that there is huge cost savings opportunies to project owner. Although due to uncertainty, contract demand can not be reduced and it is also dependent on government policy. It is clear that building one has put some energy efficiency measures thereby energy consumption has reduced significantly.

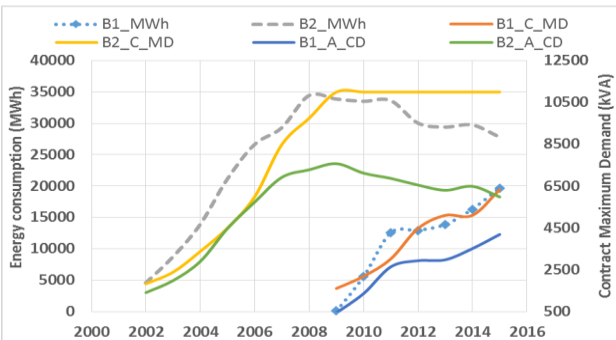


Fig. 3. ITES building energy consumption (MWh) and contract & actual demand (kVA)

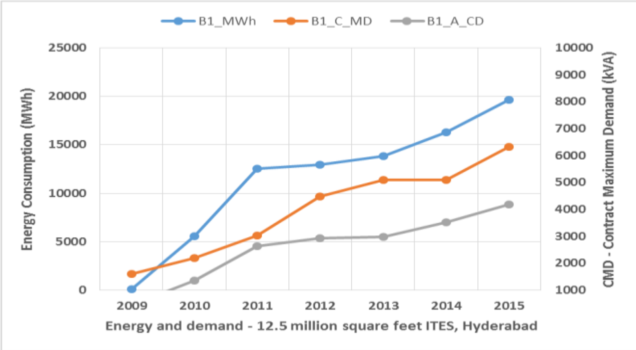


Fig. 4. ITES building energy consumption (MWh) and contract & actual demand (kVA)

C. Energy saving potentail and proposed efficiency measrues

1) LED lighting and operation of AC on adaptive thermostat

Installation of proposed energy efficiency measures would save at least 14% energy in the case study buildings. Some of the suggestive measures are installation of LED based interior lighting & exterior lighting, maintain adaptive variable thermostat setting (calculated based on comfort survey conducted for occupants of case study building) irrespective of fixed thermostat settings kept constantly. Also, a good approach in cooling tower, manage separate DX system and condenser

2) Cooling tower approach

Before EPM, an extensive energy audit was carried out that found significant energy saving by adjusting operation of cooling tower. The cold well temperature of the cooling tower was found to be 28 ^{o}C and the wet bulb temperature was 21^{o}C.The approach of the cooling tower was calculated to be 7^{o}C. The ideal approach of the cooling tower should be 4 ^{o}C. There is a good potential to reduce the approach of the cooling tower to 4^{o}C by operating all the cooling tower fans with VFD and utilizing all three cooling towers. This would reduce the power consumed by the chiller compressor as the condenser pressure of the refrigerant will decrease with reduction in condenser water temperature, returning from the cooling tower.

3) Schematic arrangement cooling tower water

During the audit, it was observed that separate plate heat exchangers and supplementary cooling water pumps are installed for the water cooled packaged DX chillers. The DX chillers are used for two lift rooms on the terrace, in the gym and recreation areas in 2 floor and electrical load centers in the same floor.

It was observed during the audit that the cooling water requirement to the plate heat exchangers is being catered by the condenser pumps installed for chiller system. The total flow of the condenser pump during the audit was 730 m3/hr out of which 540 m3/hr (74%) is flowing through the chiller condenser and 190 m3/hr (26%) is flowing through the plate heat exchange. The flow through this plate heat exchanger is used to cool the supplement water passing through DX chillers.

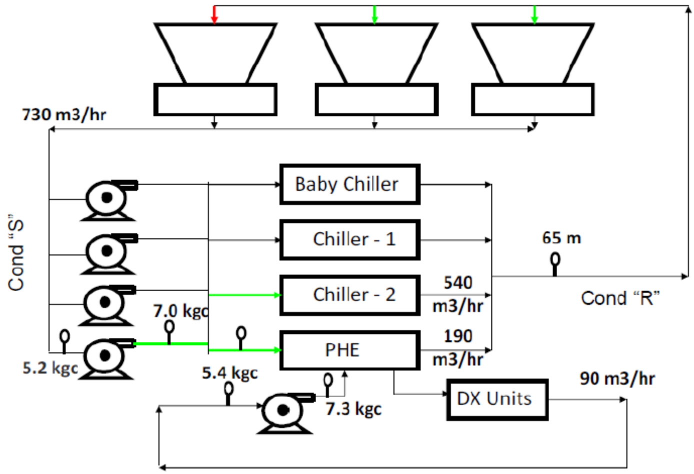


Fig. 5. Schematic diagram for cooling tower, pumps, chiller and PHE

Supplementary cooling water pump is installed to circulate cooling water through the DX units in the facility. VFD is installed for the supplementary cooling water pump and its frequency is maintained at 41 Hz as observed during the audit. The delta T across the plate heat exchanger was measured to be 0.3^{o}C in the cooling water side, which suggests that there is excess cooling water flow in the plate heat exchangers. In addition, there is additional pressure drop in the circuit due to the plate heat exchangers.

D. Economic analysis

Economic analysis is yet to be carried out for the suggestive energy efficiency measures. Monitoring and verification service will be provided to the EPM projects after one year of operation of the project. IGBC encourages the project continuously to provide yearly & monthly energy consumption. Definably, it would enable project to achieve higher energy efficiency benchmark.

Conclusion

EPM study concludes that ITES buildings have huge energy saving potential as their energy consuption is very significant as compare to office buildings. Even energy savings in the range of 5-10% will result in signifincat reduction in energy demand and will lead to huge cost savings for the projects.

Findings of energy performance monitoring study are as follows: Design case energy consumption of study building is less than the base case energy consumption. Hence Vega building meets the Mandatory requirement of IGBC Green EB Raging.

Study found 15 % improved performance of Vega building as per the Credit under IGBC Green EB Rating. Hence 6 Credit points can be awarded. Based on the financial analysis, study has recommended folding energy efficiency measures based :

- Nil investment
    - Maintain approach of cooling tower
    - System integration – PHE & DX system with the cooling tower
    - Operation of all cooling tower to maintain approach of 4 ^{o}C
- Short term proposal (2 years)
  Installation of LED based exteior lighitngs
- Medium term proposal (3-4 years)
  Installation of LED lighting for interior spaces (office and all common area)
- Long term investment (> 5 years)
  Roof top SPV system of 100 kWhp capacity

Acknowledgment

We thank you to all ITES for sharing their project data and also in taking Energy Performance Monitoring (EPM) service from Indian Green Building Council (IGBC). Of course, this work was impossible without support of all ITES and their willingness to support this initiative to measure and monitor ITES energy performance and propose energy efficiency measures.

Nomenclature

IGBC	Indian Green Building Counicl (IGBC)
Energy	kWh or MWh
C_MD	Contract maximum demand (kVA)
A_CD	Recorded contract demand (kVA)
VFD	Variable Frequency/ Speed Drive, HZ
EPM	Energy Performance Monitoring
EPC	Energy Performacnce Contract
ITES	Information Technology Enabled Services

Delta T	Difference in temperatur, ^{o}C
DX	Direct Expantion
Approach	Cold well temperature – Wet bulbt temperature, ^{o}C
WBT	Wetbulb temperature, ^{o}C
Cond	Condensor
VAV	Variable Air Volume (m3/s)
CAV	Constant Air Volume (m3/s)
AHU	Air Handling Unit
LED	Light Emitting Diode, Lighting fixture type
ECM	Energy Conservation Measures
HVAC	Heating, Ventilating and Air-conditioning
ECBC	Energy Conservation Building Code
IEQ	Indoor Environmental Quality (IEQ)
Bldg	Building
PHE	Plate Heat Exchanger

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Annexure A1.1 : Questionnaire for Project data collection

Annexure A1.1 : Online questionnaire survey for IEQ

It is to be used to evaluate workplace satisfaction (Thermal & visual comfort and Indoor Air Quality (IAQ)). To access, please use the web-link: http://goo.gl/forms/1m5eRLEA0B

Annexure A1.3 Building envelope specificatoins

Component		Proposed Design
Wall	Material	AAC brick wall (200mm) with granite cladding
	U value	0.11 Btu/hr.ft2.ºF
Slab	Material	4 inch thick RCC Slab
	U value	0.22 Btu/hr.ft2.ºF
Roof	Material	RCC slab + 75mm thick XPS Insulation
	U value	0.066 Btu/hr.ft2.ºF
	Reflectivity	0.45
Fenestration	Material	Double Glazed Unit
	U value	0.31 Btu/hr.ft2.ºF (It is unlabelled therefore a U-value of 0.90 Btu/hr.ft2.ºF has been modeled for the fenestration as per appendix A, Table 8.2 on page 105 of ASHRAE 90.1 2004.)
	SHGC	0.23
	VLT (%)	24