Project Report on
'Review and Revision of CPWD Documents to Include Energy Efficiency Parameters and Capacity Building of Professionals'

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Disclaimer

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- Ms. Alpana Jain, Shakti Sustainable Energy foundation
- Mr. R S Prasad (Coordinator/ nodal person), TERI
- Ms. Mili Majumdar, TERI
- Ms. Pooja Shukla, TERI

It is important here to mention the co-operation of the various CPWD project team officials from all over the country in providing requisite information for different CPWD buildings and providing their support during energy audits of the CPWD buildings.

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1. Introduction

Background

Although significance of energy efficiency in the Indian building sector is well established, penetration of building energy efficiency at all levels in the Indian building sector is a huge and challenging task. To ensure effective implementation of building energy efficiency in India, it is imperative that all major government and private organizations in the country adopt building energy efficiency as an inherent part of their construction process.

All across India, for building-related works like developing building specifications, preparing estimates, floating tenders and developing contracts, organizations have been referring to Central Public Works Department (CPWD) documents – CPWD Specifications, Plinth Area Rates, Delhi Schedule of Rates and Analysis of Rates.

By revising the existing CPWD documents to integrate Energy Conservation Building Code (ECBC) and GRIHA (the National Green Building Rating System of India) compliant specifications, this project will facilitate integration of energy efficient building measures in all building contract documents from the pre-design level itself, thus, ensuring that energy and resource efficiency becomes an inherent part of the existing building construction process.

Project Objective

Objective of this project was to review the existing CPWD documents (Standard specification, schedule of rates, Analysis of Rates, Plinth area rates) and provide recommendations on integration of energy efficiency and other green building measures in these documents to facilitate ECBC and GRIHA compliance.

Approach

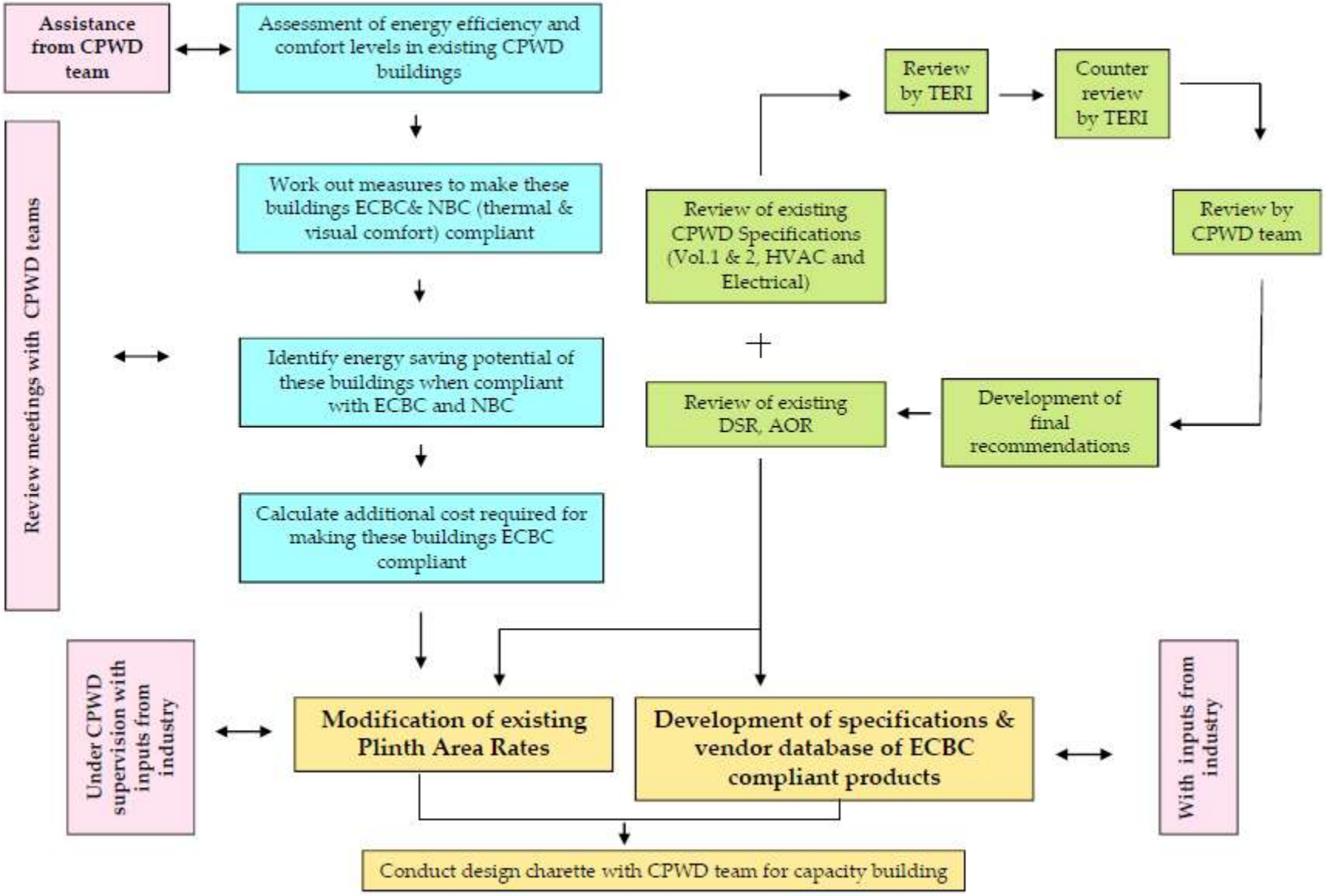
First step was to understand the current practice adopted by CPWD for construction of their buildings by reviewing some of their existing buildings and then to analyse the impact of making these buildings ECBC compliant. A parallel exercise was to review the existing CPWD specifications and schedule of rates to provide recommendations on incorporating ECBC and GRIHA compliant requirements in these documents. Based on the results of these two exercises, necessary modifications were made to the CPWD Plinth Area Rates.

To ensure effective implementation of ECBC, a database of vendors supplying ECBC compliant products, has also been prepared.

Following is the step by step methodology that has been followed for project implementation:

- Assessment of energy efficiency and comfort (thermal and visual) levels in existing CPWD buildings.
- Work out measures to make these buildings ECBC & National Building Code (thermal & visual comfort standard) compliant.

- Identification of energy saving potential of these buildings when compliant with ECBC and NBC (thermal & visual comfort standard).
- Calculation of additional cost required for making these buildings ECBC and NBC (thermal & visual comfort standard) compliant.
- Review of existing CPWD documents - specifications (Civil Volume 1 & 2, HVAC and electrical), AOR and DSR to identify points where ECBC and GRIHA can be integrated and provide necessary recommendations.
- Development of specifications and vendor database of products that will facilitate ECBC compliance.
- Modification of existing Plinth Area Rates to reflect ECBC compliance and GRIHA compliance.
- Capacity building of the CPWD team in using the revised documents by conducting two design charrettes.


Assistance from CPWD team
Assessment of energy efficiency and comfort levels in existing CPWD buildings
Review by TERI
Counter review by TERI
Review meetings with CPWD teams
Work out measures to make these buildings ECBC& NBC (thermal & visual comfort) compliant
Review of existing CPWD Specifications (Vol.1 & 2, HVAC and Electrical)
Review by CPWD team
Identify energy saving potential of these buildings when compliant with ECBC and NBC
Review of existing DSR, AOR
Development of final recommendations
Calculate additional cost required for making these buildings ECBC compliant
Under CPWD supervision with inputs from industry
Modification of existing Plinth Area Rates
Development of specifications & vendor database of ECBC compliant products
With inputs from industry
Conduct design charette with CPWD team for capacity building

2. Project Activities

This section provides a detailed description of the activities implemented under this project:

Building selection and data collection

To understand the current practice adopted by CPWD for construction of their buildings, review of some of their existing buildings was conducted. With support from the CPWD officials several building all over the country were identified for study.

Following were the criteria set for building selection:

- At least 2 buildings from four major climate zones of India: Composite, warm and humid, hot and dry, moderate.
- At least 2 buildings from each building typology specified in the existing Plinth Area Rate (PAR) document of CPWD: School, College, Hostel, Hospital, Office and Residential. In the existing PAR document- office, college and hospital have been categorised together whereas for this study, schools and colleges have been categorised together and office and hospitals are separate categories.
- For audit purpose it was necessary that the building is operational for at least 1 year so that its annual electricity load profile could be studied.
- The building should have been built in a conventional manner.

Project information including detailed project report (DPR), work specifications, estimates, architectural drawings, were sought from the project team. Extensive follow up was done with the respective CPWD project teams to obtain project information. After initial interaction with the project teams, it was realised that some of these buildings were not appropriate for the study due to various reasons like building not operational or only partially operational, building operational for less than 1 year, building construction not complete.

Collection of project documents from the concerned project teams was a taxing and very time consuming task. Data available with different CPWD departments in different offices, transfer of concerned project officials, unavailability of data, were some of the factors that affected the data collection activity. However, through constant efforts and due to co-operation of CPWD officials, out of the 20 buildings that were identified for the study, complete data for 12 buildings was received.

At the beginning of the project it was attempted to select CPWD buildings such that at least 2 buildings from each building typology included in the CPWD Plinth Area Rate document and 2 buildings from each of the 4 major climate zones of India, should be included in the study. The list of 12 buildings that were finally studied complies with both these criteria.

Below is the list of buildings that have been studied under this project:

Table 1: List of buildings

SI	Project name	Location
1	Super Specialty Hospital for Govt. Medical College	Jammu
2	Institute of Liver and Biliary Sciences	Delhi
3	Trade Centre for STC of India ltd	Bangalore
4	National Sample Survey Organization Building	Lucknow
5	CAG's Research &Training Institute Building	Mumbai
6	Census Office	Gandhinagar
7	IISER Hostel	Pune
8	Residential quarters	Bikaner
9	Residential quarters	Ahmedabad
10	Dental College at Jamia Milia Islamia University	New Delhi
11	Central School, Special Protection Group at Dwarka	Delhi
12	Distance Education Building at Nagarjuna University	Vijayawada

Building typology wise categorization

School College	Hostel	Hospital	Office	Residential
3	2	2	3	2

Climate zone wise categorization

Composite	Warm & humid	Hot & dry	Moderate
5	2	3	2

Energy Audit of selected buildings

Energy audit, including thermal and visual comfort survey, was conducted for 8 buildings out of the total 12 buildings selected for the study. Buildings were selected such that all building typologies as well as climate zones were covered.

Table 2 lists the buildings for which energy audit including thermal and visual comfort survey has been conducted.

Table 2: List of buildings for which energy audit has been conducted

SI No.	Project name	Location	Climate	Category
1	DDU (Deen Dayal Upadhayay) Hospital at Harinagar	Delhi	Composite	Hospital
2	Trade Centre for STC of India ltd	Bangalore	Moderate	Office
3	National Sample Survey Organization Building	Lucknow	Composite	Office
4	CAG's Research &Training Institute Building	Mumbai	Warm & humid	Office/ guest house
5	Census Office	Gandhinagar	Hot & dry	Office
6	IISER Hostel	Pune	Moderate	Hostel
7	Residential quarters	Ahmedabad	Hot & dry	Residential
8	Distance Education Building at Nagarjuna University	Vijayawada	Warm & humid	School/College

Data collected through energy audits was reviewed and analysed to check the following:

a. Thermal and visual comfort levels in the building with respect to the National Building Code (NBC) 2005 standards. Thermal comfort was assessed based on the temperature and relative humidity (RH) levels in the living areas of the buildings. Visual comfort was assessed based on the illuminance levels measured in Lux.

b. Design and performance of building envelope, lighting system, HVAC system and electrical equipments and systems, with respect to Energy Conservation Building Code (ECBC) requirements.

c. Energy performance of the building.

Observations

During energy audits, data such as annual electricity bills, building envelope specifications, design details of lighting and cooling system was collected. Measurements were taken using audit instruments to establish thermal and visual comfort in building spaces and to establish the hourly building load profile for one whole day.

The detailed energy audit reports of each building have been added as Annexure 1.

Below is a summary of the observations made during the building energy audits with respect to building's compliance with Energy Conservation Building Code and National Building Code-2005.

Table 3: Observations for IISER Hostel building in Pune with respect to ECBC requirements

Observations for IISER Hostel building in Pune with respect to ECBC requirements		
Parameters	**Building features**	**ECBC Requirements**
Building type	**Non Air conditioned**	
Building Design Features	Built up area is 7897 m2	
	Window glazing properties –	
	U-Value- 6.17 W/m²-K	U-Value- 6.9 W/m²-K
	SHGC - 0.52	SHGC - 0.40
	Wall properties –	
	Net U-value = 1.86 W/m2K	Net U-value = 0.44 W/m2K
	The wall on all the facades is normal 230 mm brick wall with 15 mm plaster on both the sides	
	Roof properties –	
	Net U-value of other roof = 2.35 W/m2K	Net U-value = 0.404 W/m2K
	Roof of the building is 150 mm RCC roof with water proofing using 100 mm brick bat coba and finishing with 12 mm glass reinforced tiles	
Lighting system Features	Daylight integrated with artificial lighting	
	No Lighting Controls	Mandatory controls specified in section 7.2
	Lighting power density – 5.5 W/m2	Lighting power density – 7.5 W/m2
Cooling system	Ceiling fans	Not applicable
	Cooling demand density - NA	Not applicable
	Chiller COP- NA	Not applicable
Electrical system	Power factor maintained is greater than 0.95	Power factor should be maintained equal to or greater than 0.95
	Not applicable	All the motors should have eff1 efficiency as specified in IS 12615 code
	Transformer losses at 50% and at 100% load were higher than ECBC recommendations.	Transformer losses at 50% and at 100% load should be lower than the losses mentioned in ECBC

Energy Performance Index (kWh/m²/year)	**42***

**(Energy consumption due to lighting and cooling system has been considered)*

Building comfort levels with reference to National Building code (NBC-2005) standard	
Visual Comfort	Visual comfort in the building was maintained as per National building code-2005 standard
Thermal comfort	Thermal comfort in the building was maintained as per National building code-2005 standard

Table 4: Observations for STCL building in Bangalore with respect to ECBC requirements

Observations for STCL building in Bangalore with respect to ECBC requirements		
Parameters	**Building features**	**ECBC Requirements**
Building type	**Air conditioned**	
Building Design Features	Built up area is 5245 m2	
	Window glazing properties –	
	U-Value- 2.1 W/m²-K	U-Value- 6.9 W/m²-K
	SHGC - 0.36	SHGC - 0.30
	Wall properties –	
	Net U-value = 1.873 W/m2K	Net U-value = 0.440 W/m2K
	All external walls are of 230 mm thick brick with 12 mm plaster on inside and 15 mm plaster on outside surface.	
	Roof properties –	
	Net U-value of roof = 2.776 W/m2K	Net U-value = 0.409 W/m2K
	The roof of the building is 300 mm post tensioned RCC slab on which water proofing is done using 120 mm brick bat coba	
Lighting system Features	Daylight not integrated with artificial lighting	
	No Lighting Controls	Mandatory controls specified in section 7.2
	Lighting power density – 8.5 W/m2	Lighting power density for office – 10.8 W/m2

Observations for STCL building in Bangalore with respect to ECBC requirements		
Cooling system	Ceiling fans	Not applicable
	Cooling demand density -22 sqm/TR	Not applicable
	Chiller COP- 4.2 and is as per ECBC recommendations	Chiller COP as per ECBC recommendations
Electrical system	Power factor maintained is lower than 0.95	Power factor should be maintained equal to or greater than 0.95
	Not applicable	All the motors should have eff1 efficiency as specified in IS 12615 code
	Transformer losses data was not available	Transformer losses at 50% and at 100% load should be lower than the losses mentioned in ECBC

Energy Performance Index (kWh/m²/year)	**142***

**(Energy consumption due to lighting and cooling system has been considered)*

Building comfort levels with reference to National Building code (NBC-2005) standard		
Visual Comfort	Visual comfort in the building was maintained as per National building code-2005 standard	
Thermal comfort	Thermal comfort on third floor office space was not as per National building code-2005 standard	

Table 5: Observations for RTI building in Mumbai with respect to ECBC requirements

Observations for RTI building in Mumbai with respect to ECBC requirements		
Parameters	**Building features**	**ECBC Requirements**
Building type	**Air conditioned**	
Building Design Features	Built up area is 4972 m2	
	Air conditioned area is 3693 sqm	
	Window glazing properties –	
	U-Value- 2.74 W/m²-K	U-Value- 3.3 W/m²-K
	SHGC - 0.56	SHGC - 0.25
	Wall properties –	
	Net U-value = 1.86 W/m2K	Net U-value = 0.44 W/m2K

Observations for RTI building in Mumbai with respect to ECBC requirements		
	All external walls are 200 mm concrete blocks with 15 mm plaster on both sides	
	Roof properties –	
	Net U-value of other roof = 1.88 W/m2K	Net U-value = 0.409 W/m2K
	Roof of the building is 150 mm thick RCC with water proofing 150 mm brick bat coba and finishing with 12 mm china mosaic	
Lighting system Features	Daylight integrated with artificial lighting	
	No Lighting Controls	Mandatory controls specified in section 7.2
	Lighting power density –10.76 W/m2	Lighting power density – 10.76 W/m2
Cooling system	Air cooled screw chiller	Not applicable
	Cooling demand density - 9.4 sqm/TR	Not applicable
	Chiller COP- 3.2	Chiller COP- 3.05
Electrical system	Power factor maintained is greater than 0.95	Power factor should be maintained equal to or greater than 0.95
	Pump motors efficiency is lower than eff1 efficiency specified in IS 12615 code	All the motors should have eff1 efficiency as specified in IS 12615 code
	Transformer losses data was not available	Transformer losses at 50% and at 100% load should be lower than the losses mentioned in ECBC

Energy Performance Index (kWh/m²/year)	**238***

**(Energy consumption due to lighting and cooling system has been considered)*

Building comfort levels with reference to National Building code (NBC-2005) standard	
Visual Comfort	Visual comfort in the office spaces is not meeting the National building code-2005 standard
Thermal comfort	Thermal comfort in the building was as per National building code-2005 standard

Table 6: Observations for NSSO building in Lucknow with respect to ECBC requirements

Observations for NSSO building in Lucknow with respect to ECBC requirements		
Parameters	**Building features**	**ECBC Requirements**
Building type	**Non Air conditioned**	
Building Design Features	Built up area is 2354 m2	
	Window glazing properties –	
	U-Value- 6.06 W/m²-K	U-Value- 3.3 W/m²-K
	SHGC - 0.87	SHGC - 0.25
	Wall properties –	
	Net U-value = 1.828 W/m2K	Net U-value = 0.440 W/m2K
	All external walls are made of 230 mm thick brick with 12 mm plaster on inside and 25 mm grit-wash on outside surface	
	Roof properties –	
	Net U-value of other roof = 2.839 W/m2K	Net U-value = 0.409 W/m2K
	The roof of the building is 150 mm RCC roof with water proofing using 120 mm brick bat coba	
Lighting system Features	Daylight not integrated with artificial lighting	
	No Lighting Controls	Mandatory controls specified in section 7.2
	Lighting power density – 8.5 W/m2	Lighting power density for office – 10.8 W/m2
Cooling system	Ceiling fans	Not applicable
	Cooling demand density - NA	Not applicable
	Chiller COP- NA	Not applicable
Electrical system	Power factor maintained is greater than 0.95	Power factor should be maintained equal to or greater than 0.95
	Not applicable	All the motors should have eff1 efficiency as specified in IS 12615 code
	Transformer losses data was not available	Transformer losses at 50% and at 100% load should be lower than the losses mentioned in ECBC

Energy Performance Index (kWh/m²/year)	**32***

**(Energy consumption due to lighting and cooling system has been considered)*

Building comfort levels with reference to National Building code (NBC-2005) standard	
Visual Comfort	Visual comfort was maintained as per National building code-2005 standard
Thermal comfort	Thermal comfort not meeting on top floor office spaces as per National building code-2005 standard

Table 7: Observations for Census building in Gandhinagar with respect to ECBC requirements

Parameters	Building Features	ECBC Compliances
Building type	**Office, Non Air Conditioned**	
Building Design Features	Built up area is 4009 m2	
	AC area = 1002 m2	
	Window glazing properties –	
	U-Value- 6.17 W/m²-K	U-Value- 3.3 W/m²-K
	SHGC - 0.815	SHGC - 0.25
	Wall properties –	
	Net U-value = 1.873 W/m²K	Net U-value = 0.44 W/m²K
	The wall on all external facades is 230 mm brick with 12 mm plaster on inside and 15 mm plaster on outside	
	Roof properties –	
	Net U-value of other roof = 2.09 W/m²K	Net U-value = 0.409 W/m2K
	The roof of the building is 150 mm RCC slab with water proofing using 120 mm brick bat coba on the exterior surface and 6 mm cement plaster on inside surface	
Lighting system Features	Adequate daylight was available but was not integrated with artificial lighting system	
	No daylighting and artificial Lighting Controls	All the mandatory controls specified in section 7.2
	Lighting power density –11 W/m²	Lighting power density – 10.8 W/m²

Parameters	Building Features	ECBC Compliances
	Visual comfort was maintained as per National building code-2005 standard in some of the spaces.	Not applicable
Cooling system	Ceiling fans and Unitary ACs	BEE star rated
	Cooling demand - 11.3 sqm/TR	Not applicable
	Chiller COP for few of the ACs was as per BEE star recommended ACs.	Not applicable
	Thermal comfort in AC and Non AC spaces was maintained as per National building code-2005 standard	Not applicable
Electrical system	Power factor maintained is greater than 0.95	Power factor should be maintained equal to or greater than 0.95
	Not applicable	All the motors should have eff1 efficiency as specified in IS 12615 code
	Transformer losses at 100% loading are as per ECBC recommendations. Data on losses at 50% loading was not available.	Transformer losses at 50% and at 100% load should be lower than the losses mentioned in ECBC
Energy Performance Index (kWh/m²/year)	**63**	Not applicable

Energy Performance Index (kWh/m²/year)	**63***

**(Energy consumption due to lighting and cooling system has been considered)*

Table 8: Observations for Distance Education building in Vijayawada with respect to ECBC requirements

Parameters	Building Features	ECBC Compliances
Building type	**Non AC (College/University)**	
Building Design Features	Built up area is 10657 m2	
	Window glazing properties –	
	U-Value- 6.17 W/m²-K	U-Value- 3.3 W/m²-K
	SHGC - 0.815	SHGC - 0.25
	Wall properties –	
	Net U-value = 1.873 W/m2K	Net U-value = 0.44 W/m2K
	The wall on all external facades is 230 mm FAL-G brick with 15 mm plaster on inside and 12 mm plaster on outside	

Parameters	Building Features	ECBC Compliances
	Roof properties –	
	Net U-value of other roof = 2.09 W/m²K	Net U-value = 0.409 W/m²K
	The roof of the building is 6 mm plaster from inside, 150 mm RCC slab with water proofing using 120 mm brick bat coba from outside	
Lighting system Features	Adequate daylight was available but was not integrated with artificial lighting system	
	No day lighting and artificial lighting controls	All the mandatory controls specified in section 7.2
	Lighting power density –7.8 W/m²	Lighting power density – 12.9 W/m²
	Visual comfort was maintained as per National building code-2005 standard in some of the spaces.	Not applicable
Cooling system	Ceiling fans and Unitary ACs	BEE star rated ACs
	Cooling demand-not applicable, (most of the building spaces are non AC)	Not applicable
	BEE star rated ACs	Chiller COP -2.7 for 1 star ACs
	Thermal comfort in Non AC spaces was maintained as per National building code-2005 standard	Not applicable
Electrical system	Power factor at building level was lower than 0.95	Power factor should be maintained equal to or greater than 0.95
	Not applicable	All the motors should have eff1 efficiency as specified in IS 12615 code
	Not applicable as there is no dedicated transformer at the building level.	Transformer losses at 50% and at 100% load should be lower than the losses mentioned in ECBC

Table 9: Observations for Residential Building in Ahmedabad with respect to ECBC requirements

Parameters	Building Features	ECBC Compliances
Building type	**Residential, Non Air conditioned**	
Building Design Features	Built up area is 4877 m2	
	Window glazing properties –	
	U-Value- 6.17 W/m²-K	U-Value- 3.3 W/m²-K
	SHGC - 0.815	SHGC - 0.25
	Wall properties –	
	Net U-value = 1.87 W/m2K	Net U-value = 0.44 W/m2K
	The wall on all external facades is 230 mm brick with 12 mm plaster on inside and 15 mm plaster on outside	
	Roof properties –	
	Net U-value of other roof = 2.09 W/m2K	Net U-value = 0.404 W/m2K
	The roof of the building is 150 mm RCC roof on which water proofing is done using 100 mm brick bat coba and the finishing of roof is done with 12 mm glass reinforced tiles	
Lighting system Features	Adequate daylight was available but was not integrated with artificial lighting system	
	Digital time switch for controlling parking light and staircase/ corridor light, No daylighting controls	All the mandatory controls specified in section 7.2
	Lighting power density – 2.5 W/m2	Lighting power density – 7.5 W/m2
	Visual comfort was maintained as per National building code-2005 standard	Not applicable
Cooling system	Ceiling fans and Unitary ACs	BEE star rated ACs
	Cooling demand density - NA	Not applicable
	BEE star rated ACs	Chiller COP-2.7 for 1 star Acs
	Thermal comfort was maintained as per National building code-2005 standard	Not applicable
Electrical system	Not applicable (the electrical system is being managed by third party and not in the scope of CPWD)	Power factor should be maintained equal to or greater than 0.95

Parameters	Building Features	ECBC Compliances
	Not applicable	All the motors should have eff1 efficiency as specified in IS 12615 code
	Not applicable (the electrical system is being managed by third party and not in the scope of CPWD)	Transformer losses at 50% and at 100% load should be lower than the losses mentioned in ECBC

Energy Performance Index (kWh/m²/year)	**33***

**(Energy consumption due to lighting and cooling system has been considered)*

Table 10: Observations for Institute of Liver & Biliary Sciences in Delhi with respect to ECBC requirements

Parameters	Building Features	ECBC Compliances
Building type	**Hospital, Non Air conditioned**	
Building Design Features	Built up area is 13662 m²	
	AC area is 13662 m²	
	Window glazing properties –	
	U-Value- 1.6 W/m²-K	U-Value- 3.3 W/m²-K
	SHGC - 0.37	SHGC - 0.25
	Wall properties –	
	Net U-value = 2.79 W/m²K	Net U-value = 0.44 W/m²K
	The wall on all external facades is 230 mm hollow cement concrete blocks with 12 mm plaster on inside surface and 25 mm grit finish on the exterior façade	
	Roof properties –	
	Net U-value of other roof = 0.760 W/m²K	Net U-value = 0.261 W/m2K
	The roof of the building is 150 mm RCC slab with water proofing using 100 mm brick bat coba on outside surface and 12 mm insulation on the inside surface	
Lighting system Features	Adequate daylight was not available	
	No day lighting and artificial lighting controls	All the mandatory controls specified in section 7.2

Parameters	Building Features	ECBC Compliances
	Lighting power density – 7.7 W/m²	Lighting power density – 12.9 W/m²
	Visual comfort was maintained as per National building code-2005 standard	Not applicable
Cooling system	Ceiling fans	Not applicable
	Cooling demand density - 14.1 sqmt/TR	Not applicable
	Chiller COP- 4.71	Chiller COP - 5.75
	Thermal comfort was maintained as per National building code-2005 standard	Not applicable
Electrical system	Power factor maintained is greater than 0.95	Power factor should be maintained equal to or greater than 0.95
	All the motors have efficiency as specified in 12615	All the motors should have efficiency as specified in IS 12615 code
	Transformer Loss details- Not available	Transformer losses at 50% and at 100% load should be lower than the losses mentioned in ECBC

Energy Performance Index (kWh/m²/year)	**298**

**(Energy consumption due to lighting and cooling system has been considered)*

Summary of observations

The data collected and measured during energy audits was reviewed and analysed with an objective to assess the building and system design with focus on ECBC compliance. Table 6 below presents a summary of assessment of building and system design of all eight audited buildings with respect to energy efficiency.

Table 11: Summary of Assessment of Building and System Design with resepct to Energy Efficiency Features

Energy Efficient features		NSSO Building- Lucknow	STCL building- Bangalore	RTI building- Mumbai	IISER Hostel building- Pune	Census Building Gujarat	CDE Vijaywada	IT Building- Ahemdabad	ILBS- Delhi
	Orientation (Longer facades facing North South)	X	X	X	X	✓	X	X	X
	Wall shading	X	X	X	X	X	X	X	X
	Roof shading	X	X	X	X	X	X	X	X
Building Design	Window shading	✓	X	X	X	✓	✓	✓	X
	Wall U-value as per ECBC	X	X	X	X	X	X	X	X
	Roof U- value as per ECBC	X	X	X	X	X	X	X	X
	Glass U- value as per ECBC	X	✓	✓	X	X	X	X	✓
Building Envelope	Glass SHGC as per ECBC	X	X	X	X	X	X	X	X
	Artificial lighting as per ECBC	✓	✓	✓	✓	X	✓	✓	✓
	Adequate Day lighting	✓	✓	X	✓	✓	✓	✓	X
	Integration of artificial and day lighting with proper controls	X	X	X	X	X	X	X	X
Lighting	Artificial lighting controls (occupancy sensors, automatic shut off).	X	X	X	X	X	X	X	X
	Efficient chillers as per ECBC	Not Applicable	Not Applicable	✓	Not Applicable	Not Applicable	Not Applicable	Not Applicable	X
	Efficient Unitary AC system (BEE star, VRV systems)	X	✓	Not Applicable	✓	X	✓	✓	Not Applicable
	Efficient Motors as per ECBC	Not Applicable	Not Applicable	X	Not Applicable	Not Applicable	Not Applicable	Not Applicable	✓
	Variable frequency drive on chilled water Pump motors	Not Applicable	Not Applicable	X	Not Applicable	Not Applicable	Not Applicable	Not Applicable	✓
Cooling system	Variable frequency drive on AHU fan motors	Not Applicable	Not Applicable	X	Not Applicable	Not Applicable	Not Applicable	Not Applicable	X
	Adequate size Capacitor banks installation to maintain power factor above 0.95	✓	X	✓	✓	✓	Not Applicable	Not Applicable	✓
	Transformer losses as per ECBC	Not available	Not available	Not available	X	Not available	Not available	Not Applicable	Not available
Electrical system	Metering of electrical parameters at LT panel	✓	✓	✓	✓	✓	✓	✓	✓
	Solar hot water system	X	X	X	✓	X	X	X	X
Renewable Energy	Renewable energy generation system (Solar PVs, Wind, biomass etc)	X	X	X	X	X	X	X	X

Following is a combined summary of observations for all eight buildings:

Building Design and Envelope

1. Although window shading has been provided in some of the buildings, it was observed that in general low energy design features like wall shading, roof shading and appropriate sun shade design and optimum orientation have not been considered while designing these buildings. *In a study conducted by TERI under Asia Pacific partnership project, it has been established that by integration of low energy design features, cooling load (TR) gets reduced by 15-20% and energy consumption get reduced by 15 to 25% in various climatic zones of India.*
2. Building envelope (including wall assembly, roof assembly and fenestrations) has not been designed considering the ECBC recommendations for building envelope.

Building lighting system

1. It was observed that in most of the building spaces the visual comfort (defined in terms of lux levels on work plane) levels were as per the standards recommended by NBC 2005. The lighting power density was as per the limits prescribed in Energy Conservation Building Code-2007.
2. Mandatory lighting controls as per ECBC-2007 have not been installed in any of the buildings. Only one building was found to have digital time switch for controlling outdoor lighting and circulation area lighting.

Building HVAC system

1. Thermal comfort in all the buildings was found to meet the standards as per NBC-2005 recommendations.
2. HVAC equipments like chillers were not as per ECBC recommendations in some buildings.
3. Split air-conditioners used in some of the buildings were BEE star rated.
4. Motor efficiencies are not as per ECBC recommendations.
5. Variable frequency drives in the air flow system have not been installed in any building.
6. Variable frequency drives in the primary pump of chilled water flow system have been installed.

Building Electrical system

1. Centralised BMS (Building management system) for controlling/operation/energy efficiency enhancement is not installed anywhere.
2. Power factor as recommended in ECBC-2007 is not being maintained in some of the buildings. In some buildings, APFC (Auto power factor correction) panels are not

installed. There is no arrangement for maintaining power factor in the residential building.

3. Electrical meters installed at LT panels of commercial buildings were provided with the recording of general electrical parameters except THD (total harmonic distortion).

Identification of Energy Efficient features

Based on the observations made during the energy audits and after assessing the existing energy performance of these buildings, next step was to identify energy efficiency features that could be incorporated in these buildings to improve their energy performance.

For air conditioned buildings

For air conditioned buildings, computer simulation was used to study the impact of incorporating ECBC 2007 requirements and other energy efficiency features on improving the energy performance of an air conditioned building in different climate zones of India. The simulation was conducted using weather data for four Indian cities- Ahmedabad (Hot and dry climate zone), Delhi (Composite climate zone), Mumbai (Warm and humid climate zone)and Bangalore (Moderate climate zone).

Virtual model of a building was developed in standard building energy simulation software with the help of the architectural drawings and other building information such as envelope, electro-mechanical systems, operating schedules, and weather data etc.. This model was calibrated to first behave as the actual building based on the current energy performance data collected through the energy audit. The energy performance (in kWh/m^2/ annum) of the actual case was recorded.

Then the calibrated model was used to predict the energy performance of the building after incorporating energy efficiency features.

This energy performance index (EPI) of the building model was compared with the GRIHA specified EPI to check whether the building would meet the GRIHA energy performance benchmark and how many points could be scored under GRIHA criteria 14.

Identified energy efficiency features:

1. Efficient roof: U-value for roof assembly recommended by ECBC for different climate zones
2. Cool roof: Roof surface with solar reflectance value of 0.7
3. Efficient glazing: U-value and SHGC for the glazing as prescribed by the ECBC code
4. Efficient wall: U-value for wall assembly recommended by ECBC for different climate zones
5. Daylight Integration: Daylight integration with artificial lighting
6. Energy Recovery Ventilator: Energy recover ventilators to pre-cool the fresh air
7. Variable air volume system: Variable air volume system with VSDs on the Air Handling Units
8. Water cooled chiller with chilled water distribution system as constant primary loop only

9. Water cooled chiller with chilled water distribution system as two loop, constant primary/ secondary variable

Table 12: Reduction in energy performance index (EPI) of building after incorporating energy efficient features, in different climatic zones

	Ahmedabad (kWh/m²/yr)	Delhi (kWh/m²/yr)	Mumbai (kWh/m²/yr)	Bangalore (kWh/m²/yr)
EPI of existing building	274	256	252	198
Predicted energy performance of building after incorporating ECBC recommended and other energy efficient features	87	80	81	74
GRIHA energy performance benchmark*	165*	165*	165*	153*
% potential energy consumption reduction	47%	52%	51%	52%

*Calculation of GRIHA energy performance benchmark

Following images show the EPI values recommended by GRIHA

Table 14.3 Benchmark energy performance index (EPI) for air-conditioned buildings

Benchmark EPI for air-conditioned commercial buildings		
Climate Classification	EPI (kWh/ m2/year)	EPI (kWh/ m2/year)
	Daytime occupancy	24-hour occupancy
	5 days a week	7 days a week
Moderate	120	350
Composite/warm and humid/hot and dry	140	450

Benchmark EPI for air-conditioned residential buildings	
Composite/warm and humid/hot and dry	200

* Non-airconditioned spaces are classified into living and non living spaces. The examples of non living spaces are parking area, boiler room, mechanical room, generator room, etc.

Since this building consists of office and residential areas, the modified GRIHA energy performance benchmark will be calculated as follows:

Modified GRIHA energy performance benchmark= (A1xE1+A2xE2)/(A1+A2) where,

A1 is Air-conditioned area of office tower=1924 m², A2 is Air-conditioned area of residence tower=1363 m²

E1 is EPI for office building, E2 is EPI for residential building

i) For composite, warm & humid and hot and dry climate

*Modified GRIHA benchmark EPI=(1924x140+1363*200)/(1924+1363)=165*

ii) For moderate climate

*Modified GRIHA benchmark EPI=(1924x120+1363*200)/(1924+1363)=153*

Results

1. As shown in Table 12 the predicted energy performance of the building is less than the GRIHA energy performance benchmark.
2. The potential energy consumption reduction /savings in different climatic zones has been calculated and shown in Table 12. It is evident that in all climatic zones it is more than 40%. Therefore, all the 10 points related to energy performance under GRIHA criteria 14 can be scored.
3. Cooling demand for actual and energy efficient case for different climatic conditions is shown in Table 13 below. Cooling demand is expressed in sqft/TR and is a measure of envelope efficiency of AC buildings.

Table 13: Improvement in cooling demand (sqft/TR)

	Ahmedabad (sqft/TR)	New Delhi (sqft/TR)	Mumbai (sqft/TR)	Bangalore (sqft/TR)
Existing case	168	175	194	223
After incorporating ECBC recommended and other energy efficient features	248	273	292	295
% improvement	48%	56%	51%	32%

For non-air-conditioned buildings

For non ac buildings following energy efficient features have been recommended:

1. Roof:
    a. Cool roof: Roofs with slopes less than 20 degrees should have an initial solar reflectance greater than 0.7. This can be achieved by painting the roof with reflective paint with SRO > 0.7, or by applying heat resistant tiles.
    b. Over deck roof insulation
2. Wall:
    a. Application of heat reflective paint/coating on external walls
    b. Use of autoclaved aerated concrete (AAC) blocks for external walls or cavity wall construction
3. Fenestration:
    a. Glass: Use of single 6 mm glass with reflective coating, and at least 0.5 visible light transmittance (VLT) value.
    b. Appropriate sun shades
4. Mechanical cooling:
    a. Use of two stage evaporative coolers for mechanical cooling of the building (if required)

Review of CPWD documents

CPWD documents (as listed below) have been reviewed and recommendations have been made on additions/modifications required to include ECBC and GRIHA compliant features in these documents.

Following CPWD documents have been reviewed:

- CPWD Specifications (Vol.1) 2009
- CPWD Specifications (Vol.2) 2009
- CPWD General Specifications for HVAC Works 2004
- CPWD General Specifications for Electrical Works (Internal) 2005
- CPWD General Specifications for Electrical Works part IV (Sub Stations) 2007
- CPWD Delhi Schedule of Rates 2007 (Reprint 2010)
- CPWD Analysis of rates for Delhi (Vol.1) 2007 (Reprint 2010)
- CPWD Analysis of rates for Delhi (Vol.2) 2007 (Reprint 2010)

Review has been done in consultation with the concerned CPWD officials and the final recommendations have been prepared after incorporating the comments/ inputs received from the CPWD officials.

Civil Works related documents:

The Specifications for Civil Works Volume 1&2 have been reviewed and recommendations for revision have been provided. Detailed specifications of new insulation and masonry items have been developed and included in the specifications. In addition to recommendations for revision in Civil Specifications two more documents have been prepared-'Guidelines for Energy Efficient Building Design' and 'Energy Efficient Building Envelope'. The 'Guidelines for Energy Efficient Building Design' document provides guidelines for optimized building design for reducing the conventional energy demand of the buildings. The document on 'Energy Efficient Building Envelope' provides the recommended Thermal transmittance values (U-value) for wall assembly, roof assembly and glazing as per ECBC requirements. It describes the procedure to calculate the U-Value. Examples of some typical wall/roof assembly and glazing options to achieve the recommended U-values have been given. The information provided in these two documents is design related and cannot be included in the Specifications. It has been suggested by TERI that CPWD can forward these documents to all concerned CPWD departments in the form of circulars.

A list of Civil Works related items proposed for inclusion in the Delhi Schedule of Rates, has been prepared. Several manufacturers of energy efficient products were contacted to collect information on their products including cost related information. Based on the information provided by the manufacturers description of each proposed item and their corresponding rates have been provided. Detailed analysis of rates of each proposed item has also been provided.

The revised Civil Works Specifications, documents on 'Guidelines for Energy Efficient Building Design' and 'Energy Efficient Building Envelope', list of items proposed for inclusion in the Delhi Schedule of Rates with analysis of rates, have been attached as Annexure 2.

HVAC and Electrical Works Documents

The CPWD Specifications for HVAC and Electrical Works (Internal and Sub stations) have been reviewed and recommendations for inclusion of energy efficiency features have been provided. All the ECBC compliance requirements have been suitably incorporated in the HVAC and Electrical specifications, thus ensuring that use of these specifications will automatically ensure incorporation of ECBC compliant features in the buildings. Detailed information on several new energy efficient technologies has been incorporated in the specifications documents. TERI team contacted various HVAC & Electrical equipment vendors to collect technical literature on latest technologies available in the market. This literature was reviewed and suitably included in the specifications.

The revised HVAC and Electrical Specifications documents have been attached as Annexure 3.

Recommendations for revision of the CPWD Plinth Area Rates- 2007 (Reprint 2010)

The CPWD Plinth Area Rates (PAR) -2007 document is used to prepare preliminary estimates for building projects. The existing PAR document does not cover the cost of energy efficient features. Thus, the cost of energy efficient measures cannot be encompassed in the preliminary estimates and is taken as per actuals.

As part of this project modifications have been proposed in the existing PAR document to incorporate cost of energy efficiency features.

Methodology for PAR revision: Civil Works

Step 1: Extracting items that would be affected if the buildings were to be green

The project documents (detailed estimates, agreement, final bills, etc) related to civil works collected for CPWD buildings, were reviewed to extract the items that would be affected if these buildings were to be made ECBC and GRIHA compliant.

Step 2: Calculating the present cost of the items extracted in step 1

The present cost of the items that would be affected if these buildings were to be made ECBC and GRIHA compliant, was calculated using the latest Delhi Schedule of Rate published in 2012. For items whose cost is not available in DSR 2012, present market rate has been taken.

Step 3: Calculating the present cost of the items extracted in step 1, if they were to be green

The present cost of the green items, was calculated using the latest Delhi Schedule of Rate published in 2012 and present market rate.

Step 4: Calculating the increment in cost by addition of green feature

The item wise additional cost incurred by addition of energy efficiency and other green features was calculated by subtracting the cost of conventional item from the cost of green item. The total increment in the civil works cost by addition of energy efficiency and other green features is calculated by adding up all the item wise increment in cost.

Step 5: Normalizing the total project Civil Works cost

The buildings have been selected from all over India and were built in different years, thus, it was required to normalize the building costs as if they were built in Delhi in the reference year. The reference year has been taken as year 2011.

This normalization of cost was done by using cost index values of different cities in different years provided by CPWD. Wherever cost index values were not available for a specific year, estimations were made using the available data.

Table 14: Cost Index Values for Delhi

Delhi	
Date	**Cost Index**
01-01-1992	100
01-04-2003	197
01-04-2004	209
01-04-2005	223
01-04-2006	236
01-10-2007	100
01-04-2008	114
01-10-2008	119
01-04-2009	113
01-10-2009	126
01-04-2010	136
01-10-2010	139
01-04-2011	149
01-10-2011	151

Table 15: Cost Index Values for Different Cities

City	As on	Cost Index
Ahmedabad	Apr-08	109
Gandhinagar	Apr-08	112
Jammu	Jun-04	207
Pune	Apr-11	151
Lucknow	Jan-10	142
Mumbai	Apr-09	144
Vijaywada	Oct-07	119
Bikaner	Jun-11	133
Bangalore	Jul-10	138

Step 6: Calculating % increment in the cost due to green features

The total increment in the civil works cost by addition of energy efficiency and other green features, calculated by adding up all the item wise increment in cost (calculated in step 4) was divided by the normalized total project Civil Works cost (calculated in step 5), to get the percentage increment in the cost.

For each project, the percentage increment in the civil works cost due to incorporation of green features, was calculated.

Table 16 provides the percentage increment in total Civil Works cost by incorporating energy efficiency/green features for all the projects.

Table 16: Percentage increment in total Civil Works cost by incorporating energy efficiency/green features

	Building Name	Typology	Location	Climate	AC/Non AC	Year	% increment in total Civil Works cost
1	Institute of Liver & Biliary Sciences	Hospital	Delhi	Composite	AC	2004	1.2%
2	Dental College at Jamia Milia Islamia	College	Delhi	Composite	AC	2007	2.1%
3	Kendriya Vidyalaya	School	Delhi	Composite	Non AC	2008	3.9%
4	Residential Quarters	Residential	Ahmedabad	Hot & Dry	Non AC	2005	2.3%
5	Super Speciality Hospital	Hospital	Jammu	Composite	AC	2007	5.9%
6	IISER Hostel	Hostel	Pune	Moderate	Non AC	2007	5.8%
7	Census Office	Office	Gandhinagar	Hot & Dry	Non AC	2005	4.3%
8	Centre for Distance Education Bldg, Nagarjuna University	College/Office	Vijaywada	Warm & humid	Non AC	2006	7.0%
9	Residential Quarters	Residential	Bikaner	Hot & Dry	Non AC	2006	6.6%
10	NSSO Office	Office	Lucknow	Composite	Non AC	2005	5.5%
11	RTI & Hostel Bldg for CAG	Hostel/ Training Institute	Mumbai	Warm & humid	AC	2011	3.5%

Following are the green measures that were considered while calculating the incremental cost in Civil Works

Envelope measures

1. **Roof**
   - Over deck insulation with 50mm Polyurethane foam slab
   - Application of high SRI reflective paint on the roof

2. **Wall**
    - Brick work in super structure with Autoclave Aerated Concrete (AAC) blocks
    - Half brick masonry in superstructure with fly ash bricks

3. **Window**
    - Non AC buildings: 6mm glass with reflective coating
    - AC buildings: High performance double glazed unit

Paints

- Replacement with low VOC options

Sanitary fixtures

- Replacement of WC (Indian and European types) with dual flush EWC fittings
- Replacement of conventional pillar cocks with pillar Cocks with infrared sensor and foam flow technology (Only in hospital buildings)

As seen in the table above, increment in the Civil works cost due to incorporation of energy efficiency/green measures, in the 11 projects studied here is in the range of 1.2 to 7%, and an average of 4.4%.

HVAC and Electrical Works

The present PAR document does not include cost of lighting controls and air conditioning. However, as part of this project, it was suggested to include the cost of these items in the PAR.

During the energy audit of 8 CPWD buildings it was observed that in most of the buildings energy efficient lighting fixtures were used and in most spaces the lighting power density was as per the limits prescribed in Energy conservation building code-2007. However, mandatory lighting controls as per ECBC-2007 were not installed in any of the buildings.

After discussions with the concerned Electrical department officials, it was decided that the cost of lighting controls as per ECBC will be added in the existing PAR, and the per unit area cost of lighting controls will be worked out in consultation with the manufacturers.

For HVAC works, the CPWD officials suggested that cost per TR should be worked out for different types of energy efficient air conditioning systems and added to the PAR.

Based on the cost data provided by various manufacturers, cost per TR for different types of energy efficient air conditioning systems have been worked out as follows:

Table 17: Cost of different types of Energy Efficient Air Conditioning Systems

	Type of Energy Efficient Air Conditioning Systems	Cost per TR
1	BEE rated 5 star unitary air conditioner (Window /Split AC)	Rs. 35000
2	Split air conditioner with invertor technology	Rs. 45000
3	Variable refrigerant flow/volume (VRF/VRV) with centralized controls	Rs. 65000
4	Green centralized air conditioning system*	Rs. 90000

*It includes

- ECBC compliant chiller machine
- EFF1 type motors for chilled water, condenser water pumps and cooling tower, AHU fans.
- High efficiency (minimum 75%) chilled water and condenser water pump efficiency.
- Variable speed drive on chilled water pumps and AHU fans.
- Chiller plant optimizer

Based on the cost data provided by various manufacturers, cost of Building Management System Works has been worked out as follows:

Table 18: Cost of Building Management System

Type of BMS System	Cost per Input/output point
BMS system with MS conduit	Rs 10000 per Input/output point
BMS system with PVC conduit or armoured cable	Rs 8000 per Input/output point

To integrate lighting controls (as per ECBC) in the artificial lighting system, two options have been recommended. Based on the cost data provided by various manufacturers, cost per square feet for lighting controls for both options has been worked out as follows:

- **Option 1 (Localized ON/OFF) - Rs. 10/Sq. Feet**
  The lighting control option 1 shall include the following
  a. Localized control where daylight sensor helps to switch ON/OFF the connected lighting circuit
  b. Dual (Infrared & ultrasonic) occupancy sensors for major and minor motion or Passive Infrared (PIR) for major motion only.
  c. Timer control switch (chronological & astronomical programmed) for controlling the lighting system during non- operating hours.
  d. Remote control to manual override and control the specific group of lighting from a single place.

- **Option 2 (Centralized dimming) - Rs. 35/Sq. Feet**
  The lighting control option 2 shall include the following
  a. Centralized control where lighting circuits can be controlled from any place.
  b. Lighting fixtures shall be equipped with 0-10 V dimmable ballast.
  c. Dual (Infrared & ultrasonic) occupancy sensors for major and minor motion or Passive Infrared (PIR) for major motion only.
  d. Timer control switch (chronological & astronomical programmed) for controlling the lighting system during non- operating hours.
  e. Remote control to manual override and control the specific group of lighting from a single place.
  f. CAT 6 type control wiring.

General Details	Option 1- Lighting control (ECBC)	Option 2- Lighitng control (ECBC)
Price/Area	Rs. 10/Sq. feet	Rs. 35/Sq. feet
Control Type	Localized/Standalone	Centralized
Daylight Sensor	Automatic On/off	Automatic dimmed

Table 19: Comparison of options 1 and 2

Occupancy sensor	Dual Technology – Ultrasonic & Passive infrared ,ON/OFF	Dual Technology –Ultrasonic & Passive infrared, ON/OFF
Timer Switch	Chronological ON/OFF	Chronological ON/OFF
Remote Control	For recall the preset scenes	For recall and program the preset scenes
Centralized Processor	No	Yes
Fixture ballast	Non-Dimmable	Dimmable 0-10v
Wiring	Conventional	Control wiring (CAT 6)
Control Options	From dedicated switch only	From anywhere with the keypads
Dimming	No	YES
Lamp Life	Better	Best
Operating cost	Better	Best
Energy Saving	Better	Best
Commissioning & installation cost	7-10 %	10- 15%

Financial Feasibility Analysis of Energy Efficiency Features

To investigate the financial feasibility of the additional cost incurred due to addition of energy efficiency and other green building measures in a building, a financial feasibility exercise was conducted for one of the study buildings.

The study was conducted for the RTI & Hostel Building for CAG in Mumbai. Energy audit of this building was conducted as part of the project and the energy performance of the building by incorporating energy efficient features, was worked out. Based on results of the simulation exercise conducted, the annual energy consumption of the base case and the green case was calculated. The cost details of the actual building were available from the project documents and the cost of the green case has been calculated.

Following are the building information details:

Total built up area: 5011 m^2

Total cost of base case (Including civil, electrical and mechanical works): Rs. 31, 86, 38, 857

Total cost of energy efficient case (Including civil, electrical and mechanical works): Rs. 32, 77, 07,443

Annual energy consumption of base case= 10, 02, 290 kWh

Annual energy consumption of energy efficient case= 4, 38, 183 kWh

Assuming:

Nominal discount rate as 16%

Inflation rate as 4.9%

Nominal escalation rate as 7.6%

Energy rate as Rs.6/kWh

Study period: 15 Year

Financial Feasibility Analysis

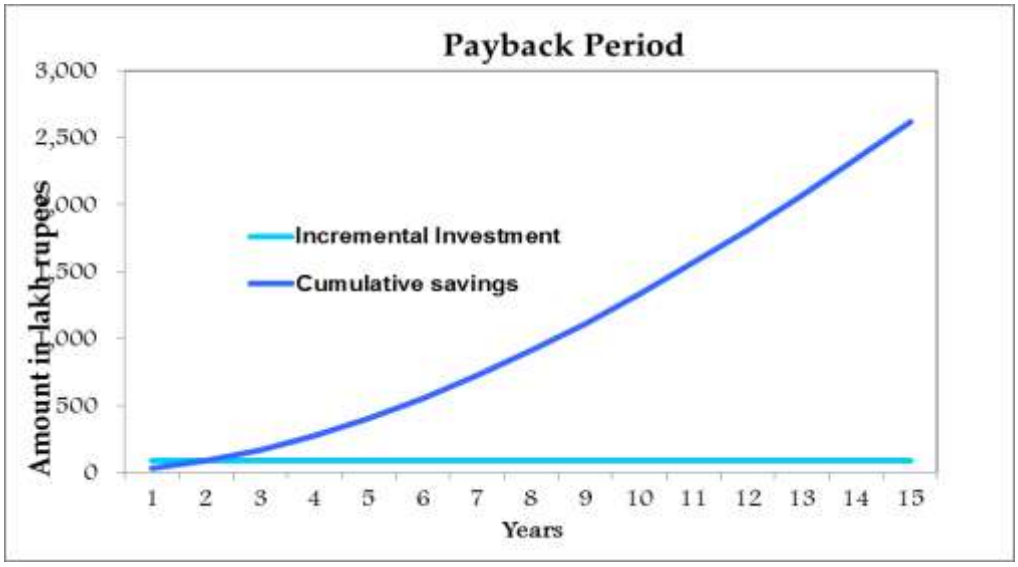


Figure 1: Payback period

As observed in the figure above, the payback period of the incremental cost is within 2 years.

This economic feasibility study shows that although there is an increment in the initial investment cost of an energy efficient building as compared to that of a conventional building, with payback period of just 2 years, cash savings accrued from energy efficient buildings not only compensate for this initial cost increment but provide benefits to the owners/occupants throughout the life time of the building.

Vendor database

To ease the process of finding manufacturers/ suppliers of energy efficient items being proposed for addition in the CPWD documents, a vendor database has been prepared that includes contact details of various manufacturers/ suppliers of energy efficient products. It has been suggested to CPWD that this vendor data base can be uploaded on the CPWD website so that it can be easily used by everybody.

The vendor data base has been attached as Annexure 4.

Design Charrettes

As part of the project, two design charrettes have been conducted for two of the upcoming CPWD projects.

The main objective of this design charette exercise was capacity building of the CPWD officials in using the CPWD documents revised/ developed as part of this project.

With the help of CPWD officials two upcoming projects were identified and the preliminary drawings were collected and studied by the TERI team. These two projects included an office building and a residential colony. The aim of these design charette exercises was to review the preliminary design of the identified CPWD project and provide recommendations for incorporating energy efficiency features with respect to Energy Conservation Building Code and provide guidance to the project team in using the revised CPWD documents.

The detailed reports of the design charrettes have been attached as Annexure 5.

Steering Committee

At the beginning of the project a steering committee comprising of representatives from TERI, CPWD, BEE and Shakti Foundation was constituted for providing necessary inputs from time to time for taking the project forward. This committee was constituted during the project kick-off meeting held between TERI, CPWD, BEE and Shakti Foundation. This Steering Committee met as and when required to review the progress of the project and provide their feedback.

The minutes of the kick off meeting and other Steering Committee meetings have been attached as Annexure 6.

Co-ordination and consultation with CPWD officials

For successful implementation of this project it was very important to have regular interaction and guidance from the concerned CPWD officials. Throughout the project duration regular interactions were held with CPWD officials to apprise them about the progress of project activities and get their support, guidance and feedback as and when required. Minutes of all the important meetings that were held with CPWD officials have been attached as Annexure 7.

3. Annexure

Annexure 1: Detailed Audit Reports of 8 buildings

Refer folder named Annexure 1 sent as separate Attachment.

Annexure 2: Revised Documents related to Civil Works

Refer folder named Annexure 2 sent as separate Attachment.

Annexure 3: Revised Documents related to HVAC and Electrical Works

Refer folder named Annexure 3 sent as separate attachment.

Annexure 4: Database of Vendors of Energy Efficient/ Green products

Refer folder named Annexure 4 sent as separate attachment.

Annexure 5: Report of Design Charettes

Refer folder named Annexure 5 sent as separate attachment.

Annexure 6: Minutes of Steering Committee Meetings

Minutes of Meeting

Steering Committee Meeting to discuss progress of the project on

'Review & revision of CPWD documents'

At TERI

On 25th August 2011

Attendees:

Steering Committee members:

Mr. S.P. Chaudhary, S.E. (TAS), CPWD (In place of Mr. MayankTilak)

Mr. S. Sengupta, S.A(IV.), CPWD

Mr. Girija Shankar, BEE

Ms. Alpana Jain, Shakti Foundation (In place of Ms. Tara Parthasarthy))

Mr. R S Prasad (coordinator/ nodal person), TERI

Ms. Mili Majumdar, TERI

Ms. Pooja Shukla, TERI (In place of Ms. Priyanka Kochhar)

Special Invitiees

Mr. R M Aggarwal, Chief Architect, NR, CPWD

Dr. Hina Zia, TERI

Mr. NitishPoonia, TERI

Mr. Deepak Tewari, TERI

At the outset Mr. R.S.Prasad welcomed all the members and briefly spoke about the background and significance of the project.

Ms. Pooja Shukla gave a presentation on the project describing its objective, methodology, activities and progress achieved till date.

Mr. Sanjib Sengupta suggested a Hospital Building at Delhi that can be studied under the project.

TERI reiterated the request to CPWD to facilitate the process of developing vendor database and obtaining costs of the new materials,products and technologies based on the specifications that shall be furnished by TERI, from potential vendors,for inclusion in the revised PAR/Schedules.

Mr. Chaudhary raised the issue of availability of test certification in respect of new(green) materials/products from recognized and credible agencies .Ms.Majumdar informed that certification facilities and validation regimen of data provided by the manufacturers of green products/technologies in many cases, are still evolving. Certification of products at present is generally provided by the manufacturers based on relevant existing national/international norms and standards.

It was finally concluded that CPWD could judge the set of green products/processes and credentials of vendors/manufacturers based on the recommendation made by TERI and take appropriate decision in the matter.

It was decided that the draft recommendations made by TERI regarding the Specifications for Civil and Electrical Works, will be forwarded to CPWD in phases for their perusal, scrutiny and concurrence, before it is included in the TERI's final recommendation to CPWD for adoption.

TERI requested CPWD to organize a meeting for TERI team where CPWD officials would explain the methodology adopted for calculating the PAR, as this will help the TERI team in recommending modifications to the PAR.

It was decided that the Steering Committee shall meet regularly, preferably every month, to discuss the progress and for ensuring timeliness of all activities involved in the project.

Minutes of Meeting

Steering Committee Meeting to discuss progress of the project on

'Review & revision of CPWD documents'

At TERI

On 21st February 2012

Attendees:

Steering Committee members:

Mr. S.P. Chaudhary, S.E. (TAS), CPWD

Mr. S. Sengupta, S.A(IV.), CPWD

Mr. Girija Shankar, BEE

Ms. Alpana Jain, Shakti Foundation

Ms. Mili Majumdar, TERI

Ms. Pooja Shukla, TERI

Special Invitiees

Mr. Mukesh Vij, Chief Engineer (E), CPWD

Mr. R M Aggarwal, Chief Architect (E), CPWD

Mr. Khandelwal, S.E (E), CPWD

Ms. Smita Chandiwala, Shakti Foundation

Mr. Tarun Garg, TERI

TERI gave a presentation on the project describing its objective, methodology, and progress achieved till date.

The draft of the revised Specifications for Civil Works has been shared with Mr. Chaudhary, S.E. (TAS) for his comments. A document with a set of guidelines for Energy Efficient Building design has also been prepared by TERI and has been shared with Mr. Chaudhary for review.

The draft of the revised Specifications for HVAC and Electrical Works has been shared with CPWD Electrical Department for review. Mr. Vij mentioned that concerned CPWD officials will review the revised documents and get back to TERI with their comments.

The methodology for inclusion of cost of HVAC Works in the PAR will be worked out by TERI and CPWD officials (Electrical Department). A meeting will be held in the second week of March (tentatively) between TERI and CPWD for discussing this. These Plinth Area Rates will be developed only for energy efficient HVAC systems.

It was suggested that in the revised PAR document cost of green features should not be an additional cost that can be added to the estimated project cost (without green features),

instead cost of each item in the PAR should be revised to incorporate green features cost. Mr. Chaudhary informed that to do this kind of revision in the PAR, an extensive database of information on existing green building projects is required and presently this kind of detailed information on green buildings is not available with CPWD. TERI and CPWD will have further discussions to finalize the modifications in the PAR.

TERI informed that as part of this project activity, two design workshops will be conducted for two selected building projects for capacity building of CPWD officials in effective utilization of the revised documents. Two upcoming CPWD projects (Medium size: Approximately 5000-10,000 m^2 built up area) have to be identified for conducting this exercise. Mr. Aggarwal said he will help in the identification of suitable projects.

Annexure 7: Minutes of Meetings with CPWD Officials

Minutes of meeting held

on 26th May 2011

between TERI, CPWD, BEE & Shakti Foundation,

at Nirman Bhawan

A meeting was held by TERI with DG-CPWD, Shri C.S. Prasad in Chair. The following were present.

1. Shri Ajay Mathur DG, BEE
2. Shri P.K Gupta ADG (TD),CPWD
3. Shri D.K.Gupta ADG (Arch.), CPWD
4. Shri V.K.Motwani CE, CSQ, CPWD
5. Shri Mukesh Vij CE(E), CPWD
6. Shri R.M. Aggarawal CA (NR), CPWD
7. Shri R.K. Kakkar CA (NDR), CPWD
8. Shri Sanjay Seth Energy Economist, BEE
9. Shri Mayank Tilak SE(TAS) ,CPWD
10. Shri Manohar Lal SE(TRG),CPWD
11. Ms Natasha Bhan Shakti Foundation
12. Ms Mili Majumdar Director (Sustainable Habitats), TERI
13. Shri R.S.Prasad Consultant, TERI
14. Ms Priyanka Kochhar TERI

TERI has undertaken a project for modification of CPWD's PAR/Schedules/ Specifications for incorporating green features to ensure ECBC and GRIHA compliance. This project is supported by the Shakti Foundation.

Considering that CPWD shall make all future buildings GRIHA compliant (minimum 3-Star rating); and compliance with ECBC is embedded in GRIHA, the following activities shall be undertaken by TERI:

- Revision of CPWD Plinth Area Rates to facilitate integration of ECBC and GRIHA
- Review of other CPWD documents in light of NBC, ECBC and GRIHA compliance. (Based on this report, CPWD shall modify these documents, i.e. schedules & specifications)
- Preparation of a vendor database of ECBC and GRIHA compliant products

At the outset DGW, CPWD and Ms.Majumdar underlined the pressing need for undertaking this initiative to facilitate mainstreaming of ECBC and GRIHA in CPWD, and the Construction Industry at large. DG, BEE spoke about the crucial role BEE is playing in nation wide energy conservation and energy -efficiency programs and offered unstinted help to CPWD in implementing ECBC mandate.

In this meeting, the following issues relating to the initiative were discussed:

- Methodology and activities planned for undertaking the work of modification of CPWD's PAR/Schedules/ Specifications for incorporating green features to ensure ECBC and GRIHA compliance.
- Formation of a Committee of CPWD , BEE , TERI& Shakti Foundation representatives.(This committee shall be supported by internal teams within the partner organizations)
- Timelines and specific deliverables
- Selection of buildings that may be taken up for the study

The Committee, for steering the project, was constituted during the meeting itself, comprising of representation from CPWD, BEE, Shakti Foundation and TERI. This Committee could co-opt anyone, from time to time for seeking necessary inputs required for taking the project forward.

The following members shall comprise the Committee:

- Mr. V K Mittal, S.E. (S/S), El., CPWD
- Mr. Mayank Tilak, S.E. (TAS), CPWD
- Mr. S. Sengupta, S.A(IV.), CPWD
- Mr. Girija Shankar, BEE
- Ms. Tara Parthasarathy, Shakti Foundation
- Mr. R S Prasad (coordinator/ nodal person), TERI
- Ms. Mili Majumdar, TERI
- Ms. Priyanka Kochhar, TERI

It was agreed that:

1. Projects in the composite climate zone (which is the dominant climate zone of India) shall be identified.
2. Review (on design, specification, and energy parameters) of ten building projects shall be conducted; i.e. two projects per typology (Residential, Offices, Hospitals, Colleges/Schools, and Hostels).
3. The prelim audit (on thermal and visual comfort) shall be conducted for five buildings; i.e. one building per each typology.

It was decided that identification of buildings to be done immediately. Some of the buildings suggested in the meeting were:

- Staff Quarters, Semapuri
- New Gils' Hostel, IIT Delhi
- Dental College, Jamia Milia Islamia
- Central School, Dwarka
- Bunglow: 7 Motilal Nehru Marg
- CAG building

The Committee shall meet and decide about all the buildings to form part of the study.

The meeting ended with a vote of thanks to the chair.

Minutes of meeting between TERI & CPWD

on 14-09-2011

at Nirman Bhawan

Attendees:

Mr. S.P. Choudhary, S.E. (TAS), CPWD

Mr. R S Prasad (coordinator/ nodal person), TERI

Mr. Pradeep Kumar, TERI

Mr. Deepak Tewari, TERI

Mr. Tarun Garg, TERI

Ms. Pooja Shukla, TERI

A meeting was held with Mr S.P.Choudhary,S.E. (TAS) to brief TERI professionals engaged on the project about the various stages involved in undertaking and executing projects by CPWD and, also about the methodology and process through which the PAR is derived.

Minutes

- Mr. Choudhary explained the various steps involved in implementation of building projects/works undertaken by CPWD.

Listed below are the steps:

- CPWD receives requisition from client organizations and departments for their planned project.
- A checklist is forwarded by CPWD to client to get basic information/particulars regarding the proposed building/projects
- Based on the information received from the client, preliminary/concepts drawings are prepared by the architectural wing of the concerned CPWD unit.
- Approval of preliminary drawings is then obtained from the client.
- After receiving client's approval, drawings are forwarded to all concerned departments of CPWD for preparation of preliminary estimate of components from various disciplines i.e. civil, electrical, horticulture etc based on PAR market rates. The Preliminary estimate is then compiled by the competent authority in CPWD.
- The preliminary estimate is then, forwarded to client for their approval. The client conveys the administrative approval and expenditure sanction (A/A&E/S) to the project.
- After receipt of the sanction detailed drawings are prepared by the architectural wing, and structural drawings by the concerned planning unit.

  Based on the detailed drawings , detailed estimates (DE) for civil, electrical and all other works are prepared using Delhi Schedule of Rates (DSR). Non- schedules items are listed separately and their rates are taken as per the market rates. Technical sanction (TS) is

then issued by the competent authorities in CPWD for the component/package of works of the sanctioned project . TS include detailed financial estimate and specifications.

- On the basis of above technical sanctions NITs (Notice inviting tenders) are prepared and tenders are called from various eligible/prequalified contractors. Primarily there are two types of tenders:
    a. Item rate tender: contractor quotes rates of individual items
    b. Percentage rate tender: DSR rates for all items are mentioned by CPWD and contractor quotes above or below that rate (in percentage)

Item rate tender is used more often.

- Tender is accepted by competent authority in CPWD and work awarded to the Contractor. An agreement is signed between CPWD and Contractor.
- A work completion certificate is issued after completion of work.

Other discussion points:

- The items/ materials and systems to be used in the building construction is decided by the architect and technical sanctioning authorities.
- Criteria related to site suitability (as per GRIHA) should be incorporated at appropriate place
- Methodology to be adopted towards revising the PAR, was discussed. This exercise will require extensive interaction between the TERI team and CPWD officials. It was decided that to begin the data analysis, TERI team will first undertake following activities:
    - Identify items that need to be added / modified and categorize them under subheads like Civil (Including earthwork, water conservation, efficient materials, etc.), Electrical (Internal electrical, HVAC, etc.), Plumbing, lighting (inside, campus, controls, etc.).
    - Identify parameters
    - From the data received for selected projects, work out total project cost (basic cost of building per square meter) and extract item wise cost data. This data should be extracted from the final bills preferably but in case that is not available, cost can be taken from the schedule of work specified in the agreement. For items and systems not covered in projects and CPWD documents as of now, the rates from relevant vendors is required to be collected.
- Additions/ modifications to the PAR (for green items, features and systems) can be made by modifying the existing rates or adding extra items. These rates can be in the form of Rs./ m2 of built up area or percentage of basic project cost. All these issues will be finalized later after discussions with CPWD.
- It is proposed that the cost of HVAC systems should be included in the PAR among other things. At present it is not there.
- A sample draft recommendations made by TERI team after reviewing the CPWD Specifications Volume 1& 2 were given to Mr. Choudhary for review and comments.

Minutes of meeting between TERI & CPWD Electrical Department

on 16-11-2011

at Vidyut Bhawan

Attendees:

Mr. MukeshVij, Chief Engineer (E), CPWD

Mr. S.K.Chawla, S.E (E), CPWD

Mr. R S Prasad (coordinator/ nodal person), TERI

Mr. Pradeep Kumar, TERI

Mr. Deepak Tewari, TERI

Mr. TarunGarg, TERI

Mr. Nitish Poonia, TERI

Ms. Pooja Shukla, TERI

The purpose of this meeting was to have a discussion between TERI and CPWD officials on revision of CPWD 'General Specifications for Electrical Works-2005' and 'General Specifications for HVAC Works-2004' documents.

Minutes

- After a brief overview of the project, discussion was held over preliminary modifications/ additions thought of, by TERI after first stage review of HVAC & Electrical specification documents. All suggested recommendations were discussed one by one.
- CPWD officials stated that the HVAC and Electrical Specification documents need to be comprehensively updated to incorporate latest products, systems and technologies that are well established in the market.
- It was mentioned that Plinth Area Rates should include cost of HVAC systems, sub stations and DG sets also.
- CPWD officials informed that soft copy of the specification documents is available with them and TERI can use them for review & revision exercises.
- Renewable energy requirement as per GRIHA should be included in chapter 2 (of Electrical Specification) as a separate section 2.15. However, for detailed specifications of renewable energy technologies, a separate document needs to be prepared.
- Chapter 12 (of Electrical Specification)on energy conservation should be restructured in a detailed manner into subheads- lighting and controls, efficient motors, metering (location of meters), etc.

- All mandatory compliances of ECBC and GRIHA should be worded such that they are mandatorily followed.
- For transformers, ECBC compliance requirement should be added in the concerned chapter of Electrical Specification document.
- Specifications for efficient pumps and motors should be added in both Electrical and HVAC specification documents.
- ECBC recommendation regarding cable losses should be included in the Electrical specification document.
- Different options for HVAC design should be explained in the HVAC specification document.
- Compliance requirements related to CFC & HCFC free insulation and low VOC paints for ducting should be included in the HVAC specification document.
- New technologies like chilled beams, use of geothermal energy for pre-cooling of fresh air, etc. should be included in the HVAC specification document.
- A new chapter on low side/ air side design should be included in the HVAC specification document.
- Chapter 18 (of HVAC specification) on building management systems should be elaborated further to include BEMS/ IBMS.
- CPWD will provide assistance to TERI for costing of new items to be added in the Specification and Schedule of Rate documents.
- TERI team will compile their detailed recommendations for modification in 'General Specifications for Electrical Works' and 'General Specifications for HVAC Works' and share the same with CPWD officials by mid December for their feedback.

Minutes of meeting between TERI & CPWD

on 21-12-2011

at NirmanBhawan

Attendees:

Mr. S.P. Choudhary, S.E. (TAS), CPWD

Mr. R S Prasad , TERI (Present for some duration of the meeting)

Mr. Tarun Garg, TERI

Ms. Pooja Shukla, TERI

A meeting was held with Mr. S.P.Choudhary,S.E. (TAS) to brief him about the present status of the project and discuss the PAR revision methodology.

Minutes

- Ms. PoojaShukla gave a brief update on the present status of the project activities.
- Mr. Chaudhary informed that CPWD has revised the Delhi Schedule of Rates document and will be publishing the revised document soon. It was suggested that TERI could review the same and identify items that are missing from this document with respect to ECBC and GRIHA compliance. TERI's recommendations and report shall essentially cover those items.
- For efficient wall assembly, roof assembly and glazing, a list of options for each will be prepared and all these items will be added in the Schedule of Rates document. These wall assembly, roof assembly and glazing options should have U-Values same as per ECBC prescribed values or better.
- Regarding Plinth Area Rates revision methodology, it was decided that for each of the 12 projects being studied by TERI, in addition to the actual cost (taken from agreement/final bill documents), an estimated cost and cost after adding green feature may be worked out. The estimated cost could be worked out for each item by taking the rates from the CPWD schedule of rates document. Cost after adding green features will be worked out by taking the current rates. As all these projects were built in different years, the actual costs and estimated costs shall have to be normalized to the present year using cost index.
- Once the above mentioned exercise is complete for all 12 projects, a discussion will be held between TERI and CPWD to study and analyze the cost figures and to work out the PAR modification.

Minutes of meeting between TERI & CPWD

on 9-01-2012

at TERI Office

Attendees:

Mr. MukeshVij, Chief Engineer (E), CPWD

Mr. S.K.Chawla, S.E (E), CPWD

Mr. R S Prasad (coordinator/ nodal person), TERI

Mr. Pradeep Kumar, TERI

Mr. Deepak Tewari, TERI

Mr. TarunGarg, TERI

Mr. Rana Pratap Poddar, TERI

Ms. Pooja Shukla, TERI

The purpose of this meeting was to review and discuss the recommendations suggested by TERI for revising the CPWD 'General Specifications for Electrical Works- Internal & Sub-station' and 'General Specifications for HVAC Works-2004' documents.

Minutes

Detailed review of the revised document for the 'General Specifications for Electrical Works- Internal & Sub-station' was held. Following are some of the major points discussed during the meeting:

Electrical specifications

- All GRIHA criteria related to Renewable Energy should be included in full detail including mandatory as well as non mandatory points.
- Ceiling fans selection chart included in the specifications from the ECBC user guide, should be cross checked.
- Section on lighting and controls will be detailed out further after meeting with relevant manufacturers.
- Complete Table (from NBC 2005) specifying illuminance values for different spaces should be included.
- Modifications related to separate rising mains for lighting, equipments, AHUs and cooling plant, suggested by TERI needs to be further discussed before addition in the specification.
- Include section on night light pollution and light trespassing.
- Existing cable selection chart to be revised as per the ECBC recommendations.
- Other modifications to be made as highlighted in the document during discussion.

HVAC specifications

- Instead of specifying refrigerant type, only CFC/HCFC refrigerants shall be mentioned everywhere in the specification and a list of these refrigerants will be provided as Annexure.
- Complete table on Air Change Values from SP-41 document, shall be added.
- New technologies like radiant slab cooling, chilled beams, VAM, CHP, VAV boxes, heat machines should be added in relevant chapters. Generic information on these technologies to be added along with technical details on installation, etc.
- Other modifications to be made as highlighted in the document during discussion.

Further action

- TERI officials will collect technical literature on latest technologies available in the market from various HVAC & Electrical equipment vendors in forthcoming weeks. This literature will be reviewed and suitable included in the specifications.
- TERI officials will send the
  - Revised electrical specifications documents to CPWD officials on 17th February 2012.
  - Revised HVAC specifications document to CPWD officials on 30th January 2012.
  - CPWD team will review these documents and provide their feedback.

Minutes of meeting between TERI & CPWD

on 04-04-2012

at Vidyut Bhawan

Attendees:

Mr. S.K.Chawla, S.E (E), CPWD

Mr. R S Prasad (coordinator/ nodal person), TERI

Mr. Pradeep Kumar, TERI

Mr. Tarun Garg, TERI

Ms. Pooja Shukla, TERI

The main purpose of this meeting was to have a discussion on the methodology for revising the Plinth Area Rates (PAR) document with respect to HVAC and Electrical Works.

Minutes

- The recommendations suggested by TERI for revision in HVAC works and Electrical Works Specifications documents have been sent to the concerned CPWD specifications review committee and response is awaited.
- The present PAR document does not include cost of lighting controls and air conditioning.
- Specification of lighting controls required as per ECBC will be developed and quotations for cost of the same will be obtained from manufacturers (preferably 3). Per unit area cost of lighting controls will be added in the PAR document in Annexure 1 Section 3 (Services).
- For HVAC work cost per TR will be worked out for different types of air conditioning systems:
    - Central
    - Distributed
        - VRF
        - Split AC with inverter
        - Window units
- Cost of HVAC controls- Energy management controls with plant optimizer will also be worked out on per TR basis.
- Quotations for cost of HVAC equipments + installation and HVAC controls will be obtained from manufacturers (preferably 3).
- Per TR cost of HVAC equipments + installation and HVAC controls will be added in the PAR document in Annexure 1 as a separate section.
- TERI will review the model NIT (Notice inviting tender) in the HVAC works specifications document and provide recommendations for revision wherever required.

Centre for Research on Sustainable Building Science (CRSBS) facilitates development and mainstreaming of sustainable buildings, improvement of performance levels of existing buildings, and raise awareness on sustainable buildings. It has contributed to development of all key codes and standards that regulate and are referred to, in design and development of green buildings and habitats in the country (e.g. Energy Conservation Building Code of India and National Building Code of India 2005). In addition, it has contributed to and reviewed the National Mission on Sustainable Habitats (one of the 8 missions under the National Action Plan on Climate Change for India) and is also part of the core committee to work on specific components that are being developed under the Mission.

Another major achievement of CRSBS, TERI has been the drafting of an indigenous green building rating system for India that has been suitably adapted and adopted by the Ministry of New and Renewable Energy, Government of India as national green building rating system for India.

CRSBS has been offering environmental design solutions for habitat and buildings of various complexities and functions for nearly two decades. Services offered include Environmental design consultancy, facilitation of GRIHA (Green Rating for Integrated Habitat Assessment)-the national rating system endorsed by the Ministry of New and Renewable Energy, energy audits and development of energy management programs, awareness generation and capacity building, enabling policy, formulation of norms, and standards .

The Energy and Resources Institute
www. teriin.org