



Solar Power and Energy Efficiency in Government Buildings

CENTRAL PUBLIC WORKS DEPARTMENT
Ministry of Housing and Urban Affairs





Solar Power And Energy Efficiency In Government Buildings

Central Public Works Department

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Director General



सत्यमेव जयते

भारत सरकार
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केन्द्रीय लोक निर्माण विभाग

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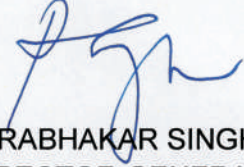
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FOREWORD

CPWD being the Principal Technical Advisor to Government of India has been the frontrunner in formulating and implementing the Government Policies in the field of Construction Sector. Keeping this tradition alive Department started installing solar rooftops on Govt. Buildings under its Maintenance in RESCO Mode and instilling Energy Efficiency by retrofitting LED Lighting System and Star Labelled Fans and Air Conditioners in ESCO Mode since 2015. This work was carried out in all the existing GPOA Buildings throughout the country by adopting the RESCO and ESCO Models for solar rooftops and Energy Efficiency Measures. The Power Purchase Agreements with the RESCO firms were signed for purchasing the solar power generated at a tariff fixed for a period of 25 Years. Similarly Performance Contracts were signed with the ESCO firms for installing energy efficient lighting, fans and air conditioners. This not only allowed these measures to be carried out without capital expenditure but also accrued the benefits of reduction in electricity bills. Some of the works are planned to be carried out in Capex Mode. Thus, CPWD played a lead role in implementing Govt. Policies and earned accolades from Ministry of New and Renewable Energy as well as Ministry of Power. The present book gives an account of CPWD's efforts in implementing these policy initiatives of Government of India. I acknowledge the hard work done by Sh. C.K.Varma CE CSQ (E) and his team under the leadership of Dr. K.M.Soni, ADG(TD) for bringing this document.

Place: New Delhi
Date: March 2019


(PRABHAKAR SINGH)
DIRECTOR GENERAL



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PREFACE

CPWD implemented two important policies of Government of India since 2015 as per the mandate derived through National Action Plan on Climate change. These were installation of Solar Rooftops on the vacant rooftops of Government Buildings and energy efficiency measures in such buildings to reduce carbon footprints of these buildings during their entire Life Cycle. This was significant in view of growing concern about climate change internationally and country's lead role in reducing the GHG emissions. The policy of the government though very comprehensive, the implementation was challenging and exciting. These challenges and their solutions along with the account of these works in central Government buildings have been documented in the present book with the sole aim to present glimpses of the difficulties, learning and way forward. I hope this document will provide readymade account of what initiatives were taken by CPWD in the field of green power generation and reduction in energy use within its resources and will reflect the will to do the difficult tasks reasonable well. My acknowledgements are due to Sh. C.K.Varma CE CSQ (E) and his team of officers in documenting CPWD's foray into reducing carbon footprints in the building sector considerably.

Place: New Delhi
Date: March 2019

(Dr.K.M.Soni)
Addl. Director General (TD)

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OBJECTIVES OF SOLAR POWER & ENERGY EFFICIENCY

“National Action Plan on climate change” at the apex level released on June 2008 was the key driver to push many missions undertaken by the country to reduce the stress on climate change while carrying out its rapid development and fast economic growth. The main thrust of this action plan is to attain sustainable growth without affecting the climate change. The focus of the plan is on promoting the understanding of climate change, energy efficiency and resource conservation. In order to respond to the challenges of climate change effectively an Advisory council on climate change has been created chaired by Prime Minister of India having broad based representations from key stake holders including from government, industry and civil society.

National Solar Mission & National Mission on Sustainable Habitat are two important missions out of the eight core missions emanating from “National Action Plan on climate change” and have multi-pronged, long term and integrated strategies for achieving the defined goals in the context of climate change.

The prime objective of the **National Solar Mission** is to significantly increase the share of solar energy in the national energy scenario to reduce the dependence on conventional sources of power generation without compromising the power needs of the country while that of **National Mission on Sustainable Habitat** is to make habitat sustainable through improvements in energy efficiency in buildings.

Goals of Solar Mission:

Main goals of the solar mission are reduction in transmission losses and more importantly reduction in green house gas emissions affecting the climate. Another goal of the solar mission is to launch a major R&D program along with international cooperation. Promoting Innovations and making it more affordable for everyone are also associated with the mission.

Goals of National Mission of Sustainable Habitat (NMSH)

Prime Goal of National Mission on Sustainable Habitat is to promote energy efficiency as an integral component of urban planning and urban renewal. The Energy Conservation Building Code which addresses the design of large and commercial buildings to optimize their energy demand will be extended in its application and incentives provided for retooling existing building block.

Further, Capacity building will be an important component of both the Missions, while

Mission for Enhanced Energy Efficiency will provide a legal mandate through Energy Conservation Act 2001 for implementation of Energy Conservation measures via Institutional Mechanisms of Bureau of Energy Efficiency in the central Government and designated agencies in each State.

National solar mission was launched by Government of India in January 2010 with a scaled up target of 100GW capacity by 2022 in the year 2015 to promote solar power as a substitute of conventional coal based power. Out of this 40% of the target is to be met by Solar Rooftop Plants. The solar power which is a green power and available free of cost as India has vast potential of solar energy being a tropical country. Most of the part of the country receives 4-7 kWh per sqm/day of solar energy. Solar power, abundantly available in the country, can add to the energy while negating the climate changes.

National LED programme to facilitate rapid adoption of LED based home and street lighting across the country was launched by Hon'ble Prime Minister on 5th January 2015. Since Government buildings are a major source of energy consumption, usage of LED based lightings and energy efficient equipments in Government buildings will lead to economy in expenditure and savings in the long run through reduction in energy consumed. The programme along with Building Energy Efficiency Programme (BEEP) is under implementation by Energy Efficiency Services Limited (EESL) a Joint Venture company of four power sector Central PSUs. EESL works on Energy Services Company (ESCO) model wherein upfront investment is done by EESL and the investment is recouped on annuity basis with performance based guaranteed energy saving during the project period. Keeping in view of economy in expenditure and savings that will entail, all Ministries/Departments were directed to convert the existing lightings/equipments into LED based lightings and energy efficient equipments on priority utilizing the services of CPWD/EESL vide circular F.No. 25(24)/E.Coord/2017 dated 04.08.2017 issued by Ministry of Finance, Department of Expenditure. Pursuant to the above, Central Government has taken a decision for mandatory installation of LED based lighting and energy efficient equipment (Fans & ACs) in all Government buildings.

PROLOGUE

To achieve the objectives of National Solar Mission, CPWD under directions from Ministry of Housing & Urban Affairs (MoHUA) Government of India, utilized vacant spaces on rooftops of all government buildings under its control and maintenance by installing solar rooftops and harnessing solar energy instead of depending entirely on electricity from Discoms. Further CPWD took up this task in such a way that no capital expenditure is incurred on installation of solar rooftop plants generally being capital intensive. This was a formidable task hence RESCO (Renewable Energy Service Company) model was selected as a business model for execution in which no upfront expenditure is made by the roof owner and return on capital expenditure by a third party is made by monthly payment of the green power generated by the roof top solar plant at an agreed rate for a period of 25 years through a power purchase agreement.

Similarly the objectives of the National Mission on Sustainable Habitat were achieved by undertaking the energy efficiency measures in various buildings under maintenance of CPWD through ESCO Mode without any upfront Capital Expenditure and returning the ROI of the Agency making the initial Capital Investment through monthly installments out of the savings on account of efficiency improvements in monthly electricity bills.

IMPLEMENTATION OF SOLAR ROOFTOP

Though CPWD provided solar rooftops on building rooftops but on selective basis i.e. after getting Administrative Approval & Expenditure Sanction from the concerned authorities. However, due to drive initiated during 2015 this work was taken up on a national level in existing central government buildings. Also it was taken up in RESCO mode i.e. without any upfront capital investment and paying the private investor in installments through guaranteed generation of green energy at a predetermined levelized tariff obtained through competitive bidding quite lower than the tariff charged by DISCOMs and that too frozen for a period of 25 years.

This drive brought besides capacity building & experience, laurels to CPWD. The efforts of CPWD were appreciated and acknowledged by MNRE by selecting CPWD and the then Ministry of Urban Development jointly for the award in the category of Government Buildings which was received by the then Secretary Mood Sh. Rajiv Gauba and DG, CPWD on 07.06.2016 from Hon'ble MOS(I/C) MNRE Shri Piyush Goel at Vigyan Bhavan, New Delhi.

Every Work has essentially many Milestones which are intermittent points of importance from the viewpoint of achievements and experience. In this drive also, many milestones were crossed. A glimpse into these, in order of their occurrence brings out the difficulties and how these were overcome.

1. Identification of Rooftops and assessing the Total capacity :-

The first way forward in this drive was identification of Government Buildings and the capacity assessment of Roof Top Solar (RTS) Plants on the available vacant area on the rooftop. Collection of data from various field units spread all across the country was an uphill task. However, with multiple efforts, the data collection was accomplished. Next job was to organize and structure this huge data in usable shape. Ultimately the task was finished with the repeat exercise being carried out in some of the cases.

Since the time was short and deliverance was more, hence identification and association of a right partner was very essential. Accordingly Solar Energy Corporation of India (SECI), a public sector company under administrative control of MNRE was identified as implementing agency.

2. Signing of MoU between CPWD and SECI



Figure 1 Signing of MoU between CPWD and SECI on 06.1.2015

An MoU with SECI was therefore signed on 06-01-2015 by DG, CPWD and CMD SECI in the presence of Hon'ble Minister of Urban Development, Hon'ble Minister of State of Urban Development and Hon'ble State Minister of Power (Independent Charge).

The Areas of Cooperation of MoU was:

“Both parties shall co-operate in various endeavors of solar sector for mutual development of rooftop Grid tied projects on its own or through its identified developers in RESCO mode”.

Despite signing of the MoU, the requisite results were not forthcoming because the number, capacity allocation of SECI vendors in RESCO Mode as well as time allowed to vendors was very less in its available awarded tender. In addition, the PPA (Power Purchase Agreement) was not standardized. The PPA submitted by the vendors was also not balanced and needed both sided approach. Security issues were also involved in some of the Government buildings for allowing access to a private company on the rooftops. All these problems were resolved by a series of meetings with SECI officials, SECI Vendors, different CPWD field formations and CPWD Directorate officers.

3. First phase of Implementation:- Considering constraints, the First phase of implementation was narrowed down to the buildings located in Delhi only. Only seven Government buildings were provided with solar rooftops as shown in Table 1:

Table 1: Building details of 1st phase of solar rooftop installation

S.No.	Name of Building	City	Capacity of Solar Rooftop in MWp
1	Nirman Bhawan	New Delhi	0.2 MWp
2	East Block, R.K. Puram	New Delhi	0.25 MWp
3	Sewa Bhawan	New Delhi	0.1 MWp
4	Shastri Bhawan	New Delhi	0.25 MWp
5	Pushpa Bhawan	New Delhi	0.5 MWp
6	CGO Complex	New Delhi	0.15 MWp
7	Transport Bhawan	New Delhi	0.07 MWp
		Total	1.52 MWp



**Sewa Bhawan
New Delhi**



**Pushpa Bhawan
New Delhi**



**East Block
New Delhi**



**Pushpa Bhawan
New Delhi**

Thus a humble beginning was made after these RTS Plants were installed. However, their commissioning was delayed due to the issue of Net Metering and imbalances in the supply grid by injection of electrical power of small and varying magnitude during the day, raised by NDMC which was subsequently resolved.

4. Second Phase of Implementation: - The difficulties in implementation during first phase provided enormous learning experiences in implementing Solar Rooftops via RESCO route in the second phase. The reasons were identified, analyzed and solutions devised for implementation during second phase. Some of the reasons identified were:

1. Not many RESCO Vendors were available.
2. The Vendors were available only in a few states while Govt. buildings were in all States.
3. The PPA was not standardized.
4. The Vendors available were having their own priority areas, hence gave less attention to Government buildings.
5. Vendors were having many apprehensions in working with Government sector.
6. Some of the conditions of earlier tender of SECI were required to be modified as per site requirements.

Accordingly a meeting was conducted in the Ministry of New and Renewable Energy between SECI and CPWD for addition of solar rooftop Plants in Government Buildings expeditiously .In that meeting, it was decided to call an exclusive tender for CPWD by SECI in RESCO mode with PPA as part of NIT. Further it was decided that CPWD would examine the NIT of SECI from the angle of ease of implementation and also participate in the Pre bid /technical bid meeting with prospective bidders.

Finally an exclusive tender for CPWD maintained buildings for 42.5 MWp capacity to 14 bidders in 16 nos. of states was finalized in the last week of December 2015. By virtue of this, in the second phase, work could be carried out in 33 buildings as shown in Table 2.

Table-2: Building details of 2nd phase of solar rooftop installation

S.No.	Name of Building	City	Capacity of Solar Rooftop in MWp
1.	CGO Building at Plot 2 Sector 10, Navi Mumbai	Mumbai	0.07
2.	Kendriya Sadan at Plot No.38 Sec.10	Mumbai	0.037
3.	Krishi Bhawan	Delhi	0.2

4.	Vigyan Bhawan & Vigyan Bhawan Annexe	Delhi	0.16
5.	Kendriya Sadan	Lucknow	0.035
6.	Kedriya Sadan , Koramangla	Bangalore	0.1
7.	GPO	Agra	0.05
8.	Lok Nayak Bhawan	Delhi	0.09
9.	DF Block, CGO Complex	Kolkata	0.25
10.	Nizam Palace, 1st & 2nd MSO Bldg.	Kolkata	0.065
11.	I.P Bhawan	Delhi	0.2
12.	Sardar Patel Bhawan	Delhi	0.06
13.	Shram Shakti Bhawan	Delhi	0.125
14.	GPOA, Rajaji Bhawan	Chennai	0.252
15.	Shastri Bhawan/ Shastri Bhawan Annexe	Chennai	0.05
16.	Vidyut Bhawan	Delhi	0.06
17.	CGO Complex	Nagpur	0.195
18.	NS Building	Nagpur	0.16
19.	Pratishtha Bhawan Marine Lines	Mumbai	0.06
20.	Kendriya Sadan	Hyderabad	0.1
21.	Old CGO Complex NH-IV	Faridabad	0.125
22.	New CGO Complex NH-IV	Faridabad	0.125
23.	CPWD Nirman Bhawan	Bhubaneswar	0.03
24.	Udyog Bhawan	Delhi	0.2
25.	GPO Building	Ghaziabad	0.113
26.	CGO Building	Ghaziabad	0.126
27.	1, Council House Street	Kolkata	0.110
28.	GISO at 3 Church Lane	Kolkata	0.08
29.	CPWD Building	Jammu	0.04
30.	Kendriya Sadan	Chandigarh	0.078
31.	Govt of India Press Old and New Santragachi Howrah	Kolkata	0.12

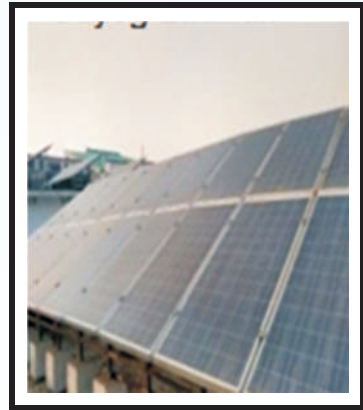
32.	GOI, Temple Street	Kolkata	0.05
33.	Govt. of India Press	Faridabad	0.2
	TOTAL		3.72
Grand Total = Total of Table 1 + Table 2 = 5.3			



**Krishi Bhawan
New Delhi**



**Vigyan Bhawan
New Delhi**



**Udyog Bhawan
New Delhi**



**I.P. Bhawan
New Delhi**



**Sharm Shakti Bhawan
New Delhi**



**Lok Nayak Bhawan
New Delhi**

With this CPWD completed the target of 5 MWp in existing buildings constructed and maintained by CPWD as per the commitment given by the then Secretary UD to the Cabinet Secretary. CPWD thus demonstrated its will & capacity to abide by the Government's Plan Implementations and supplemented the energy security of the country substantially.

5. Additional Work: - To harness further solar power, CPWD carried out the installation of RTS Plants in other Government office buildings maintained by CPWD i.e. in non GPOA buildings. The work has been carried out in 58 non-GPOA buildings to produce 8.2 MWp generation.

SOLAR POWER ON ROOFTOP OF CENTRAL GOVERNMENT RESIDENCES

After successful implementation of Solar Rooftop Projects in GPOA and Non-GPOA buildings, CPWD started looking towards General Pool Residential Accommodation (GPRA) colonies because this was one more area where ample roof space was available but with some constraints. GPRA colonies have various types of Quarters ranging from type I to type VII to VVIP's bungalows. Higher type of accommodation has higher potential of solar power generation because of large rooftop area available but with the constraint that there is only a single beneficiary who may not like to pay more license fee on account of provision of solar rooftop. Further, maintenance, change of incumbency, Security of the Solar Rooftop Plants were the other issues involved.

Meanwhile Hon'ble Minister of State of HUA(I/C) expressed the need to provide rooftop solar power in government residences also. A committee was therefore formed by DG CPWD to look into feasibility and various other associated aspects. The committee decided to implement pilot project in few identified Government colonies at Delhi to examine the feasibility before implementing in all colonies.

The points considered while planning solar power in the residential colonies included;

1. Assessment of Vacant Rooftop for solar Installation
2. Assessment of solar potential and limitations if any.
3. Assessment of the options for going solar
4. Type of Quarters and Number of Storeys A
5. Maintenance and Security of Solar Rooftop
6. Net metering

Based on the recommendation of the Committee, the policy guidelines to provide solar power on rooftop of GPRA buildings were issued vide OM no. 01/ECC/RESCO/2018/483 dated 19.11.2018 which is reiterated here for the sake of ready reference:

OFFICE MEMORANDUM

Sub: Installation of Solar Panel in Govt. Buildings and Residences.

With reference to above, following directions are being issued for compliance of all concerned:

The Grid interactive Solar PV Rooftop plants shall be provided in all Government Buildings and Residences as per the feasibility to provide Green Power and also save natural resources.

This issues with the approval of DG, CPWD.

Sd/-

C.K. Varma)

Chief Engineer CSQ (E)

A FEW IMPORTANT SOLAR PROJECTS AND SOLAR TREES EXECUTED BY CPWD



Bird's Eye view of Solar Panels on Indira Prayavaran Bhawan, New Delhi – Capacity 930 KWp.



**Extension Building to Parliament House Annexe, New Delhi Solar Power - 40KW Peak,
saving energy of app. 54,000 units per annum**



**1400KWp capacity Solar Panels installed at Additional Office complex
for supreme court, New Delhi**



75 KWp at Western Court Annexe Building at Janpath, New Delhi



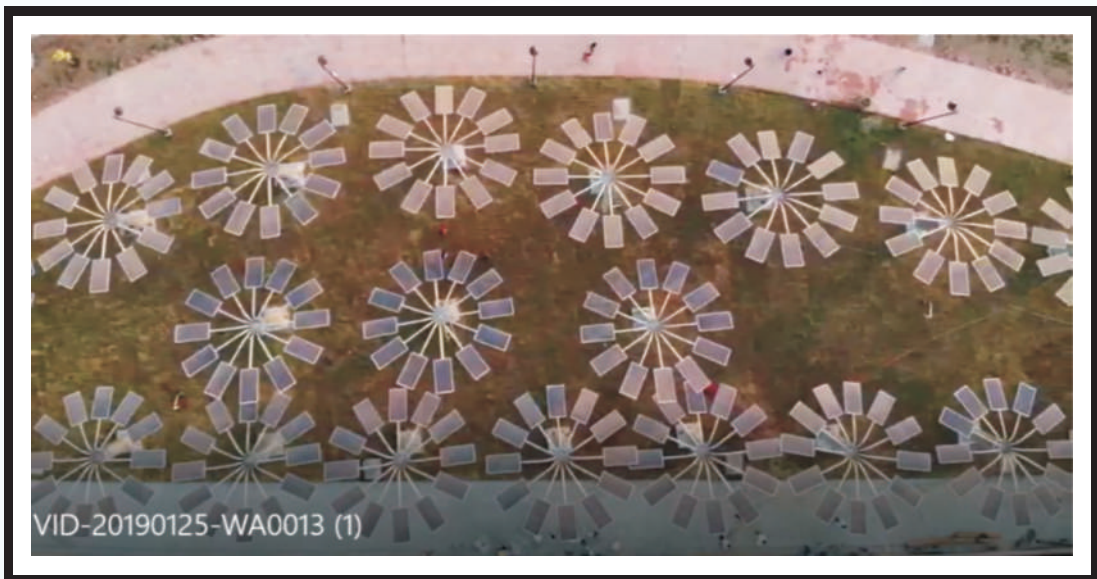
200 KWp Rooftop Solar Panel at PNB Headquarter Building, Dwarka, New Delhi

SOLAR TREES

CPWD also has the distinction of providing solar trees in one of the recently completed National Memorial of the country. In National Salt Satyagraha Memorial project at Dandi, Gujarat executed by CPWD, 41 Solar trees have been provided to produce sufficient energy to meet its requirements. Thus the Memorial was dedicated to the Nation by Prime Minister on January 30, has Energy Neutral Design.



A View of Solar Trees at Dandi Memorial Gujarat



Bird's Eye View of Solar Trees at Dandi

Technical Specifications of Solar Module

Mono crystalline Solar PV Module, Make-Waaree		
S.No.	Parameter	Technical Specification
1	Cell type	Monocrystalline
2	Wattage	370WP

3	Efficiency	19.07 percent
4	No. of cells	72
5	Open circuit voltage	47 volt
6	Short circuit current	10.15 amps
7	Maximum power voltage	38.15 Volt
8	Maximum power current	9.70 Amps
9	Maximum system voltage	1000 Volt DC
10	Certifications/Standards	IEC-61215,IEC-61730-1,IEC-61730-2,IEC-61701,UL listed

Technical Specifications for on grid solar inverter

On Grid Solar Inverter, Make-Delta		
S.No.	Parameter	Technical Specification
1	Maximum DC power	37.5 KWp dc
2	Rated output power	30 KVA
3	Efficiency	98.6 percent peak
4	IP Rating	IP-65
5	Input voltage Range	200-1000 Vdc
6	Nominal Output Ac voltage	415 Volt
7	Total Input current	60 amps
8	maximum output current	50 amps
9	Harmonics	Less than 3 percent at rated power
10	output frequency range	45-55 HZ
11	Certifications/Standards	IEC-61000,IEC-62116,IEC-61727,IEC-62109-2:2011,IEC-61683:1999

Technical Specifications of “off grid” solar inverter

Off Grid Solar Inverter, Make-consul Neowatt		
S.No.	Parameter	Technical Specification
1	System Rating	20 KW
2	Efficiency	more than 88 percent
3	IP Rating	IP-20
4	MPPT voltage Range	165-265 Vdc
5	Nominal Grid input voltage	415 Volt
6	Battery Voltage	240 Volt
7	Maximum Input current	70 amps
8	Harmonics	Less than 5 percent at rated power
9	output frequency range	47.5-52.5HZ
10	Certifications/Standards	IEC-60068,IEC-62116,IEC-62040,IEC-61683:1999



Concept of Solar Tree



Completed solar Trees- A View

IMPLEMENTATION OF ENERGY EFFICIENCY MEASURES

The work of Energy Efficiency Measures in Government buildings in an organised manner was undertaken since 2015 when a decision was taken to implement it in ESCO Mode by MoHUA, the then MoUD. The first Energy Performance Agreement was signed with EESL for I.P. Bhawan, New Delhi in April 2015. Subsequently, many other buildings all across the country were taken up for Energy Efficiency Measures by signing the Performance contract with EESL. These were the GPOA Buildings where electricity bills were paid by CPWD from the budget grant of the Ministry of HUA. However, in some buildings EESL expressed its inability to carry out the work on account of non feasibility due to small size of the building.

First Phase of Implementation

The work was implemented in the following 20Nos. GPOA buildings of Delhi in the first phase:-

List of GPOA buildings of Delhi where energy efficiency work has been completed during First Phase of Implementation.		
S.No.	Name of Building	City /State
1	I.P. Bhawan	New Delhi
2	Nirman Bhawan	New Delhi
3	Sardar Patel Bhawan	New Delhi
4	Transport Bhawan	New Delhi
5	Vidyut Bhawan	New Delhi
6	Sewa Bhawan	New Delhi
7	West Block	New Delhi
8	Shastri Bhawan	New Delhi
9	Krishi Bhawan	New Delhi
10	North Block	New Delhi
11	Vigyan Bhawan & Vigyan Bhawan Annexe	New Delhi
12	Lok Nayak Bhawan	New Delhi

13	Pushpa Bhawan	New Delhi
14	South Block	New Delhi
15	Sharam Shakti Bhawan	New Delhi
16	Niti Aayog	New Delhi
17	East Block	New Delhi
18	CGO Complex	New Delhi
19	Udyog Bhawan	New Delhi
20	GPOA INA	New Delhi

Second Phase of Implementation

Thereafter in the Second Phase, EEM Work in GPOA Buildings outside Delhi was initiated as per the policy decision by MoHUA to convert all existing Central Govt. buildings into energy efficient buildings on PPP model (ESCO) i.e. where no capital upfront expenditure will be done by Govt. but required capital investment to be made by private concessionaire which will be returned to them from the resulting savings in electricity bills of the buildings.

As of now, work in 150 out of 150 nos. GPOA buildings have been completed as per the following details in which work in some of the buildings were carried out in Capex Mode also.

List of GPOA buildings where energy efficiency works has been completed during Second Phase of Implementation.		
S No	Name of Building	City /State
1	North Block	New Delhi
2	South Block	New Delhi
3	PM Office South Block	New Delhi
4	Lok Nayak Bhawan	New Delhi
5	I.P Bhawan	New Delhi
6	East Block 1 to 10, R.K. Puram	New Delhi
7	Trikoot Bhawan Block -1 to 3	New Delhi
8	West Block 1 to 8	New Delhi
9	Sewa Bhawan	New Delhi
10	GPO, INA	New Delhi
11	Sardar Patel Bhawan	New Delhi
12	Nirvachan Bhawan	New Delhi
13	Niti Ayog Bhawan (Yojna Bhawan)	New Delhi

14	Shram Shakti Bhawan	New Delhi
15	Janpath Bhawan	New Delhi
16	Transport Bhawan	New Delhi
17	Jam Nagar House	New Delhi
18	CPWD Office	Ajmer
19	Jaisalmer House	New Delhi
20	Proctor of Emigration	New Delhi
21	Darbhanga House 25 Akbar Road	New Delhi
22	Darbhanga House 7 Man Singh Road	New Delhi
23	Central Hindi Training Institute (2A Prithvi Raj Road)	New Delhi
24	Vigyan Bhawan	New Delhi
25	Vigyan Bhawan Annexe	New Delhi
26	Nirman Bhawan	New Delhi
27	Shastri Bhawan	New Delhi
28	Krishi Bhawan	New Delhi
29	Udyog Bhawan	New Delhi
30	Vidyut Bhawan	New Delhi
31	Pushpa Bhawan	New Delhi
32	CGO Complex Lodhi Road	New Delhi
33	Institute of Secretariat Training and Management (ISTM), Old JNU Campus	New Delhi
34	CGO-1	Ghaziabad
35	CGO-2	Ghaziabad
36	Old CGO	Faridabad
37	New CGO	Faridabad
38	CPWD Training Institute, Kamla Nehru Nagar	Ghaziabad
39	Kendriya Sadan Building, Sec-9A	Chandigarh
40	CPWD Office	Jammu
41	CGO Complex, Longwood	Shimla
42	CPWD Enquiry Offices (Longwood, Bemloe, Phagli, Summer Hill, R.P.	Shimla
43	Craigdhu -20	Shimla
44	Clearmount Building (Labour Bureau)	Shimla
45	Railway Board Building	Shimla
46	Office Building & Other of CPWD Properties	Mount Abu
47	Dormer (SIB)	Shimla
48	Boswell Building (NSSO , Custom Excise)	Shimla
49	Kennedy Cottage and CPWD Store	Shimla
50	Oak Lodge (SSB , Spl, Bureau)	Shimla
51	CPWD Civil Division and CPWDElect.	Madhopur

52	Kendriya Bhawan	Lucknow
53	Kendralaya	Agra
54	Nirman Jyoti	Bareilly
55	GPOA	Jaisalmer
56	GPOA Nirman Bhawan	Jodhpur
57	Nirman Bhawan	Jaipur
58	Kendriya Sadan Building, (Block - A),	Jaipur
59	Kendriya Sadan (Block No- B)	Jaipur
60	Office Building , GPOA	Udaipur
61	GPOA	Bikaner
62	Children School	Mumbai
63	Old CGO Building and Annexe (Pratishtha Bhawan)	Mumbai
64	New CGO Building	Mumbai
65	Exchange Building , Ballard Estate	Mumbai
66	Nav Bhawan , Ballard Estate	Mumbai
67	Everest House	Mumbai
68	Hyderabad Estate	Mumbai
69	Enquiry Office at Kane Nagar	Mumbai
70	CPWD office at S.M Plot	Mumbai
71	CPWD Office at SAP /GKP	Mumbai
72	Election office	Mumbai
73	Elect, Sub- Div, office , CPWD	Mumbai
74	Civil sub- div, CPWD	Mumbai
75	(CPWD) Service Centre	Mumbai
76	Community Centre	Mumbai
77	Godown	Mumbai
78	Dispensary	Mumbai
79	Nirman Sadan, Kane Nagar	Mumbai
80	CGO Bldg at Plot 2 Sec-10	Navi Mumbai
81	Kendriya Sadan at Plat no 38, Sec-10	Navi Mumbai
82	MCC II CPWD office	Mumbai
83	CPWD Offices at Kane Nagar	Mumbai
84	Central Bldg Kothi Compound	Rajkot
85	CGO Bldg	Vadodara
86	CPWD Building	Gandhinagar
87	Nirman Sadan , CGO Bldg.	Bhopal
88	CIA Bldg, Residency Area	Indore
89	CGO, Bldg , New White Church Square, A.B. Road	Indore
90	CPWD office Building (NCSD-I, NCSD-II NCESD)	Neemuch

91	CPWD New CIA building	Indore
92	New CIA Building	Indore
93	CPWD Office Building	Gwalior
94	Office Complex Block 4	Nagpur
95	CGO Complex Block C	Nagpur
96	CGO Complex Block A 1/C (Porch Garage)	Nagpur
97	CPWD Inspection Bungalow (B.N. 3)	Nagpur
98	CGO Complex, Block B	Nagpur
99	Community Hall	Nagpur
100	New Secretariat Bldg.	Nagpur
101	Shopping Center	Nagpur
102	Nirman Bhawan, CPWD Office Gandhinagar	Nasik
103	CPWD Enquiry office, Gandhi Nagar	Nasik
104	Govt. of India Printing Press, Gandhinagar	Nasik
105	CPWD Office, Nirman Bhawan	Pune
106	GPOA at Akurdi	Pune
107	CPWD Office, Nirman Bhawan	GOA
108	Office building(Division office community Hall & CGHS Dispensary and garage)	Nagpur
109	Old Enquiry Office	Nagpur
110	Shopping Center	Nagpur
111	Pump House Old	Nagpur
112	Office Bungalow No. 6 & 9	Nagpur
113	3rd MSO Building CGO Complex , DF Block, Salt Lake	Kolkata
114	4,5,6 & 8, Esplanade East and 6 Dacares lane	Kolkata
115	1st MSO Nizam Place	Kolkata
116	2nd MSO Nizam Place	Kolkata
117	Old Nizam Place	Kolkata
118	15, RN Mukherjee Road	Kolkata
119	5 , Esplanade Row (West)	Kolkata
120	1, Council House Street	Kolkata
121	Govt. Press & Form Store	Kolkata
122	GLSO at 3,Church Lane	Kolkata
123	2, Govt. Place	Kolkata
124	GPOA	Patna
125	CPWD Nirman Bhawan	Bhubaneswar
126	Kendriya Sadan	Silchar
127	CPWD Building Transit Hostel Building	Agartala

128	CPWD office Building Usha Bazar	Agartala
129	GPOA Building at Usha Bazar	Agartala
130	Shastri Bhawan/Shastri Bhawan Annexe	Chennai
131	Nirman Bhawan, Sub-Division Thirumangalam	Chennai
132	Rajaji Bhawan	Chennai
133	GPOA, Port Blair	Port Blair
134	CGO Towers.	Hyderabad
135	Nirman Bhawan	Hyderabad
136	Kendriya Sadan Bldg. at Sultan Bazar	Hyderabad
137	GPOA Bldg. Kavadiguda, Sikandarabad	Hyderabad
138	CPWD Subdivision + store	Tirunelveli
139	CPWD Office	Salem
140	CPWD Office Building, Tirupati	Tirupati
141	GPOA Vijayawada	Vijayawada
142	Kendriya Sadan, Koramangala	Bangalore
143	Nirman Bhawan	Mysore
144	Kendriya Bhawan, Kakkanad	Cochin
145	CPWD Office Building	Madurai
146	CPWD service centre	Madurai
147	Madurai CPWD (MCSD-I(C) & (E))	Madurai
148	Nirman Bhawan, Madurai	Madurai
149	CGO Complex Poonkulam	Trivandrum
150	Kendriya Bhawan	Calicut

Meanwhile decision to carry out EEM work in the entire Universe of Govt. Buildings covering all GPOA & Non GPOA maintained by CPWD was taken in a meeting held at cabinet secretariat by group of secretaries on 22.12.2018 in consultation with MoHUA/CPWD. Accordingly CPWD took a lead role in the implementation of this decision and the efforts are reflected in the following Table which contains 279 buildings all across the country:

List of Non-GPOA Buildings where energy efficiency measures works has been Completed		
Sl.No.	Name of Building	City
1	CGHS Dispensary, Vasant Vihar	New Delhi
2	Maternity Hospital, Sector-5, R.K. Puram	New Delhi
3	CGHS Dispensary/Hospital, Chanakyapuri	New Delhi
4	Community Centre, Chanakyapuri	New Delhi
5	R. S. Depot, Netaji Nagar	New Delhi
6	MSME Testing Centre	New Delhi
7	MSME Development Institute	New Delhi
8	MSME-DI	New Delhi

9	NCFC (Mahalanobis)	New Delhi
10	NIAP Building	New Delhi
11	Krishi Anushandhan Bhawan (KB)-I & II	New Delhi
12	Krishi Vistar Bhawan, Krishi Vistar Sadan	New Delhi
13	CPMU	New Delhi
14	GOI Press, Ring Road	New Delhi
15	Hyderabad House	New Delhi
16	1-Akbar Road, IGMT & 1- Safdarjung Road IGMT	New Delhi
17	1-Safdarjung Lane (SPG Office)	New Delhi
18	5-Tees January Marg, Gandhi	New Delhi
19	4-5 Moti Lal Nehru Place	New Delhi
20	Clock Tower	New Delhi
21	Army Guard B Barrack	New Delhi
22	Army Guard C Barrack	New Delhi
23	D Barrack/CSD Canteen	New Delhi
24	Army Guard E Barrack	New Delhi
25	PBG Officer's Mess	New Delhi
26	M.T. Garage	New Delhi
27	Clock Tower	New Delhi
28	M.I. Room	New Delhi
29	Auditorium Building Sch. B, President's Estate, Rastrapati Bhawan, New Delhi	New Delhi
30	Ceremonial Hall, Sch. B, President's Estate, Rashtrapati Bhawan, New Delhi	New Delhi
31	C.R. Building, I.P. Estate	New Delhi
32	Drum Shape Building, I.P. Estate	New Delhi
33	CHEB Building	New Delhi
34	CGHS Dispensary, Aram Bagh	New Delhi
35	CGHS Dispensary, CG Road	New Delhi
36	Central Administrative Tribunal Building (CAT)	New Delhi
37	NSD	New Delhi
38	Patiala House Courts (Main Bldg.)	New Delhi
39	ASI Building	New Delhi
40	Union Public Service Commission	New Delhi
41	Sapru House	New Delhi
42	National Museum	New Delhi
43	Vigyan Bhawan (Main)	New Delhi
44	Safdarjung Hospital Compound Light	New Delhi
45	Safdarjung Hospital VMMC Library	New Delhi
46	Safdarjung Hospital Corridor	New Delhi
47	Safdarjung Hospital Ward Block	New Delhi

48	Vidyut Bhawan	New Delhi
49	CBI Academy	Ghaziabad
50	Central Poultry Development Organization	Chandigarh
51	Central Bureau of Investigation (CBI)	Chandigarh
52	Regional Passport Office (RPO)	Chandigarh
53	Geological Survey of India	Chandigarh
54	Indian Metrological Department	Chandigarh
55	Regional Drugs Testing Laboratory (RDTL)	Chandigarh
56	Receiving and Transmitting Station	Chandigarh
57	Central Forensic Science Laboratory (CFSL)	Chandigarh
58	AG Punjab (Accounts) Phase-I	Chandigarh
59	Central Administrative Tribunal (CAT)	Chandigarh
60	Income Tax office building bay No. 41 to 42	Panchkula
61	Income Tax office building bay No. 43 to 48	Panchkula
62	Income Tax Building	Ambala Cantt.
63	Indian Institute of Advance Study	Shimla
64	Indian Metrological Department	Jammu
65	RTI Office	Jammu
66	Central Revenue Building	Amritsar
67	AGUP Office (New) Sarya NB	Allahabad
68	MSME, Fazal Ganj	Kanpur
69	RDAT Office, Udhyog Nagar	Kanpur
70	Hydrogen Factory	Agra
71	GST / Central Excise Office Building Sanjay Place	Agra
72	CE, Bhaisali.	Meerut
73	GST Audit Commissionerate, Bhaisali Ground	Meerut
74	Income Tax, Office bldg.	Bulandshahar
75	CBI Office at C Scheme	Jaipur
76	Central Excise (New)	Bhiwadi
77	Central Excise (Old)	Bhiwadi
78	Income Tax	Alwar
79	Central Excise	Alwar
80	Indian Bureau of Mines (I.B.M.)	Ajmer
81	IMD Office	Ajmer
82	Office Building CPWD	Jodhpur
83	Central Excise & Custom	Alwar
84	CBI Office	Jodhpur
85	India Metrological Department	Jodhpur
86	Locust Warning Organization	Basni Jodhpur
87	CAT	Jodhpur
88	Zoological Survey of India	Jodhpur

89	Botanical Survey of India	Jodhpur
90	Subsidiary Intelligence Bureau	Jodhpur
91	Reception block	Mussoorie
92	Post office	Mussoorie
93	Guard Post (Kempty Gate, Main Gate, Bharamputra)	Mussoorie
94	SPH Hall	Mussoorie
95	Boiler room at Kavery Hostel (OLD)	Mussoorie
96	Generator room at Kavery Hostel	Mussoorie
97	New Boiler room at Kavery Hostel Sum	Mussoorie
98	Station at Ganga Hostel	Mussoorie
99	Coffee Lounge Narmada	Mussoorie
100	Laudermat Narmada	Mussoorie
101	Covered Passage (Near SPH, Ganga, Narmada and Kavery Hostel)	Mussoorie
102	SPH New Toilet block	Mussoorie
103	Kalindi boiler room	Mussoorie
104	Sub-Station at Stapaltons	Mussoorie
105	Karshilla Lift	Mussoorie
106	Sampoornanand Lift	Mussoorie
107	Balwadi School	Mussoorie
108	Squash court and Sport store	Mussoorie
109	New Gym at Sport complex	Mussoorie
110	Stores at Badminton Court	Mussoorie
111	Sub-Station at Indira Bhawan	Mussoorie
112	Boiler Room (I.B.)	Mussoorie
113	Generator Room. (I.B.)	Mussoorie
114	New Administrative Building 6 (Gyanshilla)	Mussoorie
115	New Canteen	Mussoorie
116	Electrical Room (I.B) New Old Hostel	Mussoorie
117	Covered passage at I.B	Mussoorie
118	D.B. Room (I.B.)	Mussoorie
119	Covered parking at (I.B.)	Mussoorie
120	Plinth area of Happy Valley Guest House (Back Side Gallary)	Mussoorie
121	Pavention of riding ground	Mussoorie
122	Lift Mahanadi	Mussoorie
123	Lift Corridor	Mussoorie
124	CPWD Enquiry	Mussoorie
125	Chaukidar Hut	Mussoorie
126	Surveyor (Office)	Mussoorie
127	PTS (Vikas)	Mussoorie (Sarsawa)

128	Survey of India	Dehradun
129	GIST , Survey of India	Dehradun
130	Holiday Home	Khurpatal Nainital
131	CPWD Office building Nirman Bhawan	Siliguri
132	Regional Meteorological Centre, Alipore	Kolkata
133	Central Forensic Laboratory	Kolkata
134	Income Tax, 10 B Middleton Row.	Kolkata
135	Central Drug Laboratory Building	Kolkata
136	Survey of India Building	Kolkata
137	Income Tax Building, Bamboovila	Kolkata
138	AIIH & PH, 110, C.R. Avenue, Kolkata.	Kolkata
139	Met, Air Port	Kolkata
140	Anthropological Survey of India, EN7, Sector-V, Salt lake.	Kolkata
141	Lok Nayak Bhawan (Income Tax Office)	Patna
142	Custom Office	Raxual
143	Custom Office	Bettiah
144	Custom Office	Hajipur
145	Custom Office	Chhapara
146	RHU & TC at Singur	Hooghly
147	Met, Digha	Digha
148	CPWD	Dhanbad
149	CPWD	Hazaribagh
150	CIP, Kanke	Ranchi
151	C.I.O. (SIB), Bhubaneswar	Bhubaneswar
152	CBI Bhubaneswar	Bhubaneswar
153	Met Office	Puri
154	DAG Office	Puri
155	AG (A&E)	Shillong
156	BSI Office	Shillong
157	SIB Office	Shillong
158	CSO Office	Shillong
159	O/o the Accountant General (Audit)	Shillong
160	O/o the Regional Training Institute	Shillong
161	O/o the BSI	Shillong
162	O/o the IG, CRPF	Shillong
163	O/o the CSO at Upper	Shillong
164	CPWD Office Building	Guwahati
165	Income Tax Office Building	Dhubri
166	Custom & Central Ex Office Building	Dhubri
167	O/o the Asst. Commissioner, Income Tax, Aayakar Bhawan	Dhubri

168	Income Tax Office Building	Nalbari
169	CPWD Office Building	Doom Dooma
170	CPWD Office Building	Mohanbari
171	Sabrroom	South Tripura
172	CPWD Division Office (Usha Bazar)	Agartala
173	CPWD Division Office	Imphal
174	ISBW Office Building	Imphal
175	AG Office	Aizawl
176	GST Building	Silchar
177	Central Excise	Silchar
178	Central Excise Building	Mumbai
179	PHO	Mumbai
180	Central Excise, Bandra-Kurla Complex	Mumbai
181	MET, Vile Parle (East)	Mumbai
182	Central Excise Office, WIG, Thane	Mumbai
183	Income Tax Office (Custom House), Nhava Sheva	Navi Mumbai
184	Custom House, Alibag	Navi Mumbai
185	Community Centre, Kane Nagar, Antop Hill	Mumbai
186	Custom (P), Bassein, Vasai	Palghar
187	Custom (P) Arnala	Palghar
188	Custom, Kelwa	Palghar
189	C.P.W.D.	Gandhinagar
190	G.S.I.	Gandhinagar
191	Regional Passport Office (G +5)	Ahmedabad
192	CAT Office Building (G + 3)	Ahmedabad
193	Ayakar Bhawan	Ahmedabad
194	Met Office Building	Ahmedabad
195	Central Excise Office Building	Halol
196	Income Tax Building	Godhra
197	Central Excise & Customs Department (Old Building), Chowk Bazaar,	Surat
198	A.G. Office, Bhopal	Bhopal
199	G.S.I. office Building	Bhopal
200	Met Office at Arera Hills	Bhopal
201	CBI, Char Imli	Bhopal
202	SIB Char Imli	Bhopal
203	ISPS, Area Hills	Bhopal
204	Income Tax Building	Indore
205	Central Excise (Manik Bagh Place)	Indore
206	C/o Central Excise Office Building	Dewas
207	C/o Income Tax Office Building	Dewas

208	C/o Central Excise Office Building	Ujjain
209	CPWD Sub Division Office & Store Room, BSF	Tekampur
210	Income Tax Office Building	Guna
211	Electric Sub-Station	Shivpuri
212	Income Tax Office Building	Shivpuri
213	Meteorological Deptt. Of India Office Building	Gwalior
214	G.S.I.	Jabalpur
215	S.O.I	Jabalpur
216	METT.	Jabalpur
217	CR Bldg. (Central Exice).	Jabalpur
218	C.B.I	Jabalpur
219	Central Excise	Sagar
220	Meterological Deptt.	Sagar
221	SIB	Sagar
222	Central Excise Office Building	Satna
223	Central Training Institute, IMD,	Pashan
224	Income Tax Office Building, Patto,	Panji, Goa
225	Custom & Central Excise Office	Panji, Goa
226	Intelligence Bureau Office Building	Tonca Goa
227	New Customs House	Vasco Goa
228	Customs & Central Excise Office	Kolhapur
229	Customs & Central Excise Office	Miraj
230	B. NO. 15/1 Sadar (dn-)	Nagpur
231	C/o Office Building for IT Rajandjaon	Raipur
232	C/o Office Building for GSI	Raipur
233	C/o Admn Block, GO's Mess, SO's Mess & Qtr Gurd for ITBP Kharora ,	Raipur
234	C/o Office Building for IT	Rajandgaon
235	Office Building for Income Tax	Dhamtari
236	C/o Office Building for SIB	Ambikapur
237	CPWD Office building nirman Bhawan	Pondicherry
238	CPWD Godown	Pondicherry
239	Main building	Chennai
240	Annexe building (customs)	Chennai
241	Narmada block	Chennai
242	Krishna block	Chennai
243	Generator shed	Chennai
244	Electrical sub division	Chennai
245	Regional stationery depot	Chennai
246	Custom houses (main & annexe) (near mada krishna block generator)	Chennai
247	Micro, small & medium enterprise	Chennai
248	Central Forensic Science Laboratory	Hyderabad

249	CPWD Office	Salem
250	Botanical Survey of India	Yercaud
251	CPWD Office Building	Madurai
252	CPWD service centre	Madurai
253	Madurai CPWD (MCSD-I(C) & (E))	Madurai
254	Scooter Shed, 4 nos Garrages & Dining Hall.	Tirunelveli
255	Two wheeler parking shed	Tirunelveli
256	CPWD Subdivision + store	Tirunelveli
257	Customs Commissionerate Office Building and Preventive unit	Tuticorin
258	Customs House, Port area	Visakhapatnam
259	Central Excise Office Building Port Area	Visakhapatnam
260	CBI Office MVP Colony	Visakhapatnam
261	CTRI (Central Tobacco Research Institute), Rajahamundry, E.G. Dist. A.P.	Rajahamundry
262	Central Excise Office Building, Morrumpudi junction, Rajahamundry EG Dist. AP	Rajahamundry
263	Customs House at Kakinada	Kakinada
264	Indian Institute of Oil Palm research (IIOPR)	Peddavegi
265	Foreman Training Institute building.	Tirupati
266	Holiday Home	Tirupati
267	Central Revenue Building	Vijayawada
268	Central Revenue Building	Guntur
269	Customs and Central Excise, Income Tax,	Guntur
270	Tabacco Board Bldg	Guntur
271	C.G.O Complex,	Vijayawada
272	Tobacco Board Building,	Guntur
273	CBI office Bldg MVP , Colony	Visakhapatnam
274	Central Tobacco Research Institute	Rajahmundry
275	Income Tax, Central Revenue building.	Bangalore
276	Central Bureau of Investigation.	Bangalore
277	Central Excise office building	Mysore
278	CPWD Enquiry office (G+2), GSI Campus, Pandeshar	Bangalore & Udupi
279	Subsidiary Intelligence Bureau Office Bldg	Calicut

ONLINE REPORTING SYSTEM- IMPLEMENTATION OF SOLAR POWER & ENERGY EFFICIENCY MEASURES MODULES

The two important works of providing Solar Power & Energy Efficiency Measures in GPOA and Non-GPOA buildings as well as in New Buildings under construction by CPWD throughout the country generated enormous data and further generation of data of green power generation on continuous basis was difficult to be handled manually.

Accordingly, to compile and monitor the information related to the installation of Solar Rooftop Plants (SRP) in the existing buildings and in new buildings under construction by CPWD, necessitated the development of an IT based application which can provide updated information from time to time. This led to the development of Solar Power Module to facilitate online monitoring of progress of solar power plants installed and solar power generated from them. Similarly to compile and monitor the information related to the implementation of Energy Efficiency Measures in existing GPOA and Non-GPOA Buildings under maintenance of CPWD a reporting module for Implementation of Energy Efficiency Measures was also developed. Both these modules are available on CPWD website for viewing of Information by concerned Officers of the Department.

SIGNING OF MOU WITH BEE (BUREAU OF ENERGY EFFICIENCY) WITH CPWD FOR ENERGY PERFORMANCE RATING OF CPWD MAINTAINED BUILDINGS

Implementation of Energy Efficiency Measures in existing GPOA and Non-GPOA buildings maintained by CPWD should also pass the test of Energy Performance for their critical evaluation. With this intent in mind, CPWD signed an MoU with BEE, a statutory body formed under the provision of Electricity Conservation Act 2001 for Energy performance Rating of CPWD maintained buildings on 10.01.2019. In this MoU, other than Star rating of CPWD managed buildings with no registration or renewal fee, following more areas of cooperation were identified.

1. Awareness on Energy Efficiency in Buildings.
2. Support for ECBC (Commercial & Residential) and Capacity Building of CPWD Officials.
3. Construction of ECBC compliant new buildings.
4. Any other area with mutual consent in the area of building energy efficiency.



Figure 2 Signing of MoU between CPWD and BEE on 10.01.2019

OUTCOMES AND WAY FORWARD

Solar Rooftops:

- 1) 212.86 lakh units of Green Energy till January 2019 by 5.3 MWp capacity solar rooftops in 40 nos. GPOA buildings has been produced. This has resulted in the mitigation of 17029 Tons of CO2 emissions by avoiding production of conventional electricity and savings Rs. 21.28 Crores @ Rs. 10 per KWh as per deemed calculation.
- 2) A Policy initiative through an O.M. dated 19.11.2018 has been taken by CPWD to install Grid interactive Solar PV Rooftop plants in all Government Buildings and Residences as per the feasibility to provide Green Power and also save natural resources.
- 3) CPWD is further striving to provide solar power in all GPRA colonies throughout the country and in all its new constructions as per its own policy initiative and the norms identified by Building Bye Laws of respective Urban Local Bodies.

Energy Efficiency Measures:

- 1) Work of Energy Efficiency Measures in 150 nos. GPOA buildings till January 2019 has been carried out which has resulted into saving of 503.34 lakh units of electrical energy resulting in the reduction of 40268 tons of CO2 emission by avoiding production of conventional energy and savings of Rs. 50.33 Crores @ Rs. 10 per KWh as per deemed calculation. Further work in Non- GPOA buildings is in progress and is expected to be completed by 31.03.2019.
- 2) An MoU with BEE was signed for Energy performance rating of buildings on 10.01.2019 for evaluation of Government Buildings where Energy Efficiency Measures have been taken.
- 3) All New Buildings are being designed and constructed with Energy Efficient Fixtures in compliance to various norms of ECBC, Building bye Laws in force and sustainability measures.

REGULATIONS & CODES

Regulatory and structural framework for these two important policy implementations is being provided in MODEL BUILDING BYE LAWS- 2016, NBC-2016 and ECBC-2017; the extract of the same is reproduced here for the sake of ease of reference:

Extract from Model Building Bye Laws – 2016

Section 10 of Model Building bye Laws deals with the Green Buildings and sustainability Provisions. These provide for Water Conservation and Management, Solar Energy Utilization, Energy Efficiency and Waste Management. Water Conservation and Management covers Rain Water Harvesting, Low Water Consumption Plumbing Fixtures, Waste Water Recycle and Reuse and Reduction of Hardscape. Solar Energy Utilization covers Installation of Solar Photovoltaic, Installation of Solar Assisted Water Heating Systems. Energy Efficiency covers Low Energy Consumption Lighting Fixtures (Electric Appliances –BEE Star and Energy Efficient Appliances), Energy Efficiency in HVAC Systems and Lighting of Common areas by Solar Energy/ LED devices and Waste Management covers Segregation of Waste and Organic Waste Management.

Table No 10.1 Sustainability Provisions and applicability for various plot sizes (Residential and Non- residential)

Plot Category	Applicable plot area (sqm)	Provisions for Residential	Provisions for Non-Residential
I	Up to 100	Nil	Nil
II	100 to 500	Rain Water Harvesting, Installation of Solar Photovoltaic Panels, Installation of Solar Assisted Water Heating Systems, Segregation of Waste	Rain Water Harvesting, Installation of Solar Assisted Water Heating Systems, Segregation of Waste

500 to 1,000	Rain Water Harvesting, Waste Water Recycle and Reuse, Installation of Solar Assisted Water Heating Systems, Lighting of Common areas by Solar energy/ LED devices, Segregation of Waste	Rain Water Harvesting, Waste Water Recycle and Reuse, Installation of Solar Photovoltaic Panels, Installation of Solar Assisted Water Heating Systems, Lighting of Common areas by Solar energy/ LED devices, Segregation of Waste.
1,000 to 3,000	Rain Water Harvesting, Waste Water Recycle and Reuse, Reduction of Hardscape, Installation of Solar Photovoltaic Panels, Installation of Solar Assisted Water Heating Systems, Energy Efficiency in HVAC systems, Lighting of Common areas by Solar energy/ LED devices, Segregation of Waste	Rain Water Harvesting, Waste Water Recycle and Reuse, Reduction of Hardscape, Installation of Solar Photovoltaic Panels, Installation of Solar Assisted Water Heating Systems, Energy Efficiency in HVAC systems, Lighting of Common areas by Solar energy/ LED devices, Segregation of Waste

III	Above 3,000	Rain Water Harvesting, Low Water Consumption Plumbing Fixtures, Waste Water Recycle and Reuse, Reduction of Hardscape, Installation of Solar Photovoltaic Panels, Installation of Solar Assisted Water Heating Systems, Low Energy Consumption Lighting Fixtures, Energy Efficiency in HVAC systems, Lighting of Common areas by Solar energy/ LED devices, Segregation of Waste, Organic Waste Management	Rain Water Harvesting, Low Water Consumption Plumbing Fixtures, Waste Water Recycle and Reuse, Reduction of Hardscape, Installation of Solar Photovoltaic Panels, Installation of Solar Assisted Water Heating Systems, Low Energy Consumption Lighting Fixtures, Energy Efficiency in HVAC systems, Lighting of Common areas by Solar energy/ LED devices, Segregation of Waste, Organic Waste Management
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10.2.3 Roof Top Solar Energy Installations

Rooftop photovoltaic power station, or rooftop PV system, is a photovoltaic system that has its electricity-generating solar panels mounted on the rooftop of residential or commercial buildings. The various components of such a system include Photovoltaic modules, mounting systems, cables, solar inverters and other electrical accessories. Rooftop PV systems are faster than other types of renewable power plants. They're clean, quiet, and visually unobtrusive. Table 10.2 below stipulates the Norms for Roof Top Solar PV Installation-

Table 10.2 Norms for Roof Top Solar PV Installation and generation

S.No.	Category of buildings/ area	Area standards	Generation requirement*
Residential			
1	Plotted Housing	For HIG Plots and above	Minimum 5% of connected load or 20W/sqft for "available roof space"**, whichever is less.
2	Group Housing	All proposals, as per Group Housing Norms	Minimum 5% of connected load or 20W/sqft for "available roof space", whichever is less.
All other buildings (Government or Private, defined as per clause 1.16 b to g) (mandatory for buildings having shadow free rooftop area > 50 sqm)			
3	Educational	Plot size of 500 sqm and above	Minimum 5% of connected load or 20W/sqft for "available roof space", whichever is less.
4	Institutional		
5	Commercial		
6	Industrial		
7	Mercantile		
8	Recreational		

* Area provisions on roof top shall be @12 sqm per 1KWp, as suggested by Ministry of New and Renewable Energy.

** "available roof area" = 70% of the total roof size, considering 30% area reserved for residents' amenities.

Part 11 of NBC 2016 "Approach to Sustainability" section of NBC deals with the parameters required to be considered for planning, design, construction, operation and maintenance of buildings from the point of view of sustainability. It covers various important topics for sustainable construction and includes Needs for sustainability, Elements of Sustainability, Life Cycle Sustenance, Reduced Embody and Operational Energy, Integrated Water Management, Disaster preparedness Technology Options, Energy Efficient Design and Processes, External Development and Landscape, External Lighting Design, Envelope Optimization, Renewable Energy Integration in Envelope, Materials & Recommended Sustainable Alternatives, Water and Waste Management, Building Services Optimisation, Natural And Mechanical Ventilation Strategies, Construction Practices etc. It thus comprehensively covers methodologies, Practices, Techniques and Technologies essential for sustainability.

For renewable energy, Section 10.8 of NBC -2016 deals with the provisions of solar Photovoltaic power generating system, the main points are reproduced below for the benefits of the readers :-

10.8 Solar Photovoltaic Power Generating System

10.8.1 Solar energy, which is available in two forms, heat and light, is a renewable and inexhaustible natural resource and can supplement/augment the depleting fossil fuel resources. Greenhouse gases and pollutant emissions which result from fossil fuel generation can also be offset by solar photovoltaic power generation. Most parts of the country receive good solar radiation of 4 to 7 kWh/m² per day and almost 300 sunny days in a year making solar PV system one of the most preferred renewable energy sources in the country.

10.8.2 Solar PV power generating system consists of components and subsystems that are used to convert incident solar radiation directly into electrical energy. The energy converter (namely, solar photovoltaic cells which convert solar energy directly into D.C. electric power) does not have moving parts and has a comparatively long lifetime. Also, it can be used in decentralized/distributed mode. PV cells are made of light-sensitive semiconductor materials that use photons to dislodge electrons to drive an electric current. The available cell technology used in construction of solar PV is single crystal or mono- crystalline silicon/poly-crystalline or multi-crystalline silicon/amorphous thin film. Individual PV cells are interconnected to form a PV module. This takes the form of a panel for easy installation. The electrical parameters of the input of a subsystem should be compatible with the output electrical parameters of a preceding subsystem(s). Most solar PV systems can be mounted on a building or installed on ground. For buildings, they are either mounted on the roof or integrated into the building facade (BIPV).

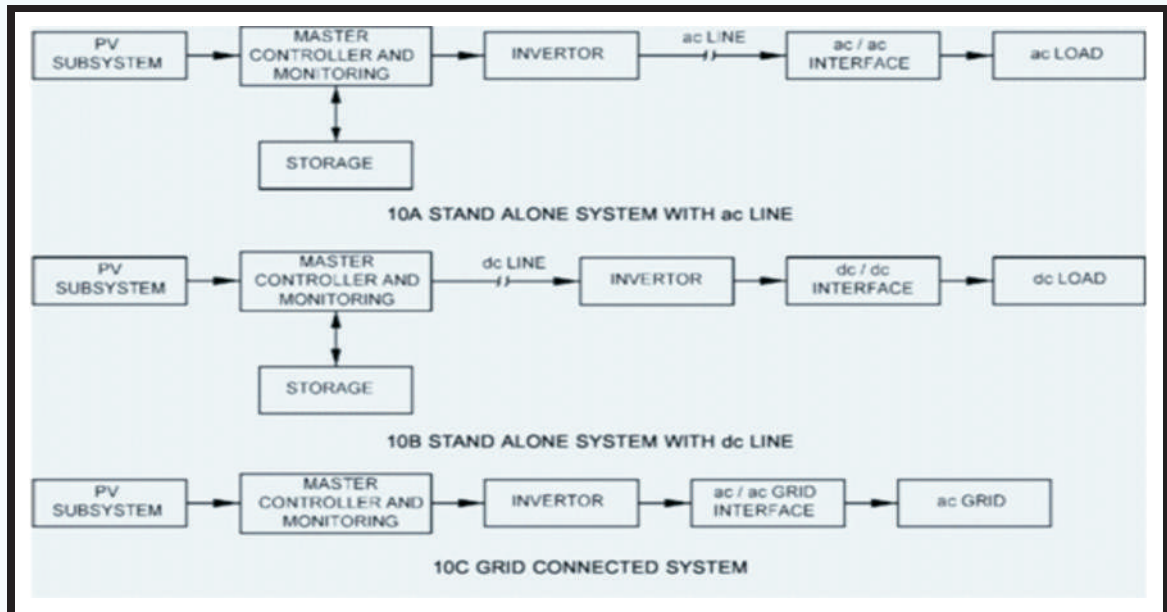
10.8.3 Types of Solar PV Generating System

When photovoltaic modules are exposed to sunlight, they generate electricity in D.C. waveform. A D.C. /A.C. inverter then converts the D.C into A.C. or stabilizes D.C. for further distribution. The PV power generating systems can broadly be classified into two categories, namely, stand-alone (with A.C. output or with D.C. output) and grid connected system (see Fig. 10).

10.8.3.1 Stand alone solar PV system

Stand alone solar PV generating system is an independent power production system that is not connected to the grid and can thus be designed free from grid code requirements. This system is also known applicable for areas where there is no available power grid, such as remote villages, forests, off-shore islands, ships. But they may also be installed within the city in situations where it is inconvenient or too costly to tap electricity from the power grid. An off-grid solar PV system needs deep cycle rechargeable batteries, such as lead-

acid, nickel- cadmium or lithium-ion batteries to store electricity for use under conditions where there is little or no output from the solar PV system, such as during the night.



10.8.3.2 Grid connected solar PV system

A grid connected solar PV generating system is interconnected with an existing electric power grid, subject to grid requirements. This system is also known as grid-tied system. A building has two parallel power supplies, one from the PV solar system and the other from the power grid. The combined power supply feeds all the loads connected to the main A.C. distribution board. The ratio of solar PV supply to power grid supply varies, depending on the size of the solar PV system. Whenever the solar PV supply exceeds the building's current demand, excess electricity is exported into the grid. When there is no sunlight to generate PV electricity at night, the power grid will feed all the building's demand. A grid-connected system can be an effective way to reduce dependence on utility power during the day, increase renewable energy production, and improve the environment.

10.8.4 When designing solar PV system, care should be taken to address design aspects relating to earthing, short circuit protection, lightning protection and switching control. This shall be done in accordance with Part 8: Solar Photovoltaic (PV) Power Supply Systems of National Electrical Code, 2011. Earthing and lightning protection of solar PV systems shall be done in accordance with the procedure laid down in 8 and 11, respectively.

ECBC-2017

The code provides minimum requirements for Energy Efficient design and Construction of Buildings. Buildings consume significant proportion of Energy resources and it is necessary to establish minimum energy performance standards to reduce energy footprints of the

building. Thus ECBC 2017 is an essential regulatory tool.

Extract for renewable energy from ECBC-2017

7.2.8.1 Renewable Energy Generating Zone (REGZ)

- (a) a dedicated REGZ equivalent to at least 25 % of roof area or area required for generation of energy equivalent to 1% of total peak demand or connected load of the building, whichever is less, shall be provided in all buildings.
- (b) The REGZ shall be free of any obstructions within its boundaries and from shadows cast by objects adjacent to the zone.
- © ECBC+ and Super ECBC building shall fulfil the additional requirements listed in Table 7-5 and Table 7-6 respectively.

Exception to § 7.2.8.1: Projects with solar hot water and/ or solar power generation systems.

Table 7-5 Minimum Solar Zone Area/Renewable Energy Generating Zone Requirement for ECBC+ Building

Building Type	Minimum Electricity to be Generated in REGZ
All building types except below	Minimum 2% of total electrical load
Star Hotel > 20,000 m ² Resort > 12,500 m ² University > 20,000 m ² Business >20,000 m ²	Minimum 3% of total electricity load

Table 7-6 Minimum Solar Zone Area/Renewable Energy Generating Requirement for Super ECBC Building7.2.8.2 Main Electrical Service Panel

Building Type	Minimum Electricity to be Generated in REGZ
All building types except below	Minimum 4% of total electrical load
Star Hotel > 20,000 m ² Resort > 12,500 m ² University > 20,000 m ² Business >20,000 m ²	Minimum 6% of total electricity load

Minimum rating shall be displayed on the main electrical service panel. Space shall be reserved for the installation of a double pole circuit breaker for a future solar electric installation.

7.2.8.3 Demarcation on Documents

The following shall be indicated in design and construction documents:

- a) Location for inverters and metering equipment,
- b) Pathway for routing of conduit from the REGZ to the point of interconnection with the electrical service,
- c) Routing of plumbing from the REGZ to the water-heating system and,
- d) Structural design loads for roof dead and live load.

REFERENCES

1. National Action Plan on Climate Change
2. National Building Code Of India 2016
3. Energy Conservation Building Code 2017
4. Model Building Bye Laws 2016

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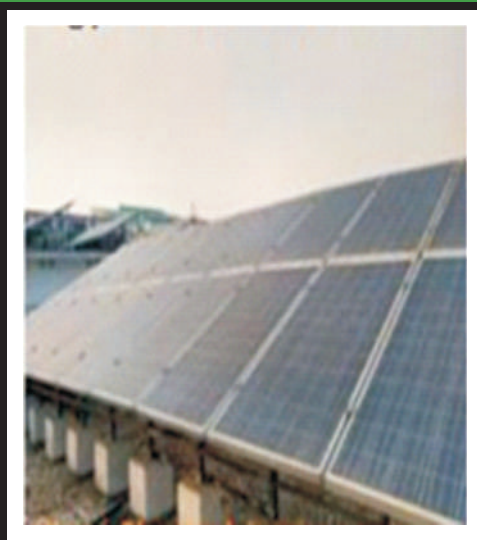
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