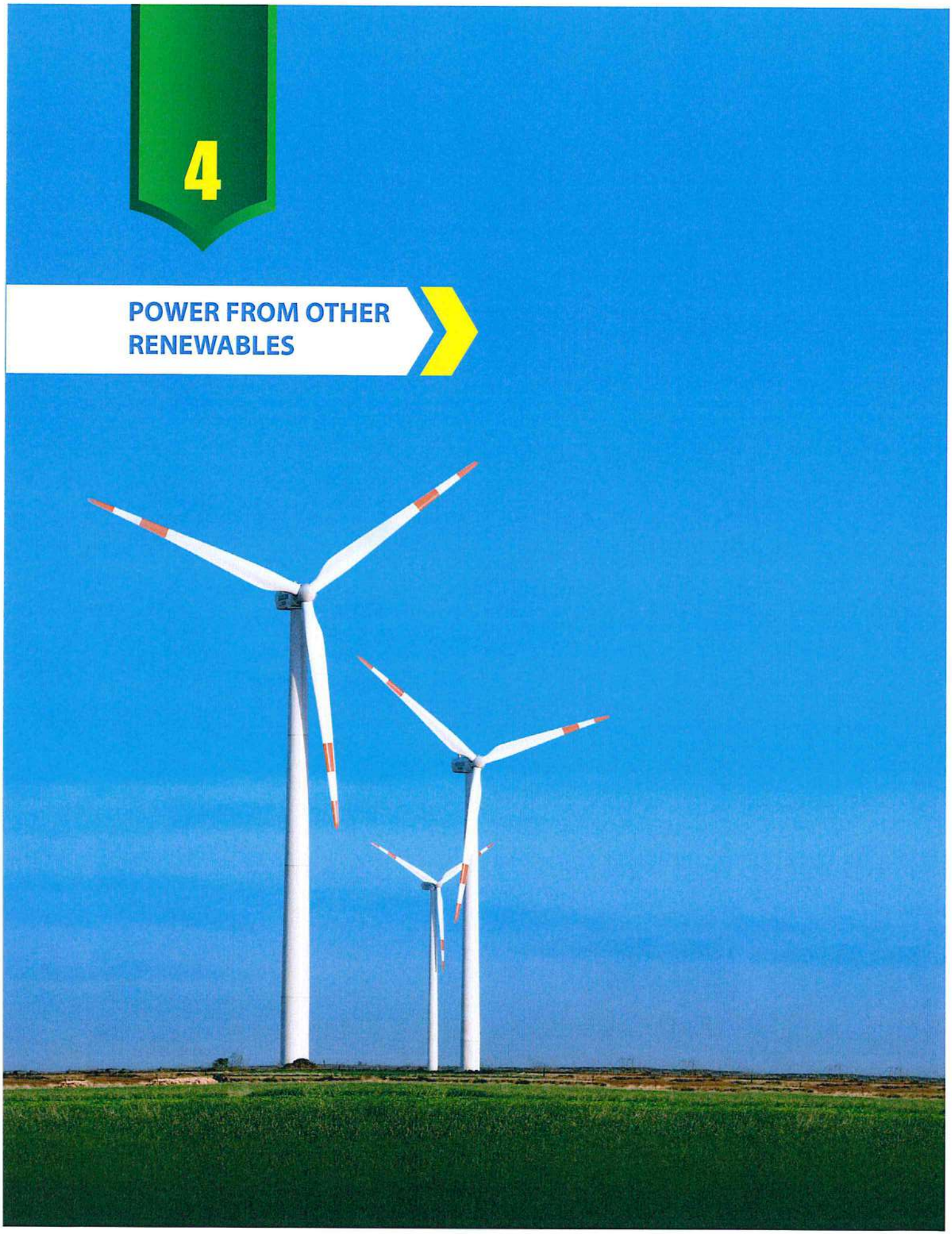
4

POWER FROM OTHER RENEWABLES



POWER FROM OTHER RENEWABLES

4.1 GRID-INTERACTIVE AND OFF GRID RENEWABLE POWER

4.1.1 India has large renewable energy potential from sources such as wind, solar, biomass, small hydro, among others. As per estimates, India has a wind potential of more than 300 GW at a hub height of 100 metre, solar potential of ~750 GW, assuming 3% wasteland is made available, small hydro potential of~20 GW, and bio-energy potential of 25 GW. Further, there exists significant potential from decentralized distributed applications for meeting the hot water requirement for residential, commercial and industrial sector through solar energy and also meeting cooking energy needs in the rural areas through biogas. Renewable energy also has the potential to usher in universal 'energy access'. In a decentralized or standalone way renewable energy is appropriate, scalable and a viable solution for providing power to un-electrified or power-deficient villages and hamlets.

4.1.2 India has achieved a cumulative installed renewable energy capacity of **92.54 GW** of which **5.47 GW** was added in the period April 2020 till January, 2021.

4.2 WIND ENERGY

4.2.1 **Introduction:** India's wind energy sector is led by indigenous wind power industry and has shown consistent progress. The expansion of the wind industry has resulted in a strong ecosystem, project operation capabilities and manufacturing base of about 10,000 MW per annum. The country currently has the fourth highest wind installed capacity in the world with total installed capacity of 38.62 GW (as on 31st December, 2020) and 64.64 Billion Units were generated from wind power during 2019-20.

4.2.2 Potential of Wind Energy in India

Wind is an intermittent and site-specific source of energy and therefore, an extensive Wind Resource Assessment is essential for the selection of potential sites. Over a period of time, the Ministry, through National Institute of Wind Energy (NIWE), has installed 890 wind-monitoring stations all over the country and issued wind potential maps at 50 m, 80 m, 100 m and 120 m above ground level. The latest assessment indicates gross wind power potential of 302.25 GW and 695.50 GW in the country at 100 meter and 120 meter respectively, above ground level. Most of this potential exists in seven windy States as given in **Table 4.1** below:

Table 4.1 Wind Power Potential in India at 100 meter and 120 meter, above ground level

S. No.	State	Wind Power Potential at 100 mtr agl in GW	Wind Power Potential at 120 mtr agl (GW)
1	Andhra Pradesh	44.23	74.90
2	Gujarat	84.43	142.56
3	Karnataka	55.86	124.15
4	Madhya Pradesh	10.48	15.40
5	Maharashtra	45.39	98.21
6	Rajasthan	18.77	127.75
7	Tamil Nadu	33.80	68.75

S. No.	State	Wind Power Potential at 100 mtr agl in GW	Wind Power Potential at 120 mtr agl (GW)
	Total (7 windy States)	292.97	651.72
	Other States	9.28	43.78
	All India Total	**302.25**	**695.50**

The wind atlas is available on the NIWE's website **http://www.niwe.res.in** and wind potential map at 100 m and 120 m above ground level is given below in **Fig. 4.1** and **Fig. 4.2** respectively.

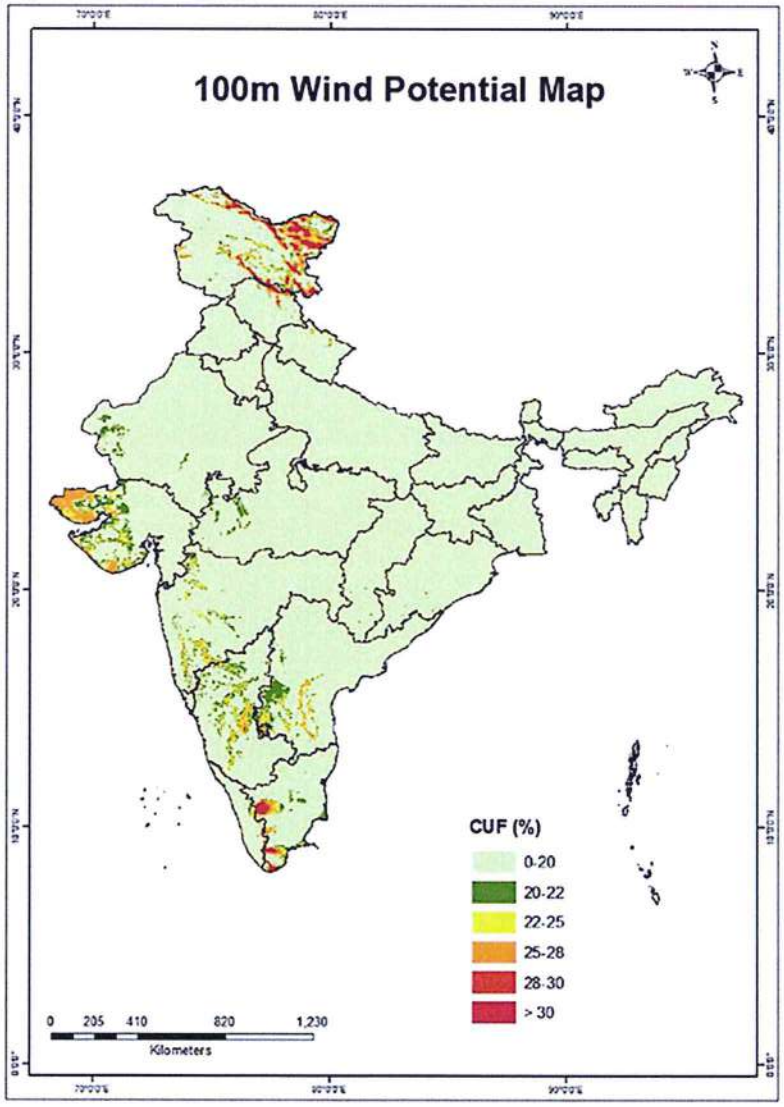


Fig. 4.1: Wind Potential Map at 100 Metres above ground level

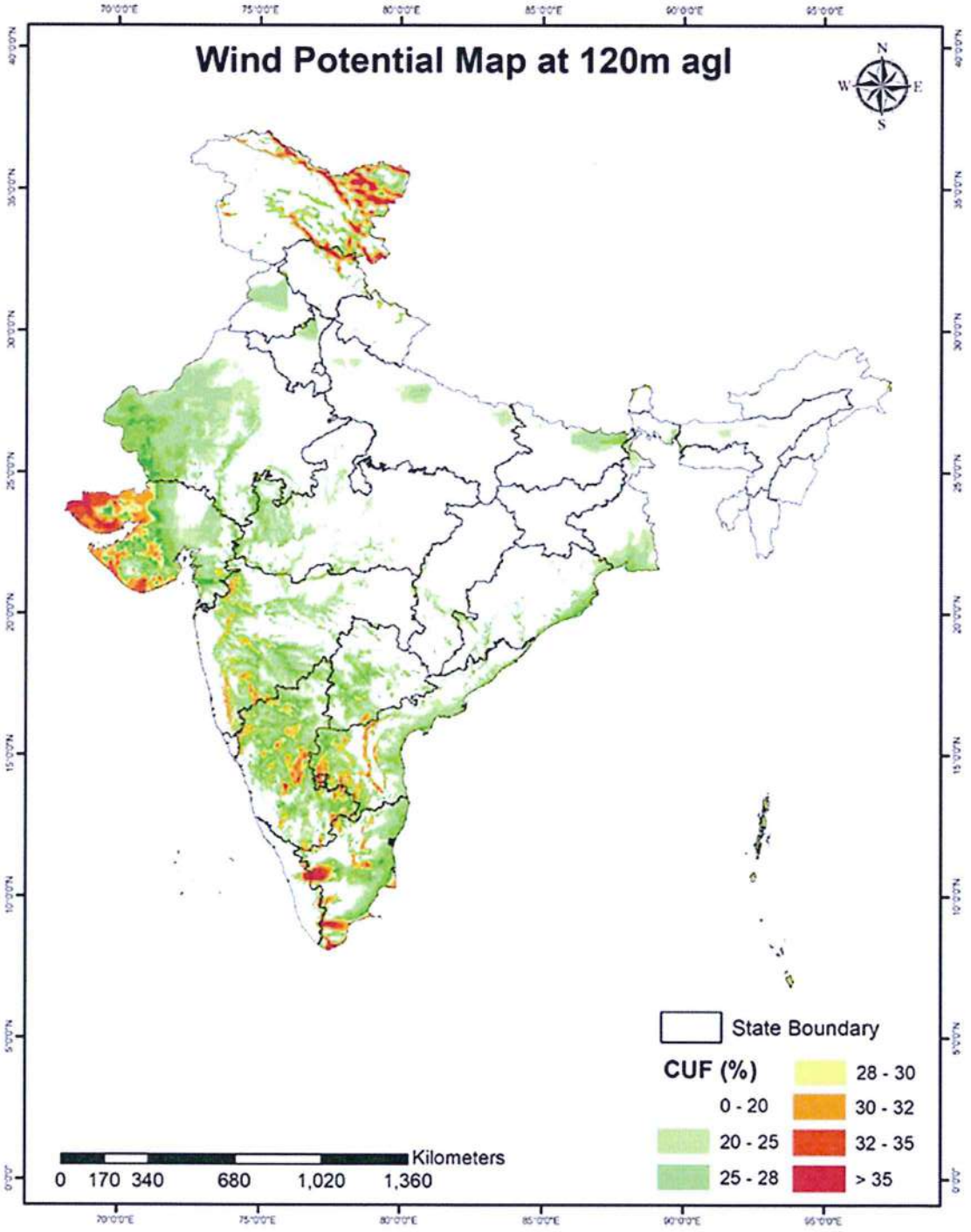


Fig. 4.2: Wind Potential Map at 120 Meters above ground level

4.2.3 Installed capacity of Wind Power in the country

The installed capacity of grid-interactive wind power in the country as on 31.12.2020 is 38.62 GW and state-wise installed capacity (in MW) is shown in **Table 4.2**.

Table 4.2: State wise Wind Power installed as on 31.12.2020

S. No.	STATE	Installed Capacity (MW)
1	Andhra Pradesh	4092.450
2	Gujarat	8192.52
3	Karnataka	4868.80
9	Kerala	62.500
4	Madhya Pradesh	2519.890
5	Maharashtra	5000.330
6	Rajasthan	4326.82
7	Tamil Nadu	9428.44
9	Telangana	128.100
10	Others	4.300
	Total (MW)	**38624.15**

The year-wise electricity generation from wind energy source is shown in **Table 4.3**.

Table 4.3: Year wise Electricity Generation from Wind Energy Sources

Sr. No.	Year	Generation (MU)
1	2014-15	33768
2	2015-16	33029
3	2016-17	46004
4	2017-18	52666
5	2018-19	62036
6	2019-20	64639
7	2020-21 (up to Nov, 2020)	46367

4.2.4 Technology development and manufacturing base for Wind Power

The Wind Turbine Generator technology has evolved and state-of-the-art technologies are available in the country for the manufacture of wind turbines. Around 75% localization has been achieved with strong domestic manufacturing capacity for wind energy turbines and its components in the country. All the major global players in this field have their presence in the country and over 31 different models of wind turbines are being manufactured by more than 13 different companies, through (i) joint ventures under licensed production (ii) subsidiaries of foreign companies, and (iii) Indian companies with their own technology. The unit size of the largest machine has gone up to 3.46 MW.

Wind turbines and components manufactured in India are also being exported to various countries. The current annual production capacity of wind turbines in the country is about 10,000 MW.

4.2.5 Tender/bidding in Wind Energy sector

Government issued Guidelines for Tariff Based Competitive Bidding Process for Procurement of Power from Grid Connected Wind Power Projects vide resolution notified on 8th December, 2017. This was done with an objective to provide a framework for procurement of wind power through a transparent process of bidding including standardization of the process and defining of roles and responsibilities of various stakeholders. These Guidelines aim to enable the Distribution Licensees to procure wind power at competitive rates in a cost-effective manner.

Based on past bidding experience and after consultation with stakeholders, the standard bidding guidelines for wind power projects were amended on 16th July, 2019 to reduce the investment risks related to the land acquisition and Capacity Utilisation Factor (CUF). Incentives were also provided for early part commissioning of project. The subjectivity in penalty provisions was removed and the penalty rate was fixed. The risk of wind power developers in case of delay in signing of Power Sale Agreement (PSA) has been mitigated by starting timeline of execution of project from date of signing of Power Purchase Agreement (PPA) or PSA, whichever is later.

The Scheme for procurement of blended wind power from 2,500 MW ISTS connected projects was introduced. The objective of the Scheme is to provide a framework for procurement of electricity from 2,500 MW Interstate Transmission System (ISTS) Grid Connected Wind Power Projects with up to 20% blending with Solar PV Power through a transparent process of bidding. Solar Energy Corporation of India Ltd. (SECI) is the nodal agency for implementation of the Scheme. It has provisions for payment security mechanism, commission schedule, power offtake constraints, power purchase agreement, among others. SECI has awarded 970 MW of projects under this scheme at discovered tariff of ₹ 2.99-3.00 per unit.

4.2.6 Status of tenders for Wind Power Projects

To enable DISCOMs of the non-windy States to fulfil their non-solar Renewable Purchase Obligation (RPO), through purchase of wind power at a tariff determined by transparent bidding process, MNRE through SECI has auctioned wind power capacity in nine tranches. Further, NTPC and the states of Gujarat, Maharashtra and Tamil Nadu have also auctioned wind power capacities.

1) Cumulative commissioned capacity till 31/12/20: 38.624 GW

2) Capacity under implementation: 8.729 GW

3) Total ongoing bids: 1.2 GW

Total (1+2+3): 48.55 GW

The Minimum Tariffs discovered from tenders auctioned for Wind Power are shown in **Table 4.4.**

Table 4.4: Minimum Tariffs discovered from Tenders Auctioned for Wind Power

Sl. No.	Bid	Capacity Awarded (MW)	Type	Min. Tariff (Rs./kwh)
1.	SECI-I	1049.9	Central	3.46
2.	SECI-II	1000	Central	2.64
3.	SECI-III	2000	Central	2.44
4.	SECI-IV	2000	Central	2.51
5.	Tamil Nadu	450	State	3.42
6.	Gujarat (GUVNL)	500	State	2.43
7.	Maharashtra (MSEDCL)	500	State	2.85
8.	SECI-V	1190	Central	2.76
9.	NTPC	850	Central	2.77
10.	SECI-VI	1200	Central	2.82
11.	SECI-VII	480	Central	2.79
12.	SECI-VIII	440	Central	2.83
13.	Gujarat (GUVNL)	202.6	State	2.80
14	SECI-IX	970	Central	2.99
	Sub Total	**12832.5**		

4.2.7 Incentives available for Wind sector

The Government is promoting wind power projects in entire country through private sector investment by providing various fiscal and financial incentives such as Accelerated Depreciation benefit; concessional custom duty exemption on certain components of wind electric generators. Besides, Generation Based Incentive (GBI) Scheme was available for the wind projects commissioned up to 31st March 2017.

In addition to fiscal and other incentives as stated above, following steps have also been taken to promote installation of wind capacity in the country. Firstly, Technical support including wind resource assessment and identification of potential sites through NIWE, Chennai.

Secondly, in order to facilitate inter-state sale of wind power, the inter-state transmission charges and losses have been waived off for wind and solar projects to be commissioned by June, 2023.

4.2.8 Offshore Wind development in India

India is blessed with a coastline of about 7600 kms surrounded by seawater on three sides and has tremendous power generation potential from offshore wind energy. Considering this, the Government had notified the National Offshore Wind Energy Policy as per the Gazette Notification dated 6th October 2015. As per the policy, Ministry of New and Renewable Energy will act as the nodal ministry for development of Offshore Wind Energy in India and work in close coordination with other government entities for Development and Use of Maritime Space within the Exclusive Economic Zone (EEZ) of the country in an effective manner for production of enormous quantity grid quality electrical power for national consumption.

National Institute of Wind Energy (NIWE), Chennai has been designated as the nodal agency to execute various pre-feasibility activities relating to resource assessment, surveys and studies within EEZ (Exclusive Economic Zone), demarcation of offshore potential blocks and facilitating offshore wind energy project developers for setting up offshore wind energy farms.

4.2.9 Present status

» Based on the preliminary assessment from satellite data and data available from other sources, 8 (eight) zones each in Gujarat and Tamil Nadu have been identified as potential zones for exploitation of offshore wind energy. Initial assessment of offshore wind energy potential within the identified zones has been estimated to be about 70 GW off the coast of Gujarat & Tamil Nadu only. (**Fig. 4.3 and Fig. 4.4**).

» In order to attract the large investment needed/required for development of the sector in India, Government of India has already announced its intention of developing 5 GW of offshore wind energy project by 2022 and 30 GW by 2030.

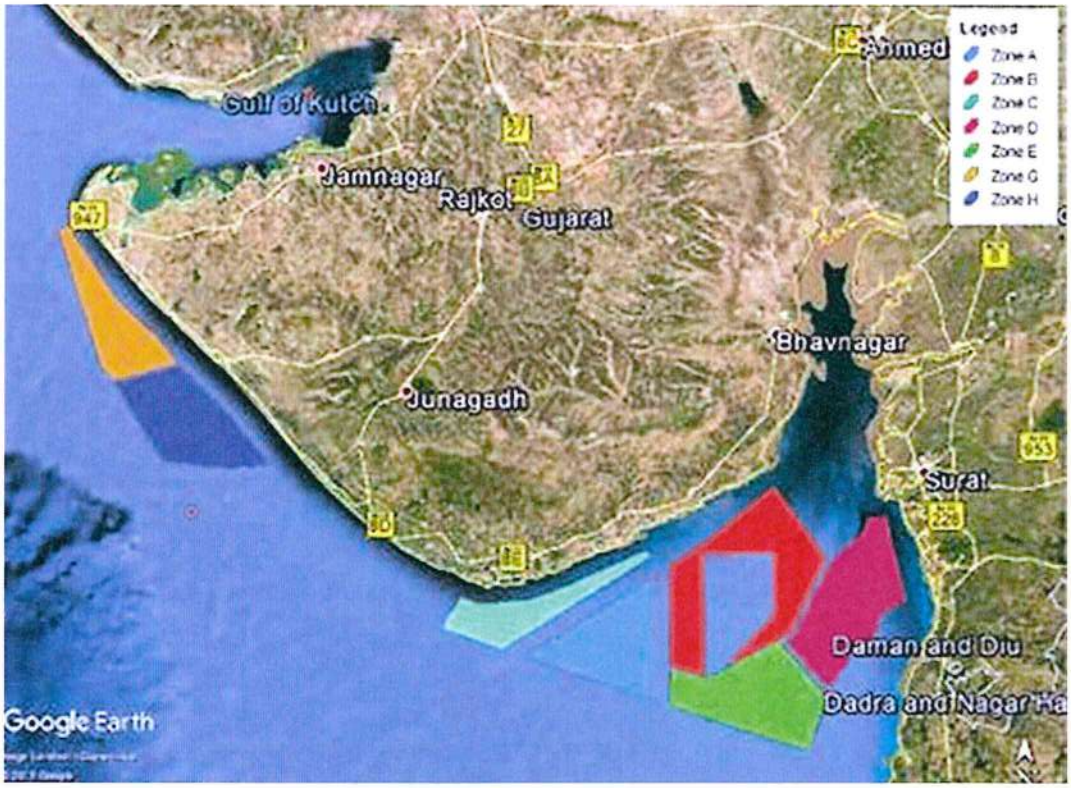


Fig. 4.3 Gujarat Offshore Wind Potential Zone

4.2.10 Studies to Assess the Potential on the Gujarat Coast

1. Offshore measurements off Gujarat coast:

LiDAR based offshore wind potential measurements for 2 years have been completed at Gulf of Khambhat off Gujarat coast. The offshore LiDAR wind data measurement report for the first and

second years have been published for benefit of stakeholder. Raw data files (time series) of two years of LiDAR measurement carried out at Gulf of Khambhat has also been uploaded in NIWE website. Four more LiDARs have been procured by NIWE for carrying out offshore wind resource assessment off Gujarat and Tamil Nadu coast. The LiDARs have already been validated in the WTRS test station Kayathar.

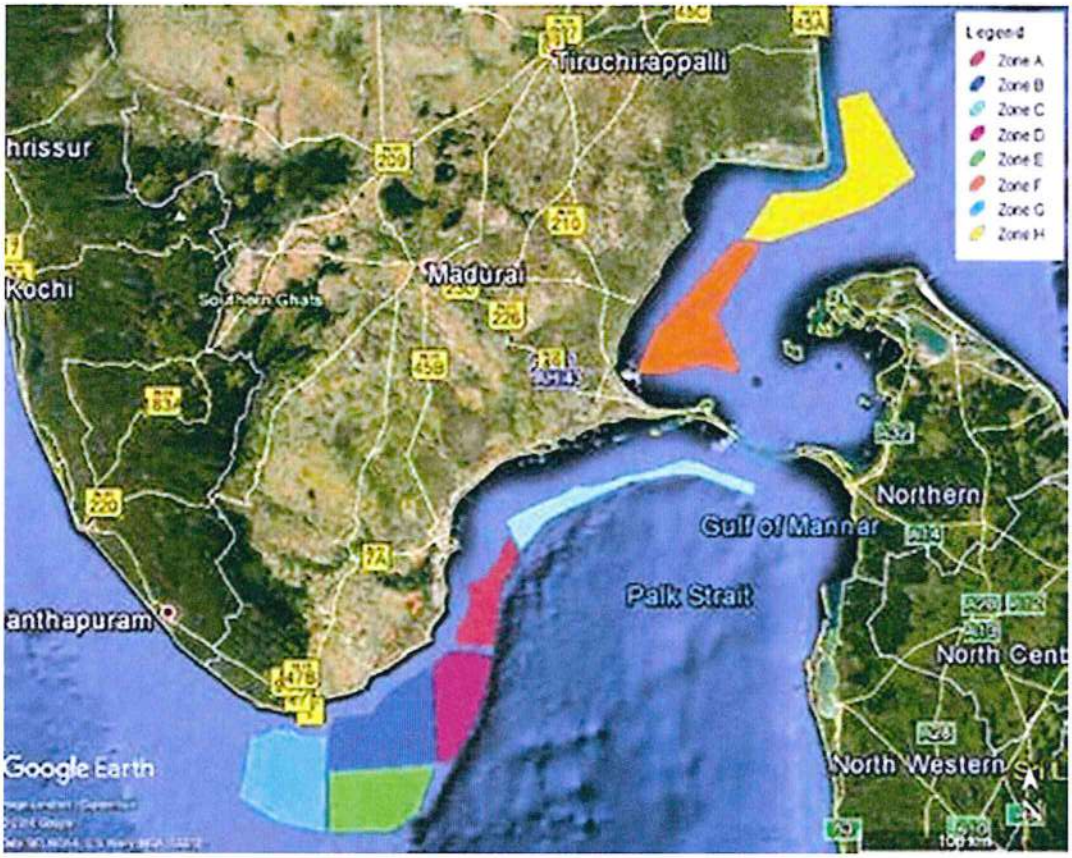


Fig. 4.4: Tamil Nadu Offshore Wind Potential Zone

2. Geophysical investigation at Gulf of Khambhat off Gujarat coast:

In order to ascertain the nature of sub sea surface and soil profile available at recommended depths for the design of foundation for offshore structures, a detailed geophysical survey is required to be carried out. Onsite Geo-physical investigation (single beam bathymetry survey, side scan sonar, sub-bottom profiling, and magnetometer survey and sediment samples) covering an area of 365 sq. km for 1GW offshore project in Gulf of Khambhat off Gujarat Coast has been completed.

3. Geotechnical Investigation at Gulf of Khambhat off Gujarat coast:

In order to understand the subsoil profile and load bearing capacity of the seabed geotechnical studies were carried out at five locations off the coast of Gujarat. The geotechnical investigations at three locations off the coast of Tamil Nadu have been completed. Based on the results of the geotechnical investigations the offshore structure (LiDAR platform) will be designed and fabricated.

4. **Rapid Environmental Impact Assessment for 1 GW offshore wind farm project at Gulf of Khambhat off Gujarat coast:**

The Rapid EIA work has been completed by National Institute of Oceanography (NIO) and the report has been finalized after carrying out the stakeholder's consultation and submitted to NIWE. The report has been shared with MoD for publication and based on the inputs received from MoD the report has been published in NIWE website.

5. **Offshore Wind Energy Lease Rules:**

In order to formulate the required framework for regulating the lease of offshore areas within the Exclusive Economic Zone (EEZ) of India for offshore wind energy development, Ministry is framing Lease Rules under the 'Territorial Waters, Continental Shelf, EEZ and Other Maritime Zones Act, 1976'. Stakeholders consultation with various Ministries and Departments including private players have been completed. Ministry is in the process of consultation with MEA, the administrative ministry for the Act for getting it notified.

6. **Offshore Wind Turbine Research and Test Centre at Dhanushkodi, Tamil Nadu:**

In order to strengthen the domestic capacity for design and development of new offshore wind energy turbines, a testing cum research facility was necessary and NIWE has already identified the suitable site at Dhanushkodi, Tamil Nadu for establishment of the testing cum research centre. The required land for the purpose has been allotted by Govt. of Tamil Nadu. NIWE is in the process of preparing a detailed project report for the centre.

7. **Committee to Finalise a Strategy for Offshore Wind Energy Development in India**

Ministry has constituted a committee to examine the various issues relating to offshore wind energy development in the country including the optimal capacity for the first project, adequate project pipeline, development models and financing mechanisms and recommend the strategy for development of this sector. The committee is in the process of deliberation on these issues and various stakeholder consultations are going on. Based on the recommendations of this committee a definitive plan will be made for establishment of offshore wind energy project in India.

4.3 ENERGY FROM WIND-SOLAR HYBRID

4.3.1 National Wind-Solar Hybrid Policy:

The Ministry issued National Wind-Solar Hybrid Policy on 14th May, 2018. The main objective of the policy is to provide a framework for promotion of large-scale grid connected wind-solar PV hybrid systems for optimal and efficient utilization of wind and solar resources, transmission infrastructure and land. The wind-solar PV hybrid systems will help in reducing the variability in renewable power generation and achieving better grid stability. The policy also aims to encourage new technologies, methods and way-outs involving combined operation of wind and solar PV plants.

4.3.2 The Major Highlights of the Policy are as under:

» A wind-solar plant will be recognized as hybrid plant if the rated power capacity of one resource is at least 25% of the rated power capacity of other resource.

- Both AC and DC integration of wind-solar hybrid project are allowed.
- The power procured from the hybrid project may be used for fulfilment of solar RPO and non-solar RPO in the proportion of rated capacity of solar and wind power in the hybrid plant respectively.
- Existing wind or solar power projects, willing to install solar PV plant or Wind Turbine Generators (WTGs) respectively, to avail benefit of hybrid project, may be allowed.
- All fiscal and financial incentives available to wind and solar power projects will also be made available to hybrid projects.
- The Central Electricity Authority (CEA) and Central Electricity Regulatory Commission (CERC) shall formulate necessary standards and regulations including metering methodology and standards, forecasting and scheduling regulations, REC mechanism, grant of connectivity and sharing of transmission lines, etc., for wind-solar hybrid systems.
- Storage may be added to the hybrid project to ensure availability of firm power for a particular period.

4.3.3 Wind-Solar Hybrid Projects

4.3.4 The following are the Projects under the Wind-Solar Hybrid Programme

- In order to implement the National Wind-Solar Hybrid Policy, a scheme for setting up of 2500 MW Inter State Transmission System (ISTS) connected wind-solar hybrid projects was sanctioned on 25.05.2018. The Solar Energy Corporation of India (SECI) was the nodal agency for implementation of the scheme through tariff based transparent competitive bidding process.
- Guidelines for Tariff Based Competitive Bidding Process for procurement of power from Grid Connected Wind Solar Hybrid Projects were issued on 14.10.2020. The objective is to provide a framework for procurement of electricity from ISTS Grid Connected Wind-Solar Hybrid Power Projects through a transparent process of bidding. Individual minimum size of project allowed is 50 MW at one site and a single bidder cannot bid for less than 50 MW. The rated power capacity of one resource (wind or solar) shall be at least 33% of the total contracted capacity. It has provisions for payment security mechanism, commission schedule, power offtake constraints, power purchase agreement, etc. SECI is the nodal agency for implementation of the Scheme.
- SECI has awarded 2550 MW capacity of wind-solar hybrid projects after e- reverse auction, as shown in **Table 4.5**.

Table 4.5: Minimum Tariffs discovered from tenders auctioned for Wind-Solar Hybrid Power Projects

Sl. No.	Bid	Capacity Awarded (MW)	Min. Tariff (Rs./kwh)
1.	SECI Hybrid – I	840	2.67
2.	SECI Hybrid -II	600	2.69
3.	SECI Hybrid -III	1110	2.41
	Total	**2550**	

4.3.5 Issuance of Concessional Customs Duty Certificates for Manufacturing of Wind Turbines

Ministry is issuing Concessional Customs Duty Certificates (CCDC) to the manufacturers of wind operated electricity generators as per Ministry of Finance tariff notification no. 50/2017-customs dated 30.06.2017. For this purpose the eligible turbine and component manufacturers are required to get the bill of material for turbine models approved, which are listed in Revised List of Manufacture and Models (RLMM) and then apply in prescribed formats to Ministry for issue of CCDC (Concessional Custom Duty Certificate) for their import consignments. In order to make the entire process fast and transparent, an online portal was developed and is active since Oct, 2019. A total 245 nos. of CCDC have been issued in the FY 2020-21 till 31.12.2020.

4.4 GRID CONNECTED BIOMASS POWER AND BAGASSE BASED CO-GENERATION

4.4.1 Ministry has been promoting Biomass Power and Bagasse Co-generation Programme with the aim to recover energy from biomass including bagasse, agricultural residues such as shells, husks, de-oiled cakes and wood from dedicated energy plantations for power generation. A scheme to support promotion of biomass-based cogeneration in sugar mills and other industries was notified on 11.05.2018. The potential for power generation from agricultural and agro-industrial residues is estimated at about 18,000 MW. With progressive higher steam temperature and pressure and efficient project configuration in new sugar mills and modernization of existing ones, the potential of surplus power generation through bagasse cogeneration in sugar mills is estimated at around 8,000 MW. Thus the total estimated potential for biomass power is about 26,000 MW.

4.4.2 Sugar industry has been traditionally practicing incidental cogeneration by using bagasse as a fuel for meeting the steam and power requirements of sugar processing and sugar mill complex. With the advancement in the boiler and turbine technologies for generation and utilization of steam at high temperature and pressure, sugar industry has been producing electricity and steam for their own requirements and selling surplus electricity to the grid by optimally utilizing the bagasse. The sale of surplus power generated through optimum cogeneration is helping improvement of viability of sugar mills and their profitability, apart from creating additional power generation capacity in the country.

4.4.3 More than 550 Nos of Biomass IPP and Bagasse Cogeneration based power plants with aggregate capacity of 9373 MW have been installed in the country upto December, 2020.

4.4.4 Bagasse based cogeneration in sugar mills for export of surplus power to grid is the main grid connected component of the Programme. India has more than 540 Nos of sugar mills, out of which around 360 sugar mills have installed cogeneration power plant capacity of 7547 MW.

4.4.5 Objectives of the Programme are:

- To promote efficient and economic use of surplus biomass for power generation.
- To maximize surplus power generation from sugar mills using improved technologies.
- To promote technologies of co-generation for supplementing conventional power.

4.4.6 For the purpose of biomass-based cogeneration programme following nomenclature are broadly adopted:

- **Biomass Resources:** The programme will provide CFA for projects utilizing biomass like bagasse,

agro-based industrial residue, crop residues, wood produced through energy plantations, weeds, wood waste produced in industrial operations, among others.

- **Financing Institutions:** All registered financial Institutions, development and investment corporations; all nationalized bank, private banks, Central & State Cooperative Banks, State/Public Sector Leasing and Financing corporations.
- **Promoters:** Promoters include individual / independent registered companies, Joint Sector / public sector companies/ state agencies and private and public sector investors having technical and managerial capabilities for implementing Bagasse cogeneration projects.
- **Central Financial Assistance (CFA):** As per the scheme, to support biomass-based cogeneration in sugar mills and other industries Central Financial Assistance (CFA) will be provided at the rate of Rs.25 Lakh / MW for bagasse cogeneration projects on surplus exportable capacity under the scheme. CFA is calculated on surplus exportable power as mentioned in Power Purchase Agreement (PPA)/ Appraisal Report. The CFA is back-ended and is released in one instalment after successful commissioning and commencement of commercial generation and performance testing of the plant to the term loan account to reduce the loan component of the promoter. No advance CFA is released under the scheme and is provided only for projects which install new boiler and turbines.
- **Achievements:** A cumulative capacity of 9,373 MW in over 550 of power plants has been commissioned so far mainly in the states of Maharashtra, Uttar Pradesh, Karnataka, Tamil Nadu, Andhra Pradesh, Chhattisgarh, West Bengal and Punjab. This includes 7547 MW from Bagasse Cogeneration Sector and 1826 MW from Biomass IPP Sector.

4.4.7 New Initiatives

- The Ministry has launched Bio-urja Portal to facilitate the online submission of proposal and requisite documents for availing Central Financial Assistance (CFA) under the scheme.
- An MNRE sponsored study to assess the Biomass Power and Bagasse Co-generation Potential in India is being conducted by Administrative Staff College of India, Hyderabad.

4.5 SMALL HYDRO POWER

4.5.1 The Ministry of New and Renewable Energy (MNRE) is vested with the responsibility of developing hydro power projects of capacity up to 25MW, categorized as Small Hydro Power (SHP) Projects. These projects have potential to meet power requirements of remote and isolated areas in a decentralized manner besides providing employment opportunity to local people. **(Fig. 4.5 and Fig. 4.6)** Small Hydro Power projects are further categorized into small, mini and micro hydel projects based on their capacity as follows:

Micro hydel ≤ 0.1 MW

Mini hydel > 0.10 MW to ≤ 2.00 MW

Small Hydel > 2.00 MW to ≤ 25.00 MW

Fig.4.5: *Khandi SHP (1000kW), District Kargil , UT of Ladakh – View of Power House & Switchyard*

Fig.4.6: *TG sets of Baitarani SHP (24 MW) commissioned in August 2020 in Keonjhar District of Odisha*

4.5.2 The estimated potential of small, mini and micro hydel projects in the country is 21,133.65 MW from 7,133 sites located in different States of India. The SHP projects in the country are being set-up both in public and private sectors. Setting up of SHP projects normally require about 3-4 years depending upon its size and location. The national target for SHP is to achieve a cumulative capacity of 5,000 MW by 2022, under overall targets of achieving a cumulative grid connected Renewable Energy Power Projects of 175,000 MW. Against this target of achieving an aggregate capacity of 5,000 MW by the year 2022, an aggregate capacity of 4,750.46 MW been achieved by 31st December 2020 through 1,134 small hydro power projects. In addition, 96 projects of aggregate capacity of 450.80 MW are at various stages of implementation. **Table 4.6** provides state-wise details of identified potential, projects completed and those under execution.

4.5.3 For the year 2020-21, a target of commissioning of 100 MW small hydro projects was set. Against this target, six projects of aggregate capacity of 67.29 MW have been synchronized to the grid by 31st December, 2020 (**Table 4.7**). Actual physical achievement from 01.01.2020 to 31.12.2020 and estimated physical achievement from 01.01.2021 to 31.03.2021 is given in **Table 4.8**.

4.5.4 Under the 'Ladakh Renewable Energy Initiative (LREI)', one mini hydel project namely, Turtuk MHP (500kW) in village Turtuk in Leh was commissioned during current financial year by Ladakh Renewable Energy Development Agency (LREDA). In addition, two Mini Hydro Power Projects in Kargil district, namely, Matayeen (550 kW) and Khandi MHP (1,000 kW) were also completed in all respects during current financial year by Kargil Renewable Energy Development Agency (KREDA) and are ready for commissioning.

Table 4.6 State wise list of potential sites, installed projects and on-going projects in SHP sector (as on 31.12.2020)

Sl. No.	State	Total Potential		Projects Installed						Projects under Implementation	
		Nos.	Total Capacity (MW)	Upto 2019-20		2020-21		Total		Nos.	Capacity (MW)
				Nos.	Capacity (MW)	Nos.	Capacity (MW)	Nos.	Capacity (MW)		
1	Andhra Pradesh	359	409.32	44	162.11	0	0	44	162.11	0	0.00
2	Arunachal Pradesh	800	2064.92	156	131.11	0	0	156	131.11	9	6.05
3	Assam	106	201.99	6	34.11	0	0	6	34.11	1	2.00
4	Bihar	139	526.98	29	70.70	0	0	29	70.70	0	0.00
5	Chhattisgarh	199	1098.2	10	76.00	0	0	10	76.00	0	0.00
6	Goa	7	4.7	1	0.05	0	0	1	0.05	0	0.00
7	Gujarat	292	201.97	14	68.95	1	9.99	15	78.94	7	32.22
8	Haryana	33	107.4	9	73.50	0	0	9	73.50	0	0.00
9	Himachal Pradesh	1049	3460.34	196	911.51	0	0	196	911.51	13	151.60
10	UT of Jammu & Kashmir	103	1311.79	18	141.34	1	5.00	19	146.34	6	31.90
11	UT of Ladakh	199	395.65	28	39.14	1	0.50	29	39.64	9	10.15
12	Jharkhand	121	227.96	6	4.05	0	0	6	4.05	0	0.00
13	Karnataka	618	3726.49	170	1280.73	0	0	170	1280.73	3	13.00

Sl. No.	State	Total Potential		Projects Installed						Projects under Implementation	
		Nos.	Total Capacity (MW)	Upto 2019-20		2020-21		Total		Nos.	Capacity (MW)
				Nos.	Capacity (MW)	Nos.	Capacity (MW)	Nos.	Capacity (MW)		
14	Kerala	238	647.15	34	222.02	0	0	34	222.02	8	80.50
15	Madhya Pradesh	299	820.44	12	95.91	1	3.80	13	99.71	2	7.60
16	Maharashtra	270	786.46	70	379.58	0	0	70	379.58	9	10.40
17	Manipur	110	99.95	8	5.45	0	0	8	5.45	0	0.00
18	Meghalaya	97	230.05	5	32.53	0	0	5	32.53	2	25.50
19	Mizoram	72	168.9	18	36.47	0	0	18	36.47	2	8.50
20	Nagaland	98	182.18	12	30.67	0	0	12	30.67	1	1.00
21	Odisha	220	286.22	10	64.63	1	24.00	11	88.63	2	33.00
22	Punjab	375	578.28	56	173.55	0	0	56	173.55	6	4.30
23	Rajasthan	64	51.67	10	23.85	0	0	10	23.85	0	0.00
24	Sikkim	88	266.64	17	52.11	0	0	17	52.11	1	3.00
25	Tamil Nadu	191	604.46	21	123.05	0	0	21	123.05	0	0.00
26	Telangana	94	102.25	30	90.87	0	0	30	90.87	0	0.00
27	Tripura	13	46.86	3	16.01	0	0	3	16.01	0	0.00
28	A&N Islands	7	7.27	1	5.25	0	0	1	5.25	0	0.00
29	Uttar Pradesh	251	460.75	9	25.10	1	24.00	9	49.10	1	1.50
30	Uttarakhand	442	1664.31	102	214.32	0	0	102	214.32	14	28.58
31	West Bengal	179	392.06	24	98.50	0	0	24	98.50	0	0.00
Total		**7133**	**21133.62**	**1129**	**4683.17**	**6**	**67.29**	**1134**	**4750.46**	**96**	**450.80**

Table 4.7: List of SHP Projects Commissioned during 2020-21 (till 31.12.2020)

S. No.	State	Name of the project	Capacity (MW)	Name of the Agency/Developer
1	Gujarat	Kachchh Branch Canal, SHP-1, Banaskantha	**9.99**	Sardar Sarovar Narmada Nigam Limited
2	Jammu & Kashmir	Ichoo SHP, Anantnag	**5.0**	M/s O2Z Trading and Industries Pvt. Ltd.
3	Madhya Pradesh	Amhata-III, Rewa	**3.80**	M/s Amhata Hydro Energy Pvt. Ltd.
4	Odissa	Baitarani SHP, Keonjhar	**24.0**	M/s Baitarani Power Project Pvt. Ltd.
5	UT of Ladakh	Turtuk SHP, Nubra Valley	**0.50**	Ladakh Renewable Energy Development Agency
6	Uttar Pradesh	Dhukwan SHP, Jhansi	**24.0**	THDC India Limited
Aggregate Capacity			**67.29**	

Table 4.8: Actual Physical Achievement from 01.01.2020 to 31.12.2020 and Estimated physical achievement from 01.01.2021 to 31.03.2021.

Actual physical achievement from 01.01.2020 to 31.12.2020	Estimated physical achievement from 01.01.2021 to 31.03.2021
78.95 MW	**35 MW**

4.6 WASTE TO ENERGY

4.6.1 Programme on Energy from Urban, Industrial, Agricultural Wastes and Residues

i. During the year 2020-21, the Ministry has continued the implementation of the Programme on Energy from Urban, Industrial and Agricultural Wastes and Residues aimed at generation of biogas, Bio-CNG and Power from different wastes, such as Municipal Solid Waste, vegetable and other market wastes, slaughterhouse waste, agricultural residues and industrial wastes & effluents. In addition to Bio-CNG/Biogas, biogas plants generate organic fertilizer as a by-product which is valuable for agricultural fields.

ii. Such projects are being set up in a number of industry sectors namely distillery, paper and pulp solvent extraction, dairy, starch industries, sugar mills, pharmaceutical industries and sewage treatment plants.

4.6.2 Objectives of the Scheme:

i. To promote setting up of projects for recovery of energy in the form of Biogas / Bio-CNG / Power from Urban, Industrial and Agricultural Waste and Captive Power and Thermal use through Gasification in Industries.

ii. To promote setting up of projects for recovery of energy from Municipal Solid Waste (MSW) for feeding power into the grid and for meeting captive power, thermal and vehicular fuel requirements.

iii. To promote Biomass Gasifier for feeding power into the grid or meeting captive power and thermal needs of rice mills/other industries and villages.

iv. To create conducive conditions and environment, with fiscal and financial regime, to develop, demonstrate and disseminate utilization of wastes and residues for recovery of energy.

4.6.3 Subsidy, Grants and Incentive provided under the Scheme:

Central Financial Assistance (CFA) for projects of different categories is given in the form of capital subsidy to the promoters and in the form of Grants-in-Aid for other activities, as given below:

i. Biogas generation: Rs.1.0 crore per 12000cum/day (Maximum CFA-Rs.10 crore/project)

ii. Bio-CNG generation (including setting of Biogas plant): Rs.4.0 Crore per 4800Kg/day;

iii. Power generation based on Biogas (Maximum CFA- Rs.10 crore/project):

- Gas engine/turbine route: Rs.3.0 Crore per MW
- Boiler+Steam turbine route: Rs.1.5 crore / MW

iv. Power Generation (based on MSW/ RDF): Rs.5.0 crore /MW (Maximum CFA- Rs. 50 crore/project)

v. Power (Based on BTG route): Rs.0.50 crore/MW (Maximum CFA - Rs.10 Crore/Project)

vi. Biomass Gasifier:

* Rs. 2,500 per kWe with duel fuel engines for electrical application
* Rs.15,000 per kWe with 100% gas engines for electrical application
* Rs. 2 lakh per 300 kWth for thermal applications.
* Rs.10,000 per kWe for 100% producer gas engines with Gasifier system for electrical applications
* Rs.8000 per kWe for 100% producer gas engine alone for electrical applications

4.6.4 This programme is also supporting the **Sustainable Alternative Towards Affordable Transportation (SATAT)** initiative of Ministry of Petroleum and Natural Gas (MoPNG) for boosting production and availability of Compressed Bio-gas (CBG) as an alternative and affordable clean fuel for transportation sector. Under the SATAT initiative 5000 CBG plants are envisaged to be installed by 2023-24.

4.6.5 Progress during the year 2020-21

i. **Physical Achievement:** During the year 2020-21 (as on 31.12.2020), the capacities added in respect of various output products are given in **Table 4.9:**

Table 4.9 Progress of Product Output and Capacity Addition during 2020-21

Sl. No.	Output Product	No of plants	Capacity Addition in 2020-21 (as on 31 Dec 2020)	States
1	Biogas	2	35,000 m^3 per day	Maharashtra
2	Bio-CNG / CBG	3	12,440 kg/day	Gujarat, Chhattisgarh and Andhra Pradesh
3	Power	3	22.20 MW	Haryana, Telangana and Maharashtra

ii. **Biourja Application Portal:** The Ministry of New and Renewable Energy has successfully launched the Biourja Application Portal (www.biourja.mnre.gov.in) to provide service to all bio-energy project developers to smoothly proceed through the administrative procedure. The digital platform will manage projects related to waste-to-energy, biomass gasifier and biomass cogeneration. This agile platform was born out of the necessity to streamline the processing mechanism of the applications received for installation of systems. The modular design of the portal provides a robust application management system with its end-to-end solution from submission to installation and is well-equipped to adapt to the changing policies and regulations.

iii. **Concessional Custom Duty Certificates (CCDC)** are issued by the Ministry for Import of machinery and components required for initial setting up of projects for generation of Power from non-conventional materials namely agricultural, forestry, agro-industrial, industrial, municipal and urban waste, bio waste or poultry litter.

4.6.6 Projects benefitting from CCDCs

i. CCDC for import of (i) Steam Turbine and (ii) Boiler Grate & Furnace Refractory Components required for setting up 8MW Waste to Energy plant for power generation based on 550 Tons per day of Municipal Solid Waste (MSW) at Murthal, Sonipat, Haryana by M/s JBM Environment Management Pvt Ltd., Gurugram

ii. CCDC for importing MSW pre-processing equipment required for initial setting up the 13.19 MW MSW based Power Generation Project from 750 Tons per day of Municipal Solid Waste in Ramtekdi Industrial Estate 2, Hadapsar, Taluka-Haveli, Pune, Maharashtra by M/s. Pune Bio-Energy Systems Pvt. Ltd.

4.6.7 Cumulative Physical Achievement: As on 31.12.2020, the total installed capacity is 373.54 MWeq including 168.64 MW capacity of Grid-interactive Waste to Power projects, 204.90 MW capacity Off-grid Waste-to-Energy projects. The generation details as well as the output till 31.12.2020 are given in **Table 4.10:**

Table. 4.10 The Product Output and Cumulative Capacity of Waste-to-Energy Projects

Sl. No.	Output product	Cumulative capacity
1	Biogas	7,43,508 m3 per day
2	Bio-CNG/CBG	97,199 kg per day
3	Power (Grid & Offgrid)	291.34 MW

4.7 OFF-GRID RENEWABLE POWER

4.7.1 Biogas Power

Power Generation from Biogas offers a good potential in rural areas especially if they are far from the grid.

4.7.2 Biogas Power (Off-Grid) Generation and Thermal application Programme (BPGTP)

The Ministry is implementing Biogas-based Scheme/Programme for promoting biogas generation for Off-grid/distributed and decentralized Renewable Power applications in the capacity range of 3 kW to 250 kW and also for thermal energy applications having biogas generation capacity in the corresponding matching size range of 30 M^3 to 2,500 M^3 per day. The organic bio-degradable wastes from various sources such as cattle dung/animal wastes, food and kitchen waste, poultry dropping and agro-industry waste etc., are the feed stock for Biogas plants.

4.7.3 Implementation of BPGTP

The Biogas based Power Generation and Thermal Application Programme (BPGTP) is implemented through the Agriculture and Rural Development Departments of the States, Dairy Co-operatives, State Nodal Agencies (SNAs), Biogas Development and Training Centres (BDTCs), Khadi and Village Industries Commission (KVIC) and National Dairy Development Board (NDDB) from the year 2019-20.

4.7.4 Central Financial Assistance (CFA) For BPGTP

The CFA under the programme is provided varying from ₹25,000 per kW to ₹40,000 per kW for power generation as per the generation capacity slabs and ₹12,500 per kW to ₹20,000 per kW for thermal applications respectively. The CFA rates also vary depending upon the category of beneficiaries and regions/ States such as SC and ST categories and North Eastern Region States.

4.7.5 Achievements

During the year 2020-21, 4 projects have been commissioned with power generation capacity of 300 kW and corresponding biogas generation capacity of 2,500 M^3 per day. With this, the cumulative total of 325 biogas-based projects with a total power generation capacity of 7.587 MW with a cumulative total biogas generation of 72,351 M^3 per day have been set up in the country, up to 31.12.2020. Further against a target of sanction for setting up 50 new projects, 22 projects have been sanctioned for installation up to 31.12.2020.

4.7.6 Scheme to Support Biomass-Based Cogeneration in Sugar Mills and other Industries – Non-Bagasse Cogeneration (Off Grid)

Industrial and commercial sector consumes around 51% of total electricity generated. To augment its growing energy needs, industries add captive power capacity through fossil fuels such as coal, oil or natural gas. Several industries which require electrical as well as thermal energy for their operations, meet it through a mix of energy sources. A good alternative would be through co-generation. The power and steam generated from co-generation plants meet the captive requirements and the surplus power produced can be exported to the grid. Such projects are being set up in a paper and pulp industries, cement, textiles, pharmaceutical industries and rice mills, among others.

The scheme to support promotion of biomass-based co-generation in sugar mills and other industries has been under implementation since 11.05.2018 for harnessing the vast potential of biomass power in the form of thermal energy and power for captive use. The benefits from the programme are:

i. To promote efficient and economic use of surplus biomass for power generation.

ii. To aid the environmentally safe utilisation of surplus agro-residue which if left un-utilised will be disposed off by burning in open fields.

iii. To maximize surplus power generation from sugar mills using improved technologies.

iv. To promote technologies of co-generation for supplementing conventional power.

Under the scheme a Central Financial Assistance (CFA) at the rate of ₹50 lakhs per MW (Non-bagasse cogeneration projects) is being provided. CFA is released on reimbursement basis. Availing loan from any financial institution is mandatory for promoters to avail CFA.

4.7.7 Achievements

Over **200** biomass (non-bagasse) cogeneration plants with aggregate capacity of **772 MW** have been installed in the country till December, 2020.

CHAPTER

5

RENEWABLE ENERGY FOR RURAL APPLICATIONS

RENEWABLE ENERGY FOR RURAL APPLICATIONS

5.1 The MNRE is implementing and supporting Biogas Schemes for dissemination and deployment of biogas plants in remote, rural and semi- urban areas of the country. Biogas production is based on the anaerobic digestion of organic wastes/materials. Biogas is cheap, clean and environment friendly gaseous fuel for cooking, lighting and running biogas engines for motive power & electricity generation on farms. The biogas plant digested slurry contains enriched organic Nitrogen, Phosphorus and Potash (NPK) and also other major plant micronutrients free from weed seeds, smell and pathogens.

5.2 NEW NATIONAL BIOGAS AND ORGANIC MANURE PROGRAMME (NNBOMP)

The NNBOMP scheme, a central sector scheme aims for setting up small Biogas Plants in the size range varying from 1 M^3 to 25 M^3. The NNBOMP's objectives is to provide green and clean renewable gaseous fuel for cooking, lighting and small power needs of the potential farmers, cattle farmers/ users including individual households and to facilitate management and utilization of biogas plant produced slurry as an organic enriched Solid Biogas Fertilizer. In India, Biogas plants have generally used cattle dung with the option of linking with sanitary toilets.

5.2.1 Programme Implementing Agencies (PIAs) of NNBOMP

The details of the Scheme are as follows:

1. The NNBOMP is being implemented through multi-agency approach by designating the following as the Programme Implementing Agencies (PIAs) of the Scheme in the States/ UTs

   a. State Rural Development Departments (SRDDs)

   b. State Renewable Energy Agencies/Departments.

   c. Khadi and Village Industries Commission (KVIC).

   d. Biogas Development and Training Centres (BDTCs).

   e. National Dairy Development Board (NDDB).

2 The new scheme Guidelines have been made effective since 01.04.2018, to make it reachable to all states/UTs making life style changing for remote, rural and semi-urban households/ dairy farmers /Agriculture farmers etc., as far as the supply of clean and renewable gaseous fuel for cooking/lighting and biogas digested slurry is concerned. The biogas plant digested slurry is an excellent organic fertilizer /manure offering alternatives to replace costly chemical fertilizers such as Urea & DAP and have sustainable agriculture and soil health.

3. Biogas being a clean cooking fuel and produced from the wastes available at the doorsteps of the potential beneficiaries along with simultaneous production of organic nutrients enriched slurry provide opportunity to have reduction in cost/saving on an average by ₹ 9,000 to ₹ 12,000 per year, considering the plant size of 1 to 4 M^3. The efforts of setting up biogas plants across the country are contributing towards doubling the income of Farmers.

5.2.2. Subsidy and other Central Financial Assistance for setting Biogas Plants under New National Biogas and Organic Manure Programme (NNBOMP)

Under the NNBOMP, the Central Subsidy is being provided for installing biogas plants of size 1 M^3 to 25 M^3, which varies from ₹ 7500 per plant of 1 M^3 to ₹ 35,000 per plant of size 20-25 M^3. Besides this, financial support is also provided for turnkey job fee for construction, supervision etc. It also provides support for skill development programme for Biogas Mitras and to BDTCs for conducting training courses. The subsidy amount depends upon the size of a biogas plant installed, States or Regions, beneficiary category and North Eastern Region States. In addition, the States/UTs implementing the scheme are also provided administrative charges as well as trainings and publicity & technical supports through Biogas Development and Training centres (BDTCs).

5.2.3 Biogas Development and Training Centers (BDTCS)

Under the National Biogas and Organic Manure Programme, eight Biogas Development and Training Centers (BDTCs) have been established with the objective to set up good quality biogas plants as per established technical criteria and to generate sustained trained manpower in the sector of Biogas Technology. Their main functions are to extend Technical, Training and Publicity support required by the States/ UTs for the beneficiaries, including training and skill development in Biogas sector, dissemination of knowledge and publicity of biogas schemes in close co-ordination with the State Programme Implementing Agencies of NNBOMP.

Fig. 5.1 : *Biogas Power-Off-grid Project (S&P Feeds Pvt. Ltd., Vill Post- Thengoda, Block Taluka-Baglan, District-Nashik-423301 (Maharashtra)*

5.2.4 Achievements under the National Biogas Programme

A target of setting up 60,000 small Biogas Plants has been allocated to the States/ UTs for the year 2020-21. The progress under the New National Biogas and Organic Manure Programme (NNBOMP); the State/UT-wise estimated potential and cumulative achievements of small biogas plants under the NNBOMP up to 31.03.2020 and cumulative achievements as on 31.01.2021 are given in **Table 5.1**.

Table 5.1: State-wise estimated potential and State/ UT wise achievements for family type/ small biogas plants, from 1981-82 to 2019-20 under the National Biogas and Manure Management Programme (NBMMP) and Targets and achievements under NNBOMP during the year 2020-21 (up to 31.01.2021).

State/ Union Territories	Estimated Potential (Nos. of Biogas Plant units)	Cumulative achievement up to 2019-20 (31/03/2020) (Nos. of Biogas Plant units)	Targets and achievements under NNBOMP during 2020-21 (Biogas Plants in nos.)	
			Target (2020-21)	Total achievements of 2020-21 (as on 31.01.2021)
1	2	3	4	5
Andhra Pradesh	1065000	262011	4100	1089
Arunachal Pradesh	7500	3609	200	0
Assam	307000	138483	3400	400
Bihar	733000	129905	600	0
Chhattisgarh	400000	59850	2000	262
Goa	8000	4226	200	8
Gujarat	554000	435097	700	0
Haryana	300000	63221	1600	177
Himachal Pradesh	125000	47680	400	0
Jammu & Kashmir	128000	3195	300	0
Jharkhand	100000	7823	800	0
Karnataka	680000	510902	7000	1525
Kerala	150000	153001	1500	428
Madhya Pradesh	1491000	376538	4600	1022
Maharashtra	897000	925235	7000	912
Manipur	38000	2128	200	0
Meghalaya	24000	11156	300	0
Mizoram	5000	5856	200	1
Nagaland	6700	7953	200	0
Odisha	605000	271772	1400	30
Punjab	411000	185947	3500	998
Rajasthan	915000	72438	4800	132
Sikkim	7300	9044	300	0
Tamil Nadu	615000	223792	900	23

State/ Union Territories	Estimated Potential (Nos. of Biogas Plant units)	Cumulative achievement up to 2019-20 (31/03/2020) (Nos. of Biogas Plant units)	Targets and achievements under NNBOMP during 2020-21 (Biogas Plants in nos.)	
			Target (2020-21)	Total achievements of 2020-21 (as on 31.01.2021)
Telangana	0	316645	1000	0
Tripura	28000	3710	600	04
Uttar Pradesh	1938000	440915	1000	206
Uttarakhand	83000	364540	1000	433
West Bengal	695000	972	800	0
A&N Islands	2200	97	200	0
Chandigarh	1400	169	0	0
Dadra & Nagar Haveli	2000	681	200	0
Delhi/ New Delhi	12900	578	0	0
Puducherry	4300	17541	200	0
KVIC	-	1344	5200	673
NDDB, Anand	-	-	3600	160
TOTAL :	**12339300**	**5058054**	**60000**	**8483**

Fig. 5.2 *Biogas Plant at Village Chak Gulam Distt. Fazilka capacity 6 M³*

5.2.5 Biogas Application Web Portal & Mobile App for NNBOMP

The end-to-end management of the application processing will significantly reduce the time taken for the approval and the digital platform will allow seamless communication between the stakeholders. Therefore, MNRE developed the Biogas Application web Portal & Mobile application has been developed for NNBOMP scheme to provide service to all smaller biogas project proponents

to smoothly proceed through the administrative procedure. The biogas portal will act as a central repository where all the documents are stored chronologically and Efficient application tracking and monitoring at every stage. Detailed procedure for registration in the Portal, Forms, Help Desk, FAQ are given at the biogas portal.

The following services in respect of the MNRE's NNBOMP scheme has been started online through BIOGAS portal (**https://biogas.mnre.gov.in**)

a. Registration of State Programme Implementing Agencies (PIA);
b. Registration of Eligible Biogas Installer by the PIA;
c. Registration of Inspectors by the PIA;
d. Uploading the demand raised by Consumer;
e. Uploading of the work allocation to the installers by PIA;
f. Uploading the information on Project Sanctions;
g. Scheduling of Operation & Maintenance of the Installed Biogas Plant

The following services in respect of the NNBOMP scheme has been started online through Android Mobile App (available on google play store with the name of BIOGAS INDIA): -

a. Uploading the information of biogas beneficiary's details & plant installations;
b. Uploading all the information of the Biogas plant after the Plant Inspection.

CHAPTER

6

THIRD GLOBAL RE-INVEST CONFERENCE

CHAPTER

7

RESEARCH, DEVELOPMENT AND DEMONSTRATION (RD&D) IN NEW AND RENEWABLE ENERGY

RESEARCH, DEVELOPMENT AND DEMONSTRATION (RD&D) IN NEW AND RENEWABLE ENERGY

7.1 INTRODUCTION:

Research, design, development and technology demonstration for its validation are one of the core requirements for the growth of New and Renewable Energy. Ministry of New & Renewable Energy (MNRE) supports Research, Development and Demonstration (RD&D) to develop new and renewable energy technologies, processes, materials, components, sub-systems, and sets standards to enable indigenous manufacture of new and renewable energy systems and devices. MNRE initiates resource assessments to identify and confirm potential. The objective of the programme is to make the industry globally competitive in renewable energy generation, self-sustainable/profitable and thereby contribute to increase share in total energy mix in the country.

7.2 SUPPORT TO RD&D IN INDUSTRY AND INSTITUTIONS:

MNRE evaluates financial support RD&D Projects received from R&D institutions and universities, industries and NGOs active in the field of solar, wind, solar-wind hybrid, storage, small hydro power, biogas, hydrogen and fuel cells, and geothermal among others.

7.3 POLICY AND GUIDELINES

A comprehensive policy framework on RD&D is in place to support R&D in new and renewable energy sector, including associating with and supporting the demonstration of products and devices emerging out of industry for market development and deployment. The Ministry provides up to 100% financial support to Government, non-profit research organizations and NGOs; and up to 50% support to Indian industry.

The policy framework provides guidelines for project identification, formulation, monitoring, appraisal, approval and financial support. The RD&D projects received from R&D centres, academic institutions and industries, are evaluated by domain experts. The qualifying projects are appraised by R&D Project Appraisal Committees. The projects recommended by these Committees are sanctioned to prospective implementing agencies. The projects are monitored by Monitoring Committees. Projects on completion are reviewed in Project Appraisal Committee Meetings for their achievements.

7.4 RD&D FOCUS

The RD&D efforts are continued with emphasis on cost reduction, reliability and efficiency improvement. The projects in accordance with the identified R&D thrust area of the Ministry in the areas of Solar Thermal, Solar Photovoltaic, Biogas, Wind, Wind-hybrid, Energy Storage, Small Hydro Power, Hydrogen and Fuel Cells, Geothermal, etc. are supported for RD&D activity. The projects in other areas not covered under the R&D thrust areas are also considered for financial support based on their applications and practical importance.

7.5 INSTITUTIONAL MECHANISM

The Ministry is supporting creation of enabling conditions for institutional mechanism for collaboration for faster development and demonstration of technology for commercialization. The Ministry has taken initiatives strengthening its institutions, namely, National Institute of Solar Energy (NISE), Gurgaon, National Institute of Bio-Energy (NIBE), Kapurthala and National Institute of

Wind Energy (NIWE), Chennai with their functions for pursuing RD&D, testing, standardization and certification in solar, bioenergy and wind energy systems, respectively.

In addition, the MNRE is also partnering with Ministry of Education for implementation of research projects in NRE under Impacting Research Innovation and Technology (IMPRINT) and Uchhatar Avishkar Yojana (UAY) initiatives. These initiatives envisage supporting projects in consortia including industry for technology development on cost sharing basis by partner ministries, departments and industries.

7.6 SOLAR R&D

The details of activities being carried under Solar R&D (SPV) are given below:

7.6.1 Solar Photovoltaics:

Project 1: The Ministry's flagship project in Solar Photovoltaics being implemented at IIT Bombay and named National Centre for Photovoltaic Research and Education (NCPRE) Phase II, has several major areas. The progress made in each of these areas is briefly described below.

Education and Training: Various courses, workshops and training sessions were organized to extend the knowledge gathered at NCPRE to industry personnel, faculty and students from other organizations and institutions. Short-term courses on Crystalline Silicon, Thin Film, Energy Storage, Power Electronics and Module Reliability were developed and offered at this Centre. Various topics on which the short term and CEP courses were organized includes: Energy Storage for Solar PV Application, Theory and Technology of Silicon Solar Cells, Perovskite Solar Cells and Power electronics interface for PV. Furthermore, workshops were conducted on Accelerating Research and Data Driven Standards Development for Improving Quality and Reliability of Solar PV in India and Industry collaboration with NCPRE.

The facilities developed at NCPRE are unique and of its kind, to extend these to the reach of researchers working on PV across India, a pilot project called Photovoltaic Users Mentorship Programme (PUMP) is being implemented at NCPRE. Hands-on training was organized to familiarize the participants from various academic institutions and promote their interaction with NCPRE investigators through this initiative.

Fig 7.1: *Test Lab for PV Panels and Arrays*

Theme-based proposals from researchers at various academic institutions and R&D labs were invited with the objective that the people working in the area of PV in other institutions can get benefited from the expertise of investigators and the facilities built at NCPRE through funding from MNRE. They can come up with their innovative ideas and can use the facilities as well as receive guidance and mentorship from NCPRE. Under the PUMP initiative, seventy-two proposals were received, out of which thirty are in Thin Film and rest mostly in crystalline Si and few related to other research areas. Sixty-two proposals have been selected, out of which 27 are completed, 20 are under revision, one is ongoing and 14 are approved. These proposals were reviewed by NCPRE team members and based on the quality and relevance of these proposals required mentorship has been provided.

Crystalline Si Solar Cells: Standard Al:BSF Solar cells with champion cell efficiency of 19.4 % were made on 6 in x 6 in, pseudo-square, mono Si wafers. All the processes were carried out at NCPRE. Also, 18 % efficient, 6 in x 6 in mc-Si solar cells employing the texturization process developed at NCPRE for diamond wire sawn (DWS) wafers are made. (An Indian Patent has been applied for this process). Multi-crystalline Si wafer cells with wafers made at SSN College are demonstrated. For PERC cell process, a spray technique was developed for the deposition of SiO2, and Al2O3 layers (Indian patent applied) for surface passivation. A customized laser tool for contact opening for the rear contacts in Silicon for PERC cells, developed with an Indian manufacturer. Silver paste is being developed at NCPRE for contact printing in Silicon solar cells with initial promising results (JSC and VOC comparable to the Al-BSF baseline). An electro-luminescence and photo-luminescence set up is developed and is ready for licensing. A 15.24 % (active area) efficient, 2.32 sq. cm, Carrier Selective Contact solar cell was developed employing a MoO3/ n-Si(Fz) structure. Some of the Test results are presented in **Fig. 7.2a, 7.2b and 7.2c**.

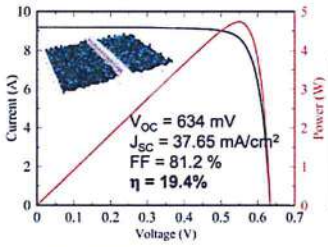


Fig. 7.2a *Representative performance of Al-BSF cells fabricated at NCPRE.*

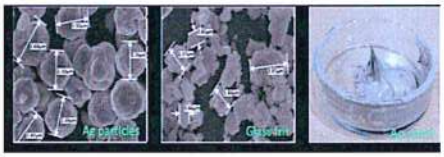


Fig. 7.2b *Silver paste developed at NCPRE. Further improvements are in progress.*

Fig. 7.2c *EL/PL setup developed at NCPRE.*

Thin Film Materials and Devices: Single junction perovskite solar cells having power conversion efficiency (PCE) of 19.7%@area 0.2 cm2; 17%@area 0.42 cm2 and 12.2%@1 cm2 was fabricated. Semi-transparent single junction perovskite solar cells with PCE of 10.3%@area 0.2 cm2 with an aim to further improve it and apply it on a Perovskite/Si tandem junction solar cell. **(Fig. 7.3)**.

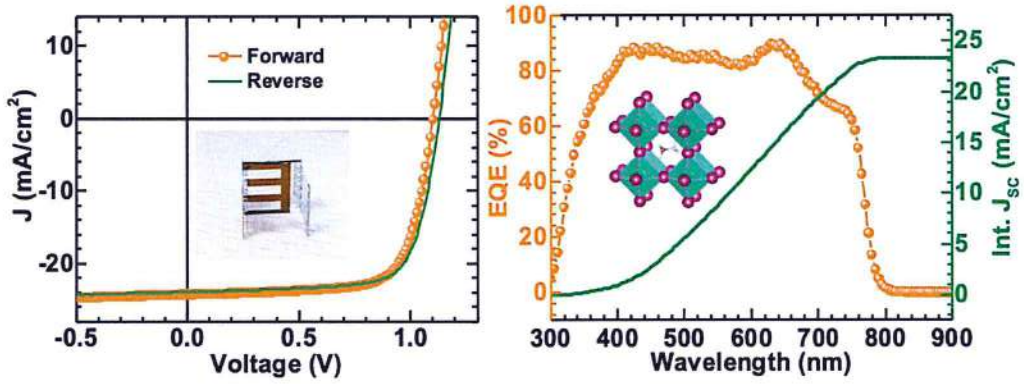


Fig. 7.3 *Characteristics of Single Junction Perovskite Solar Cells fabricated at NCPRE*

Energy Storage: The design of Li-ion pouch cell was modified in order to improve the stability and more than 100 such cells were made with a capacity of 10 Ah. Design optimization employing NMC-

graphite chemistry further led to stable pouch cells with a capacity of 7-10 Ah. **(Fig. 7.4)**.

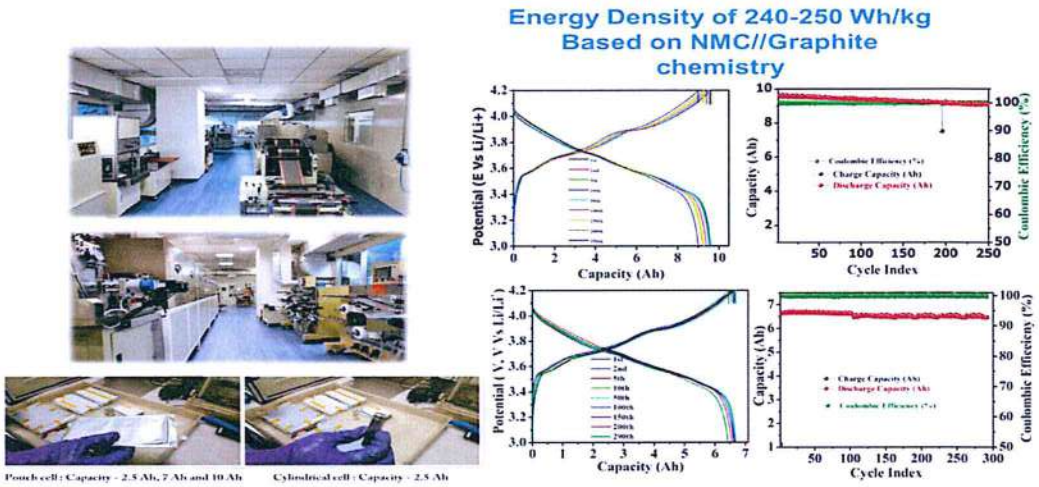


Fig. 7.4: *Lithium and sodium ion battery Fabrication facility and 10 Ah, 7 Ah pouch cell cycling behavior (C/8 rate) at 20 °C.*

Power Electronics: As an advancement on 300 VA inverter developed in NCPRE Phase 1 project, design parameters have been finalized for and 5 prototype inverters in each of 500 VA (stand-alone) and 2.5 kVA (grid connected) categories are being assembled for field testing **(Fig. 7.5a)**. Also, the first prototype for 3HP BLDC motor with the surface pump assembly is manufactured **(Fig. 7.5b)**. Sensor-less control algorithm for this motor is simulated in MATLAB and control PCB for the same is designed in DIPTRACE. Further a comprehensive test bench comprising of solar emulator, battery emulator, and an electronic load is developed to test solar inverters up to a rating of 25 kVA.

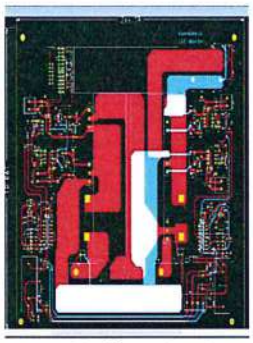


Fig. 7.5a. *Field testing Inverters*

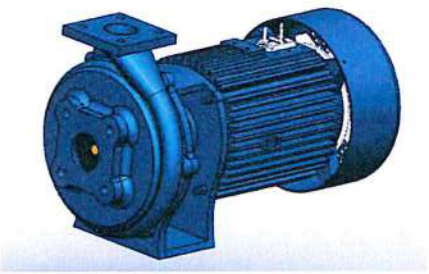


Fig. 7.5b. *3 HP Brushless Direct Current Motor*

Module Reliability: All India Survey of PV Module Reliability 2018 was completed and the report was published. Key factors responsible for high degradation such as Potential Induced Degradation, Cell Cracking, Metallization Degradation etc were identified. Guidelines for designing flood-resilient power plants were developed after a survey of flood affected PV plants in India. NCPRE actively contributed in the development of the IEC TS 63126:2020 ED1 Guidelines for qualifying PV modules, components and materials for operation at high temperatures. This IEC technical specification is especially designed to qualify modules in high temperature environments. The new bypass

diode test proposed by NCPRE is part of this standard. Also, significant progress has been made in understanding the root causes of the rapid degradation of anti-soiling coatings in the field. Role of stressors such as UV light, abrasion, acidity and impact of rain drops is being studied with a goal to develop a reliability test for qualification of anti-soiling coatings in Indian climates.

Similarly, experimental data regarding the vibration levels experienced by PV modules during transportation on Indian roads is being collected with an aim to propose a transportation standard tailored for Indian conditions. A dynamic load test facility (**Fig. 7.6a**) with in-situ EL imaging (**Fig. 7.6b**) has been developed to identify the crack-resilient module designs by studying the propensity to undergo cell cracking. Several students were facing problems in remotely attending online classes due to poor electricity connection in the COVID-19 pandemic. NCPRE developed solar based electricity backup solutions which the students can self-assemble using off-the shelf components. A Do-It-Yourself manual based on these solutions was prepared and shared with all engineering colleges affiliated with AICTE and all students of IIT Bombay. It was read over 12,300 times within few months from the date of publication.

Fig. 7.6a : *Dynamic Load testing facility*

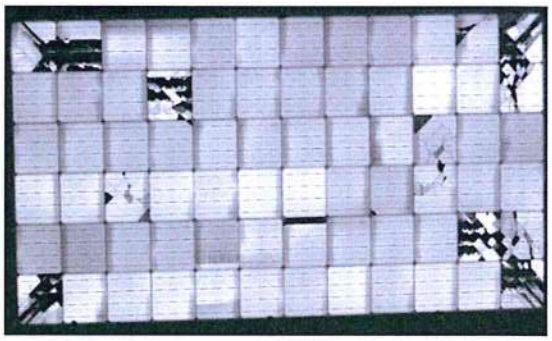


Fig. 7.6b: *In-situ EL imaging to identify the crack-resilient module designs*

The MNRE sponsored project on perovskite based thin film solar cells being implemented at IIT Bombay and showed 18% efficiency and sustained 1,000 bending cycles. In another phase in the area of Flexible Perovskite Solar Cells and Intermediate Module with a target of Laminated Roll to Roll devices with >18% efficiency with T80>10,000 hrs.

Project 2: In the on-going project on development of high efficiency solar cells using n-type Si wafers at the Meghnad Saha Institute of Technology (MSIT), Kolkata, baseline solar cells have been fabricated on small (76 mm x 76 mm), n-type mono-Si wafers with champion efficiency of 16.8 %. The project has been continued to achieve 20-22% efficiency on 6 inch x 6 inch wafer.

Project 3: NISE has completed a R&D project with Surya Enertec, a Gurugram-based private company in developing Solar-powered Clean Drinking Water Systems suitable for various locations in the country. Five machines have been designed and fabricated. The controller and remote monitoring system have been developed and fabricated in-house. First Solar Powered drinking water station was designed and fabricated. System of 500 LPH capacity has been powered by multi-crystalline solar panels installed on the roof. It was installed at the NISE campus in April 2017. New 100 LPH has been installed in the Aditya Bhavan of NISE. This machine is highly energy efficient and consumes about 600 W power only for a capacity of 100 LPH. It is a completely DC system and does not involve

an inverter. Third water purification machine of 500 LPH capacity is installed in a village: Khurampur, Distt Gurgaon. Fourth water purification machine of 200LPH capacity is installed at Safdarjung Hospital Delhi. Fifth machine of capacity 200 LPH is installed at Civil Hospital, Gurugram.

Project 4: The MNRE has also sponsored a project on Solar Photovoltaics for development of high efficiency Passive Emitter and Rear Contact (PERC) solar cells. The PERC cell project is being implemented jointly by BHEL-ASSCP. In this project, BHEL has the responsibility of cell processing while NISE has the responsibility of device simulation as well as complete characterization of solar cells. BHEL has installed all the three equipment pertaining to PERC cell fabrication viz. Diffusion furnace, Plasma Enhanced Chemical Vapor Deposition (PECVD) tool for dielectric deposition and Laser system for dielectric ablation (photographs attached). The experimental trials are being carried out extensively for the individual process steps and an indigenous PERC cell shall be fabricated within the stipulated time.

Project 5: The MNRE has sanctioned new R&D projects entitled Design and Development of high performance supercapatteries for solar applications (Solar Lantern, Solar Home Light)" implemented by Dr. S. P. Gairola, Uttaranchal University Dehradun and Dr. Yogesh Kumar Sharma, Indian Institute of Technology, (IIT-Roorkee).

7.6.2 Solar Thermal

The details of activities being carried under Solar Thermal (ST) are given below:

Project 1: 1 MWe (3.5 MWth) solar thermal power plant with 16 hours thermal storage for continuous operation based on parabolic dish solar concentrators designed and fabricated indigenously, at an estimated solar to electricity efficiency of about 16-18 %. The configuration of the power plant will include 770 solar dishes having a provision of thermal storage and each having 60 M^2 area. **(Fig. 7.7)**. The project was successfully commissioned and working satisfactory on 24 x7 basis. It is unique world class thermal power plant based on cast iron cavity heat storage.

Fig. 7.7: *One MWe (3.5 MWth) Solar Thermal Power plant based on Parabolic Dish Solar concentrators*

Project 2: Indian Institute of Science (IISc), Bangalore, has developed its prototype of pressurized air solar receiver, as part of the project titled "Development of High Efficiency Receiver for Supercritical

CO2 Integrated with Static Focus Parabolic Dish". The hybrid volumetric and cavity type receiver design consists of open-end dome-end cylindrical cavity surrounded by concentric annular porous medium, as shown in the figure below. Receiver design provides flexibility of testing different materials – steel mesh, ceramic honeycomb and foams. The receiver has been tested with a Scheffler dish concentrator having a fixed focus. The solar simulator facility under this project is being designed, built and characterized by IISc Bangalore in collaboration with 3EN CleanTech Pvt. Ltd., Dharwad, Karnataka.

Fig. 7.8: *Installation of Cast Iron receiver with piping and Insulation*

Project 3: The Ministry has sanctioned an R&D Project entitled Development of a Monitoring System for the Energy Reception Elements in Solar Thermal Plants to TERI, New Delhi in collaboration with M/s Eptisa, Spain. The project is to develop a reliable, low-cost tool that gives a precise and direct evaluation of the optical efficiency of each solar collector element including identification of the cause of the error. This project has achieved its objectives of development of technique and system. The research collaborators have developed LiDAR (Light Detection and Ranging) technology with specially developed the software for measuring the misalignment of absorber tube of PTC. The project collaborators have demonstrated the system and are now exploring possible commercialisation opportunities.

Fig. 7.9: *Light Detection and Ranging (LiDAR)*

Project 4: Ram Krishna Dharmarth Foundation (RKDF) University at Bhopal, in Collaboration with Rensselaer Polytechnic Institute (RPI) of USA, are jointly executing a project on System Design, Erection, Testing & Commissioning of 40 kWth and 10 kWe pilot plant with 24x7 Thermal storage'. This MNRE sponsored Solar Thermal Project is aiming at the feasibility Study

of MWe Scale Concentrated Solar Thermal Plant integrated with 24x7 Thermal Energy Storage. The Thermal storage device has been developed at ENLYS Energy, Hampton, USA jointly designed by RKDF & RPI Universities through a series of experiments on Halide salt in the year 2015-17 through a test bed designed to produce solar heat at over 1,400 oC and having energy density in excess of 300 kWh / m^3.

***Fig. 7.10** : Solar Thermal Power Plant at RKD Foundation University*

The novelty of project lies in indigenous production of the Thermal Storage material and the uniqueness of the Energy storage is the heat transfer of solid media to produce steam.

As regards the application aspect of this solar thermal project with 8 Scheffler discs of 16 m^2 is concerned, this impact project is also being used in the nearby Carbon sequestration plant in re-generation of solvent, a novel concept being tried first time in the country as shown below:

***Fig. 7.11:** Solar Thermal Integrated Carbon Capture Plant at RKD Foundation University*

Project 5: The MNRE has also sponsored for Development of Supercritical CO_2 Turbomachinery for

Solar Thermal Power Plants to Indian Institute of Sciences (IISc), Bangalore. The main objective of the project is to conceive turbomachinery of different design configurations suitable for testing and analysis on the existing test loop at IISc.

After the aeroloop testing of the turbine-compressor mechanical assembly at higher speeds (up to 70,000 rpm), the mechanical housing was modified to incorporate the permanent magnet generator and cooling jacket inside. The manufacturing of the new housing and mechanical assembly were completed. Bharath Bijlee developed a bi-directional high-speed drive specifically for this with the help from KBL, Germany. PI aimed to succeed in converting the generator to run in reverse mode, as a motor for driving the compressor. The new assembly with generator **(Fig. 7.12)** was run in motor mode to see the assembly stability at different speeds. The system is being analysed to sort out the issue. Turbomachinery design for the 1 MW supercritical CO2 loop (TIT: 550°C) was completed using meanline design and scaling methodologies and was verified using CFD simulations.

Fig. 7.12: *Motor mode testing of the turbine-compressor assembly with generator*

Project 6: Central Tasar Research & Training Institute (CTR & TI) Ranchi, Jharkhand has taken a lead in "Utilization of solar energy in Trasar post cocoon technology operations" Tasar Silk industry in India is Cottage Industry with an agriculture base and of labour intensive in all its stages i.e. cocoon stifling, drying, cooking reeling, spinning and the post-yarn stage processes like degumming, bleaching, dyeing, printing and mechanical finishing etc. Solar energy can prove to be a cheap, localized source of energy for Tasar silk industry of India. At CTR & TI, Ranchi, one 10 kWp roof top hybrid solar power plant has been installed and one Hot air dryer for stifling & drying of tasar cocoon is being operated by solar power. The testing was conducted for running of five reeling and spinning machines each with total capacity of 2 kW as well as hot air dryer (for cocoon drying) with capacity of 3 kW. Thus total savings of 5 kW is possible by utilization of solar energy in existing post cocoon technology operation per day.

Project 7: A project entitled Design, development and demonstration of solar dryer suitable for drying natural rubber sheets in North-East India was sanctioned to CSIR-Central Salt & Marine Chemicals Research Institute, Bhavnagar, Gujarat and NIT Agartala.

Achievements:

- 1 Kg mixed mode solar dryer developed at CSIR-CSMCRI.
- 5 Kg solar dryer installed at NIT-Agartala for drying of natural rubber sheets as demonstration unit.

Tripura (23° 84' N, 91° 42' E), located in the north-eastern part of India contributed 74139 MT natural rubber production in 2019-20 making it the second largest rubber producing state after Kerala in India. The conventional drying of rubber sheet in smoke houses during its processing requires about 0.8-1.0 kg of firewood per kg of rubber sheets and takes about 5-6 days to achieve the desired level of moisture content. Firewood, which was earlier considered as a cheap source of energy, has now become scarce and expensive. Also, the profuse smoke liberated during the drying process leads to unhealthy environmental conditions. Traditional open sun drying is also practiced for drying of the rubber sheets; however, the process takes a long time to achieve the desired moisture content. It usually takes 7-10-days' time to dry the natural rubber sheets in the open. The rolled rubber sheets from latex are dried in open sun on cords, or sometimes on roads or pavements and sometimes the sheets are hung in kitchens for smoke drying. These are the usual procedures by marginal farmers or processors **(Fig. 7.13)**. The organized sector usually dries the sheets in shared smoke houses.

Fig. 7.13. *Traditional open sun drying of natural rubber sheets; sheets being spread on pavement for faster drying ; rubber sheets hung in kitchen for domestic smoke drying*

To circumvent the problem of inferior quality of product and lengthy drying time due to the above drying methodologies, a 6 kg/batch mixed mode solar thermal dryer for drying of natural rubber sheets was designed and developed by CSIR-CSMCRI under this project and installed at the premises of NIT Agartala for demonstration **(Fig. 7.14)**. The performance analysis of drying natural rubber sheets in the installed dryer was carried out.

Fig. 7.14: *Mixed-mode Solar Dryer installed for rubber sheet drying*

The results showed that moisture content of the natural rubber sheets could be reduced from 40% to 4% (wet basis) in the solar thermal dryer vis-à-vis 11% in open sun drying conditions in 3 days' time. Quality

and colour of the solar dryer dried sheets were found to be superior to the open sun-dried ones **(Fig. 7.15)**. Some of the innovative features of the developed solar thermal dryer included (IP 320446-IN).

- Induced draft fan at the chimney operated directly by the solar photovoltaic modules, so that the speed of the fan was directly proportional to the solar radiation, which helped to control the temperature inside the drying chamber and very high stagnant temperature, was not reached.
- Recirculation of warm dehumidified exhaust air for better thermal management.
- 90% UV cut-off in the drying chamber leading to better colour retention of the dried rubber sheets.

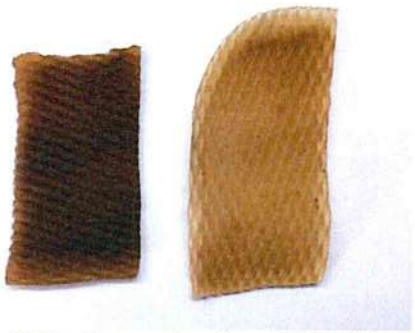


Fig. 7.15: *Conventionally dried rubber sheet (left). Solar thermal dryer dried rubber sheet (right).*

- Operation of a solar photovoltaic operated dehumidifier to prevent reabsorption of moisture onto the rubber sheets at night and to maintain low relative humidity inside the drying chamber which made the drying achievable in stipulated time, despite inclement weather.

7.6.3 Solar Radiation Resource Assessment (SRRA) Stations

In order to strengthen the solar resource assessment and to meet the requirement of availability of Solar Radiation data, In Phase- I program, 51 SRRA stations and in Phase- II, 60 SRRA stations and 4 Advanced Measurement Stations are installed at selected locations spread all over the country. This exercise has been coordinated by National Institute of Wind Energy (NIWE), Chennai an autonomous institution of the Ministry. A central server facility for data collection from all these stations has been set up at NIWE. The data so collected will be useful in developing a solar atlas for the country. In addition, all the solar power projects selected under the Mission have also set up radiation monitoring equipment at their project sites. NIWE has launched a Solar Atlas of India for firming up the solar potential of the Country.

7.7 BIOGAS RESEARCH, DESIGN AND DEVELOPMENT

7.7.1 RD&D Project on Biogas Sector continued during the current year

Development & Performance Evaluation of a 3 KW Biogas-based Power Generation System utilizing Ligno-cellular Biomass, at IIT-Guwahati.

Under this project, the 4 objectives of the project have been completed with the optimization of operating parameters of a 5 hp Gasoline engine along with the performance study by a 16 m^3 of biogas produced per day from Ligno-cellulosic feed stock materials mainly cow dung, rice straw, duck weed and switch grass and to produce 3 kWe biogas power. This has been successfully installed and maintained by IIT Guwahati at Auaniati Satara, North Guwahati, Assam. All the objectives, of the assigned project have been achieved including performance studies with the modified engine and comparative results with 100 % Gas engine. The project completion report has been received and comments of experts on the same have been received for finalization and acceptance.

Development of Hybrid-High rate Bio-methanation Reactor using locally available media for treating waste water and solid waste at Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu.

Under this project, three lab-scale hybrid reactors with acrylic sheet one of which served as control and the other two reactors with different packed media were fabricated. The stability of the reactors attained with affluent pH of 7 to 7.5 and the biogas production observed 250-300 ml in each reactor. The performance evaluation of high rate reactor and hybrid high rate reactor with community wastewater was completed and HRT was optimized. The efficient waste water treatment system through high rate and hybrid high rate bio-methanation reactor was developed, which is economic over adopting aerobic waste water treatment systems, which generates biogas and is being utilized for power generation and thermal energy applications.

The R&D project incorporated the scrubber design and for upgrading the biogas produced from waste water of Tamil Nadu Agricultural University (TNAU) hostel premises. In 4 different combinations, the molecular sieve 100 % showed the best results in terms of both high CO_2 adsorption percent and high-performance index for two design of scrubbers columns. Maximum Methane content of 96.8% has been obtained in 2 metre scrubbing column with molecular sieve (100 %) material in the pressure of 7 bar. It has been concluded that molecular sieve is the best material for Biogas purification and height of the scrubbing column should not be less than 2 metre. A low cost activated charcoal CO_2 scrubber has been developed under this project for biogas purification and upgradation.

Comparative results of High Rate Reactor (HHR) and Hybrid High Rate Reactor (HHRR): As per the norms of Central Pollution Control Board the permissible discharge limit for waste water is 250 mg/l. The comparison of High Rate Reactor (HRR) and Hybrid High Rate Reactor (HHRR) designed, installed for the project and comparative studies were done. By comparing the removal efficiencies of both the reactors, the HHRR with lower HRT showed the higher removal efficiencies of TS, VS, Biological and Chemical and Oxygen Demand (BOD and COD) in the order of 81.46 %, 83.44%, 84.33% and 86.41% respectively. The Up-flow Anaerobic Sludge Blanket (UASB) reactor comparatively worked at low organic loadings, while the hybrid reactor could work on higher organic loadings and hence works very efficiently with good removals of COD and BOD. The overall efficiencies of HRR and HHRR showed that the performance of HHRR was higher than the performance of HRR. The project has been completed by TNAU and the Project Completion Report has been received and comments of experts on the same have been received for finalization and acceptance.

Development of suitable pre-treatment system for paddy straw disintegration for biogas generation leading towards commercialization of technology.

A research project was awarded by MNRE entitled Development of suitable pre-treatment system for paddy straw disintegration for biogas generation leading towards commercialization of technology to the Indian Institute of Technology, Delhi, to address the issue in–field burning of paddy straw stubble in northern Indian states and provide a sustainable solution for the same. In the project a laboratory scale hydrothermal reactor has been developed for pre-treatment of paddy straw at different temperature and reactor loading rates. Further, a field scale hydrothermal reactor having 50 Litre capacity has also been fabricated for performing field scale experiment for performance evaluation of the model. Two of the 3 major objectives of the project have been completed. A Project

Monitoring Committee (PMC) has visited the project site in IIT, Delhi on 02.12.2019. The PMC has recommended for continuation of the project for achieving the remaining one major objective up to 31.01.2021.

7.8 HYDROGEN ENERGY AND FUEL CELLS

The Ministry has been supporting a broad-based Research and Development Programme on different aspects of hydrogen energy technologies that includes production of hydrogen, its storage and utilisation for stationary, motive and portable power generation applications using internal combustion engine and fuel cells and also for other applications. As on 31.12.2020, a total of 8 R&D projects on different aspects of hydrogen energy and fuel cells are under implementation.

On 26 November 2020, Hon'ble Prime Minister, announced India's plans to launch a comprehensive National Hydrogen Energy Mission. The Ministry has initiated a process for developing and thereafter launching the Mission for utilizing Hydrogen as a carrier and enabler of renewable energy across key economic sectors including power, transportation and industry.

The Mission would inter alia address the current challenges/gaps; recommend strategies to overcome challenges as part of the Mission approach; define broad targets/roadmap for short, medium and long term; lay down activities/steps required for achieving the targets; propose institutional framework for mission activities; and evaluate the financial and other resource requirements. A Standing Committee chaired by Secretary, MNRE with representatives from Ministries/ departments, industry, academia and other stakeholders has developed initial draft Mission document, which is under consultation and finalization process.

The Ministry has also been exploring prospects of using Green Hydrogen (produced from renewable energy sources) as an option for producing Green Ammonia. A Group chaired by Additional Secretary, MNRE and representatives from the relevant Ministries, PSUs and industry is examining alternatives for production of Green Ammonia and its use in key economic sectors.

7.9 ENERGY STORAGE

MNRE has been supporting a broad-based Research and Development Programme on energy storage. Projects are supported in industrial, academic and research institutions. Further, Ministry as a member of the Inter-Ministerial steering committee for the Faster Adoption and Manufacturing of Electric Vehicles in India (FAME-II) scheme continued to provide inputs on different aspects of electric mobility.

7.10 WIND R & D

Ministry has sanctioned 20 R & D projects from 2014-15 onwards in wind energy projects out of which two R & D projects sanctioned to NIWE are continuing. The activities carried out on these two R & D projects are given as under:

7.10.1 Met-Ocean measurements (Wind, Wave, Tide, Current, Water level measurements) at Gulf of Khambhat and Gulf of Mannar

With an objective to identify the potential subzones and blocks for promotion of offshore wind farm development in the country, NIWE was entrusted with carrying out a detailed offshore wind resource measurement along with geotechnical and oceanographic studies under this project.

Fig. 7.16: *LiDAR validation set up at WTRS, Kayathar, Tamil Nadu*

7.10.2 Integrated Wind & Solar Resource Assessment through Mapping and Measurements

Under this project, 50 numbers of 100 m tall integrated wind-solar monitoring stations with 5 levels of instrumentation are to be installed in the country. Wind resource measurements will also be carried out using Sound Detection & Ranging (SODAR) along with measurements from integrated wind-solar monitoring stations concurrently. The measurements carried out using integrated wind-solar measurements and the SODAR will be used to estimate the wind solar power potential of the country at 150 m level and for the preparation of 150 m wind-solar hybrid map.

7.11 STANDARDS & QUALITY CONTROL IN RENEWABLE ENERGY SECTOR

In pursuance to Lab Policy for Testing, Standardization and Certification for the RE Sector, which was notified by MNRE on 7th December 2017, increased interaction was made with experts, test labs and industry for development and regular updation of standards for implementation for quality control of renewable energy systems and components. Active interaction was made with the Bureau of Indian Standards (BIS) through various committees' meetings for developing/updating standards matching Indian climatic conditions, and making standards easy for implementation and for efficient delivery of testing services. Interactions were also made with National Accreditation Board for Testing & Calibration Laboratories (NABL) for proper assessment of technical competence of test labs for accreditation for specified standards. Shri Indu Shekhar Chaturvedi, Secretary, MNRE reviewed standards development, implementation, accreditation of test labs and implementation of Quality Control Order on SPV (Compulsory Registration Scheme under BIS Act) for quality control in all sectors of renewable energy in the country. Interaction was also held with the Bureau of Energy Efficiency (BEE) for developing appropriate methodology for Star Labelling of SPV Modules.

7.11.1 Standards on Renewable Energy

The standards followed in various programmes being implemented by MNRE are given in **Table 7.1:**

Table 7.1: standards followed under various MNRE programmes

Sl No	Programme	Product and Standard Title	Standards
1.	Solar Power	Crystalline Silicon Terrestrial Photovoltaic (PV) Modules (Si wafer based).	IS 14286: 2010/ IEC 61215: 2005, IS/IEC 61730 (Part 1): 2004 & IS/IEC 61730 (Part 2): 2004,
		Thin Film Terrestrial Photovoltaic (PV) Modules a-Si, CiGs and CdTe).	IS 16077: 2013/ IEC 61646: 2008, IS/IEC 61730 (Part 1): 2004 & IS/IEC 61730 (Part 2): 2004,
		Power Invertors for use in Photovoltaic Power Systems.	IS 16221 (Part 2): 2015/IEC 62109-2: 2011,
		Utility-Interconnected Photovoltaic Inverters.	IS 16221 (Part 2):2015/IEC 62109-2 :2011 & IS 16169 :2014/IEC 62116 :2008,
		Storage Batteries for SPV Applications.	IS 16270 : 2014.
2	Wind Power	Wind turbine Wind turbines - Part 22: Conformity Testing and Certification.	IS/IEC 61400-22:2010
		-Type and Component Certification Scheme	IECRE OD-501 Edition 2.0
3	Small Hydro Power	Turbines and generator (rotating electrical machines)	IEC 34 – 1: 1983, IEC 61366-1: 1998 IEC 61116-1992 IS: 4722-2001, IS 12800 (part 3) 1991. IEC 60308.
		Governing system for hydraulic turbines Transformers	IS 3156 – 1992, IS 2705 – 1992 IS 2026 - 1983.
		Inlet valves for hydro power stations & systems	IS 7326 - 1902
4.	Biomass Energy	Biomass Power -Boiler	ASME – BPVC – Section – 1 IBR 1950 and amendments thereof or conforming to these standards.
		-Steam turbine	IEC 60045, DIN 1943 (German) CSN(Czekh Republic) 080030 ASME PTC 6.2 (Steam turbine in combined cycle) or conforming to these standards.

		-Alternator/Rotating Electrical Machines	IS-4722 (Rotating Electrical Machines) IS-5422 (50HZ Turbine type Generators-Basic requirements for rotating machines, reference shall be made to IS4722) IEC60034.
		-Power Transformers	IEEE 115 or conforming to these standards IS 2026
		-Biogas (Bio-methane) -Specification	IEC 60076 or its equivalent standard IS 16087: 2016

7.11.2 Renewable Energy Standardization Cell (RESC)

On the request of BIS as part of their "Standards National Action Plan (SNAP)", MNRE in February 2020, set up a Renewable Energy Standardization Cell (RESC) in MNRE under the chairmanship of Dr. B. S. Negi, Adviser/Scientist-G, MNRE and comprising DGs of MNRE institutions and concerned programme officers in MNRE. The objectives of the RESC are as follows;

- to identify the areas in renewable energy where standards need to be developed, updated and adopted.
- identify and peruse international standards such as ISO and IEC among others, for applications in Indian climatic conditions. In case modifications are needed, the same should be done and tried in test labs for revision suitable for Indian climatic conditions.
- Initiate the process of developing standards involving experts from R&D institutions, test labs and industry.

Active interaction was made with MNRE institutions for developing/updating standards in all areas of renewable energy for quality assurance. The Cell is being revamped involving related domain experts from test labs and industries.

7.11.3 One Standard for One Product

In June 2020, Secretary, MNRE reviewed Indian Standards on Solar Photovoltaic (SPV) Modules used in Solar Power Projects. Subsequently, the MNRE set up a three-member Expert Committee, comprising representatives one each from MNRE, Solar Energy Corporation of India (SECI) and a BIS recognized Test Lab to examine the revised Indian Standards published by BIS in 2019 for implementation. The Expert Committee through virtual meet on 17.7.2020 discussed and examined Indian Standards published by BIS in 2019 in detail. In addition, the committee also discussed the relevance of recently published Indian Standard on Photovoltaic Modules –Test Methods for detection of Potential-Induced Degradation (IS 17210 Part I: 2019) adopted from IEC TS 62804-1:2015). The Expert Committee found that the revised standards in too many parts for one type of SPV module technology are confusing for implementation, and recommended that the standards need to be organized technology-wise making one standard for one type of technology of SPV Modules inclusive of all relevant testing requirements applicable to Indian climatic conditions.

On the basis of the recommendation of the Expert Committee and subsequent inputs from related stakeholders and domain experts through MNRE web meetings, MNRE in November 2020 took a view that Indian Standards need to be updated following international standards and the same need to be organized technology-wise making one standard for one product inclusive of all relevant testing requirements applicable to Indian climatic conditions. One standard for one product inclusive of all testing requirements is a major step towards streamlining testing process for efficient delivery of testing services. Effectively, one standard will require one test report for one product which is essential to simplify the testing and certification process, and hence ease of doing business in the country. Accordingly, the MNRE in November 2020 recommended to BIS to bring out one standard each for crystalline and thin film based Solar PV modules.

7.11.4 Quality Control in SPV Power Projects

» **Quality Control Order (QCO)**

The technical regulation for quality control of SPV Systems, Components and Devices as per Quality Control (Requirement for Compulsory Registration under BIS Act) Order 2017, which was notified by MNRE vide Government of India Gazette Notification No. 2561 dated 5th September 2017 was implemented as per schedules notified time to time. Active interaction was made with industry, test laboratories, and BIS for implementation of the said quality control order, which includes SPV Modules, Inverters and battery storage used in SPV power projects. All products listed in the said order should conform to specified Indian Standard/corresponding IEC, and products qualifying the standards from BIS recognized test labs are required to be registered by the respective manufacturers with BIS.

Testing of the above mentioned products is carried out in BIS recognized test labs following series guidelines notified by MNRE in consultation with related stakeholders including BIS. Only products registered with BIS are allowed for deployment in projects. In the case of SPV inverters, since the series guidelines are applicable up to 150KW capacity as per the capacity of test labs available and the nos. of such test labs are very limited, the manufacturers are exempted from BIS registration on the condition that such manufacturers should have valid IEC certificates as per IEC standards corresponding to IS specified in the Quality Control Order. Field surveillance is to be done to check the quality of products in field.

» **Test Labs for Performance Testing**

Active interaction was made with test labs and BIS for streamlining the process of testing with quality and reliability, issuing test reports and registration of products by BIS. Interaction with NABL and BIS was also made for proper assessment of test labs for their technical competence against specified standards for delivering testing services efficiently with reliable test results. In the case of inverter testing, currently the test labs are equipped for testing up to 150KW capacity inverters. The list of Test Laboratories actively engaged in testing of products for performance certification is given below in **Table 7.2.**

Table 7.2: List of Test Laboratories

Sl. No.	Product	Indian Standard Number	Title of India Standard	Test Labs Recognized by BIS
1.	Crystalline Silicon Terrestrial Photovoltaic (PV) Modules (Si Wafer based)	IS-14286	Crystalline Silicon Terrestrial Photovoltaic (PV) Modules - Design Qualification and type Approval	1. Hi Physix Laboratory India Pvt. Ltd., Pune 2. UL India Pvt. Ltd., Bengaluru 3. TUV Rheinland, Bengaluru
2.	Thin-Film Terrestrial Photovoltaic (PV) Modules (a-Si, CiGs and CdTe)	IS-16077	Thin-Film Terrestrial Photovoltaic (PV) Modules - Design Qualification and Type Approval	1. Hi Physix Laboratory India Pvt. Ltd., Pune 2. UL India Pvt. Ltd., Bengaluru
3.	PV Module (Si Wafer and Thin Film)	IS/IEC 61730 (Part-1) IS/ IEC 61730 (Part-2)	Photovoltaic (PV) Module Safety Qualification Part-1 Requirements for Construction Photovoltaic (PV) Module Safety Qualification Part-2 Requirements for Testing	1. Hi Physix Laboratory India Pvt. Ltd., Pune 2. UL India Pvt. Ltd., Bengaluru. 3. TUV Rheinland, Bengaluru
4.	Power Inverters for use in Photovoltaic Power System	IS 16221 (Part-2)	Safety of Power Converters for use in Photovoltaic Power Systems Part-2 – Particular Requirements for Inverters	1. CPRI, Bengaluru 2. Hi-Physix Laboratory India Pvt. Ltd., Pune
5.	Utility – Interconnected Photovoltaic Inverters	IS-16169	Test Procedures of Islanding Prevention Measures for Utility- Interconnected Photovoltaic Inverters	1. CPRI, Bengaluru 2. Hi-Physix Laboratory India Pvt. Ltd., Pune 3. UL India Pvt. Ltd., Bengaluru
6.	Storage Battery	IS-16270	Secondary Cells and Batteries for Solar Photovoltaic Application General - Requirements and Methods of Test	1. CPRI, Bengaluru 2. CECRI, Karaikudi, Tamil Nadu 3. Hi Physix Laboratory India Pvt. Ltd., Pune

7.11.5 BIS Registration of Products

The data on the number of registrations granted by Bureau of Indian Standards (BIS) for SPV Modules, SPV inverters and Storage Battery as per standards specified in MNRE Quality Control Order till 31.12.2020 is given in **Table 7.3.** Out of 234 nos. manufacturers who were granted registration for SPV Modules, 126 Nos. are domestic manufacturers (53%). The MNRE has decided that only SPV Modules with BIS Mark will be used in SPV Power Projects in the country. Thus, the Quality Control

Order has given boost to not only quality control of SPV Modules but also domestic manufacture of SPV Modules with quality at international level, hence fulfilling the objective of Atmanirbhar Bharat. In addition, the order also offers opportunities to domestic manufacturers for collaboration with high efficiency overseas module manufacturers for indigenous manufacture of high efficiency SPV Modules in the country.

Table 7.3: Registration Numbers granted by BIS under MNRE Quality Control Order (CRO) 2017 till 31.12.2020

Details of Indian Standards	Product Category	Domestic	Foreign
IS 14286: 2010/ IEC 61215 : 2005, IS/IEC 61730 (Part 1) : 2004 & IS/IEC 61730 (Part 2) : 2004	Crystalline Silicon Terrestrial Photovoltaic (PV) Modules (Si wafer based)	126	105
IS 16077: 2013/ IEC 61646 : 2008, IS/IEC 61730 (Part 1) : 2004 & IS/IEC 61730 (Part 2) : 2004	Thin Film Terrestrial Photovoltaic(PV) Modules a-Si, CiGs and CdTe)	0	3
IS 16221 (Part 2) : 2015/IEC 62109-2 : 2011	Power Invertors for use in Photovoltaic Power Systems	7	1
IS 16221 (Part 2):2015/IEC 62109-2 :2011 & IS 16169 :2014/IEC 62116 :2008	Utility-Interconnected Photovoltaic Inverters	4	16
IS 16270: 2014	Storage Batteries for Solar Photovoltaic Application	5	0

7.11.6 New Initiatives:

(a) Revised Standard on Battery Storage

Indian Standard (IS 16270) for "Secondary Cells and Batteries for Solar Photovoltaic Application – General requirements and Methods of Test", which is specified in quality control order as applicable to lead acid and nickel-based chemistry batteries. The standard was reviewed in consultation with subject experts and BIS. In addition, the developments in Lithium ion batteries for SPV applications was also discussed and it was considered that standard on lithium ion batteries for SPV applications should be developed. Amendments in IS 16270 and the need of standard on Lithium ion batteries was suggested to BIS. BIS in the related 21st Meeting of ETD 11 held at BIS on 20.12.2019 took a decision to set up a Panel with Dr. B S Negi, Adviser, MNRE as convener and comprising related subject experts from R&D institutions and battery industries and a Member Secretary from BIS for finalizing a draft incorporating the amendments to IS 16270 and requirements for lithium batteries covered in IEC 61427-I (Secondary Cells and batteries for renewable energy Storage-General requirements and methods of test- Part 1: Photovoltaic Off-Grid application).

Accordingly, a day-long meeting of the Panel was held on 3.2.2020 at 10:30 AM in MNRE to discuss the amendments to IS 16270 and the requirements of lithium batteries as per IEC 61427-I. Extensive discussions were held in the meeting on developing a combined standard inclusive of lead acid, nickel based, lithium ion, etc. for quality control of batteries for off-grid applications in the country. On the basis of discussions held in the meeting it was decided to prepare a draft revised standard IS 16270 covering all relevant batteries including lithium ion as per IEC 61427-I. The panel prepared a draft which was extensively reviewed through mails for finalizing the draft. In this regard a virtual meet of the Panel was held on 6th August, 2020 at 11 AM which was coordinated by the Convener for

discussion and finalizing the draft revised IS 16270, which was subsequently reviewed through mails and finally the final draft was provided to BIS in October, 2020 for necessary action. The draft revised IS 16270 (2020/21) is under process in BIS.

Fig. 7.17 *The First meeting of the Panel on 3.2.2020 in MNRE Committee Room*

(b) Quality Control Order on Solar Thermal Collectors

The MNRE reviewed standards and market of Solar Thermal Systems for quality control. A draft Quality control order was prepared by MNRE in consultation with BIS for quality control of flat plate collector and Evacuated Tube Collectors (ETC). The status of the draft order was reviewed by Secretary, Department of Consumer Affairs through a virtual meet on 18.12.2020. In this regard, a stakeholder consultations meeting was held on 6th January 2021 through virtual mode under the chairmanship of Secretary, MNRE to discuss the need of a Quality Control Order on Solar Thermal Systems. A detailed discussion was held on standards available including standards under revision and the market of solar thermal systems. The meeting was attended by 35 participants from industry, BIS and Department of Commerce. The industry representatives voiced serious concerns for quality control order for Solar Thermal Systems particularly for ETC. The MNRE is examining the proposal keeping in view the standards available and the need of test laboratories.

(c) Standard on SPV Grid-Tie Inverter

The MNRE initiated interaction with experts from R&D, academic institutions, test laboratories and industries for developing a draft standard on PV Grid Tie Inverters inclusive of all testing requirements for complete performance evaluation and certification. At present two standards on inverters are specified in the Quality Control Order. These standards cover safety requirements as per IS-16221-Part II and the corresponding IEC 62109-2:2011 and for islanding prevention measures as per IS 16169 and the corresponding IEC 62116:2008. A draft standard titled Technical Requirements for PV Grid

Tied Inverters to be Connected to the Grid" inclusive of efficiency, grid integration and environmental tests aspects as per relevant IEC and other national and international standards was prepared and was uploaded on MNRE web on 21/4/2020 for comments of stakeholders till 7/5/2020. Comments and inputs were received from experts from R&D, academic institutions, test laboratories, industries and regulatory bodies such as Power Grid Corp. of India Ltd. (PGCIL), Power System Operation Corp. Ltd. (POSOCO), and Central Electricity Authority (CEA) among others.

A group of experts from MNRE, R&D, academic institutions, Test Labs, CEA, POSOCO, and inverter industries, was set up for perusal of comments and inputs. The draft was revised incorporating the relevant comments after proper analysis, and was discussed with related select stakeholders through a series of Virtual Meets during August-October, 2020. The last virtual meet with the select stakeholders was held on 21.10.2020, when various issues were discussed for finalizing the draft document. Thereafter, the team interacted through virtual meets for finalizing the draft document which was finalized and submitted to MNRE on 14.01.2021. The draft document is under process for forwarding to BIS for further necessary action. This is an important initiative for complete performance evaluation and certification of inverters for quality control in SPV Power projects.

(d) Star Labelling for SPV Module

An Interaction was held with Bureau of Energy Efficiency (BEE) regarding the latter's proposal for Star Labelling of SPV Modules. A proper scientific methodology involving relevant performance parameters is being developed in consultation with BEE for star rating of modules.