CHAPTER 7

Renewable Energy Research and Technology Development Programme

7.1 Introduction

The Ministry of New & Renewable Energy (MNRE) supports resource assessment, research, design, development, testing, standardization, demonstration, and validation of various renewable energy technologies, processes, materials, components, subsystems, products & services to promote application-oriented research, improvements in efficiency, reliability, indigenous development and manufacturing of renewable energy systems and devices.

The Ministry's R&D initiatives aim to strengthen the global competitiveness of the Indian industry and to make renewable energy generation supply, self-sustainable/profitable thereby increasing RE's share in the country's total energy mix.

7.2 Policy and Guidelines

Under the Renewable Energy Research and Technology Development (RE-RTD) Programme, the Ministry supports R&D on renewables by providing up to 100% financial support to Government/non-profit research organizations/ NGOs and up to 50% to 70% to industry. The budget allotted for the Renewable Energy Research and Technology Development (RE-RTD) Programme is Rs. 228 crores for FY 2021-22 to 2025-26.

7.3 Research Development and Demonstration (RD&D) Focus

The projects supported for RD&D support are in line with the R&D thrust areas of the ministry identified under solar thermal, SPV, biogas, wind, wind-hybrid, storage, small Hydro Power, hydrogen, fuel cells, geothermal, etc. 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

Participation of the industry in R&D projects is encouraged. In solar thermal, the thrust areas include the development of solar thermal technology for power generation and industrial process/heat, storage systems, hybridization, etc.

7.4 Institutional Mechanism

For faster technology commercialization, the Ministry supports the strengthening of its institutions, namely, the National Institute of Solar Energy (NISE), Gurugram, Sardar Swarn Singh National Institute of Bioenergy (SSS-NIBE), Kapurthala and National Institute of Wind Energy (NIWE), Chennai for pursuing RD&D, resource assessment, testing, standardization, and certification in solar, bioenergy, and wind energy systems, respectively.

7.5 SOLAR R&D

Solar Photovoltaics

Highlights of the progress achieved under the Solar Photovoltaic (SPV) R&D projects funded by the MNRE are listed below.

A. Phase III of the Ministry's flagship project in solar photovoltaics implemented by the National Centre for Photovoltaic Research and Education (NCPRE)

This flagship project of the Ministry has several workstreams, and the main highlights of progress are briefly described below.

- **Advancements in Solar Cell Materials:** Solar cell research activities in Phase III of NCPRE are focused on mitigating challenges related to upscaling perovskite-silicon tandem solar cells. NCPRE is investigating novel laser-cutting processes for passivating the edges of perovskite/silicon tandems to prevent loss of cell efficiency and stability due to edge shunting. The NCPRE has demonstrated the 4T-tandem solar cell up to 27.14% efficiency with a bottom silicon solar cell efficiency of 23%. With the international community having achieved bottom cell efficiency of more than 26%, it is expected that NCPRE can help Indian industries cross the 30% efficiency barrier by achieving improved production of such indigenously produced bottom cells.

- **Advancements in Solar inverters for Grid Integration:** The NCPRE is working on aspects related to efficiency and identifying protection mechanisms for reliable operations of silicon carbide (SiC) inverter technology for direct MV grid integration.

- **Energy Storage:** The focus is on improving the performance of the vanadium redox flow battery (VRFB) and implementing polyoxometalates (POMs) as electrolytes in redox flow batteries.

- **Training:** NCPRE conducted several industry-oriented courses in the FY 2023-24, such as "Theory and Technology of Silicon Solar Cells" (May 11–13, 2023), "Solar Photovoltaics: Technologies, Manufacturing, and Deployment" (July 17-21, 2023), and "Photovoltaic Module Design, Testing, and Reliability" (July 25-27, 2023).

- **Supporting Startups:** NCPRE is helping startup 'Giga Connect' to set up a state-of-the-art lab for quality monitoring and reliability testing of junction boxes. It is also working with Tri-Nano Technologies to assess the durability of anti-soiling coatings.

B **National Primary Standard Facility for Solar Cell Calibration -** CSIR-NPL [exemplar of international scientific cooperation to promote India's self-reliance in solar PV cell performance measurement]

It highlights an important outcome of international scientific cooperation between CSIR NPL and Germany's Physikalisch-Technische Bundesanstalt (PTB), to establish the first-ever high-quality facility for solar cell calibration facility at NPL's campus based on "Laser-based Differential Spectral Responsivity Primary Reference (LDSR) Solar Cell Measurement System" with a world record lowest measurement uncertainty [0.35% in standard testing conditions (ISTC) at k=2 for the WPVS standard reference solar cells]. The assessment of the performance of the L-DSR system was confirmed through an inter-comparison mechanism (participating laboratories included NPL, PTB, and NREL).

Fig. 7.1 (a)

Fig. 7.1 (b)

Figure 7.1 (a and b) infrastructure for installation of the LDSR facility at CSIR-NPL.

C. Design and Development of High-Efficiency Solar Water Pumping Systems, NISE, Gurugram - leading to the development of a state-of-the-art testing facility for solar water pumping systems at NISE

The project was completed successfully with the establishment of a state-of-the-art testing and R&D facility at NISE (NABL accredited) for testing solar water pumps (of up to 50 HP capacity). A joint report was prepared in collaboration with the industry on ways to increase the daily water output of a solar water pumping system using bifacial PV modules. Test protocols and System specifications have been prepared for solar water pumps up to 50 hp capacity. Plus, guidelines for solar-based micro-pumps for 0.1 hp were prepared (based on installations and tests conducted at the facility) and shared with the MNRE.

D. Project on Flexible Perovskite Solar Cells and Intermediate Module led by IIT-Bombay - achieved path-breaking progress on Perovskite efficiency in India to pave the way for scale-up.

- Promising results were obtained by Prof. Shaibal K. Sarkar's research group at IIT Bombay, which demonstrated 24.8% efficiency in Perovskite photovoltaic devices (versus 25.6% world record) through solution and composition engineering of the active layer.
- The group also demonstrated techniques for device encapsulation in high vacuum conditions for futuristic space applications
- The project worked on improving the overall stability of the perovskite device under operational conditions by protecting the absorber layer from extrinsic degradation.
- The group, in association with Holmarc Optomechatronics Ltd., based in Cochin, has developed a unique tool combining different imaging techniques to characterize process-induced defects in solar cells. This tool is not available off-the-shelf.

E. **Development of high-efficiency PERC type of c-si/mc-si solar cell, jointly implemented by NISE and BHEL-ASSCP, Gurugram** – development of PERC solar cell development facility and achieving 22% PERC cell efficiencies.

PERC is considered the workhorse of the solar PV industry at present. This project was completed by BHEL ASCP and NISE in this financial year with the achievement of (i) a maximum PERC Solar Cell efficiency of 22%. The project has resulted in the optimization of processes such as diffusion, metallization, and printing, resulting in the **(ii) second major achievement of the project, which includes the installation of the PERC solar cell development facility (Fig 7.2).**

Fig. 7.2: PERC Solar cell development facility at BHEL ASSCP Gurugram

7.6 R&D In Wind Energy

A. **Met-ocean Measurements (Wave, tide, Current, Water Level, etc.) at Gulf of Khambhat and Gulf of Mannar for Fostering the Growth of Offshore Wind in the country"** - laying the foundation of offshore wind development in India.

NIWE has used the real-time Met-Ocean measurements generated under this project for (i) validating the **indicative Offshore Wind Potential map at 100 m hub height** (available online) that covers the 7600 km coastline of the country and (ii) to develop an **indicative bidding trajectory of 37 GW of offshore wind** (from 2023-24 till 2029-30). As the next steps, the project will focus on two main aspects: one, the development of an indigenous offshore floating Lidar buoy system and motion correction algorithm; and two, to explore the accelerated offshore measurement campaign to cover the entire 7600km of coastline across the country.

B. Integrated Wind and Solar Resource Assessment through Mapping and Measurements (IWSRA)

Progress achieved in the year 2023-24 is outlined below:

- NIWE has developed a **Wind Potential Map at 150m above ground level (agl)** that was successfully published on Global Wind Day (15.06.2023) and hosted on an interactive NIWE Web Portal. The exploitable wind potential of the country is estimated as 1164 GW at 150m agl, (as per NIWE's 150 m wind potential study).
- NIWE has also developed the integrated wind-solar hybrid map based on the National Wind-Solar Hybrid Policy 2018. The project has led to capacity building by the developers for identifying suitable lands for the installation of wind-solar hybrid projects.

  NIWE has identified 13 sites covering 7 states, namely Gujarat, West Bengal, Maharashtra, Telangana, Andhra Pradesh, Tamil Nadu, and Uttar Pradesh, for Phase II measurement. Deployment of remote sensing devices (RSDs) such as SODARs and LiDARs are being explored by NIWE for new sites to replace the mast measurement method, which is costly and time-consuming.

7.7 R&D In Waste to Energy (WtE)

A. Densification of agro-waste and assessment for its application in the gasifier, SSS National Institute of Bio Energy (NIBE), Kapurthala.

This project was sanctioned in FY 2022-23 and aims at the densification of agro-waste and assessing its potential use in the gasifier. The project so far has completed **compositional analysis for Biomass** viz. Paddy Straw, Millet, Sweet Sorghum, Cotton Stick, Corn Stover, and Mustard crop residue, and has obtained a higher heating value (in MJ/kg) for all the mentioned biomass types. The project has made use **of sophisticated instruments for the characterization and assessment of biomass properties.**

As the next steps, different types of organic binders have been identified, viz., Press Mud, Cow Dung, Groundnut Shell, Saw Dust, Municipal Solid Waste (MSW), Biogas Plant Slurry, etc., and their compositional analysis is underway for the selection of suitable binders for densified biomass production.

B. Biomass Gasification through Plasma Pyrolysis technology for Chemicals Production, IIT-Roorkee

This project was also sanctioned in the FY 2022-23 with the three-fold objective of: (i) to fabricate and install a plasma pyrolysis system for handling bagasse and rice husk initially, with the potential to treat other organic wastes in the future; (ii) **thermo-chemical characterization of various biomass sources and gases produced after gasification; and (iii) optimization of reactor design and input conditions.**

In terms of updates, the **installation of the Plasma Pyrolysis Facility** for biomass gasification is expected to be completed by the end of the financial year 2023-24 **(Fig.7.3 below). Detailed characterization studies of biomass** (sugarcane bagasse) samples were done deploying different techniques, and the high volatile matter (77.6%) and low ash (8%) content present in the sugarcane bagasse suggested potential applications for pyrolysis and gasification. Higher heating values (range of 17-20 MJ/kg) were also found, which is comparable to good quality lignin coal.

Fig. 7.3: Plasma reactor unit for biomass gasification being installed by IIT-Roorkee

7.8 R&D In Green Hydrogen

A. Generation using Biomass Gasification for Fuel Cell Application (HBGF) by the Indian Institute of Science (IISc) - a successful case study of extracting fuel cell grade hydrogen from biomass.

The project has led to the development of a Pressure Swing Absorption (PSA) system for gas separation. In a significant breakthrough, the gas composition and impurity estimation have been carried out using the 1kg/hr hydrogen system, and the separation of the gas from the mixture to obtain pure hydrogen at a scale of 99.97% has been successfully demonstrated

The project milestones have also been presented at important international workshops, for example, the International Conference on Hydrogen, organized by the MNRE on 19.08.2023, and the India-EU Trade Technology Council (TTC) Working Group 2 (WG 2) Meeting on Green and Clean Energy Technologies

B. Green Hydrogen Mobility Project at Leh implemented by NTPC - first ever field trial of commercial fuel cell bus in Leh, Ladakh achieved to aid in its decarbonization.

The project being implemented by NTPC Ltd. aims to produce green hydrogen (80 kg/day) using solar power and to compress, store, and dispense green hydrogen safely into Fuel Cell Buses (5 nos.) which will run hydrogen buses on intra-city routes (Leh, Ladakh) at an altitude of 3400 m, within a temperature range of -25 C to +30 C. The foundation of the project was laid by the Hon'ble Prime Minister on 30.07.2022.

Key activities and progress achieved by the project are listed below and depicted in Fig.7.4:

- In a significant achievement, the first field trial of a hydrogen Fuel Cell Electric Bus (manufactured by Ashok Leyland) in Leh, Ladakh, took place on 17th August 2023. Manufacturing of more buses is expected to be completed by the middle of 2024. The Fuel Cell Buses would be plying in and around Leh, each covering a total distance of 200 km each day, and are expected to mitigate 500 tons of CO2 emission annually. The pilot project would be the first commercial-scale deployment of FCEV vehicles in Indian conditions and accelerate decarbonization of the mobility sector in Ladakh and subsequently for the whole country.

- **Green Hydrogen fueling station (80 kg/day):** Detailed engineering of the hydrogen fueling station was completed on 30.06.2023. Safety approvals for hydrogen storage cylinders are under process.

- **1.70 MW Solar Plant for H2 production:** Procurement and field installation of solar equipment have been completed in this financial year. The erection of the inverter was completed on 1.09.2023.

Fig. 7.4: Progress by Green Hydrogen Mobility Project at Leh implemented by NTPC

Fig. 7.5: Automated PEMFC Assembly Pilot line facility at ARCI-CFCT - first of its kind in India

C. Design and development of 20kW Low-Temperature Polymer Electrolyte Membrane (LT-PEM) fuel cell with high indigenous content – first-of-its-kind automated PEMFC components/ stack fabrication pilot line in India

PEM fuel cell (PEMFC) is currently the leading technology for deployment in various applications, including both stationery and transport applications. However, the fuel cell demonstrations, which are under development in India are reliant on imported, costly, LT-PEM fuel cell stacks.

This project has resulted in a **significant breakthrough** through the establishment of an automated PEMFC components/stack fabrication pilot line **(Fig. 7.5)** for improving mass manufacturability, process simplification, and standardization. Additionally, indigenously developed catalyst-coated membranes using an in-house electrocatalyst, gas diffusion layer, and bipolar plates are being used for stack fabrication using the automated assembly line. This is the **first-of-its-kind facility in India**, providing a much-needed impetus to the manufacturing capability for PEMFC stack fabrication in the country, which remains one of the major R&D gaps hindering cost reduction and implementation of this technology.

D. Setting up of a Centre of Excellence on Hydrogen Energy at the National Institute of Solar Energy (NISE), Gwal Pahari, Haryana

The main objectives of the project include (i) operation and maintenance of country's solar-powered (120 kWp) SPV green hydrogen generation and dispensing station (capable of dispensing hydrogen at 350 bars to the vehicles at 1kg/min) already established at the NISE campus, as well as (ii) augmenting green hydrogen production capacity by setting up an additional 10 Nm3/hr electrolyser. In terms of key developments, an augmentation of green hydrogen production capacity was undertaken at NISE with the addition of a 10 Nm3/hr alkaline electrolyzer (Fig.7.6), increasing total hydrogen production capacity to a total of 15 Nm3/hr (about 1.35 kg/hr). NISE is also in the process of reviving the existing station and integrating the new electrolyzer into the dispenser.

Fig.7.6: Installation of new electrolyser at NISE hydrogen generation facility

7.9 R&D In Small Hydro

A. Centre of Excellence for Small Hydropower, IIT Roorkee

A Centre of Excellence for Small Hydropower at Department of Hydro and Renewable Energy, IIT Roorkee, initiated this project in April 2023 with the three main objectives of (a) Development of Ultra Low Head Turbine (ULH), (b) Development of Hydro Kinetic Turbine (HKT) and (c) Development of Guidelines for performance prediction of Small Hydro turbines & reversible Pump turbine by Computational Fluid Dynamics (CFD).

7.10 MAJOR ACTIVITIES UNDERTAKEN DURING FY 2023-24

i. The MNRE, in collaboration with the Shakti Foundation and RTI International, organized the "R&D Conclave on Renewable Energy" on 11-12 April 2023, in MNRE, New Delhi, to highlight the latest R&D developments, scale up adoption of industry-ready technologies, and collaborative R&D efforts between different stakeholders. The Conclave also unveiled the MNRE R&D Portal. Details are available on the MNRE website.

ii The MNRE R&D Division supported the Office of Principal Scientific Adviser (PSA) to the Government of India to organize a two-day workshop, "India-European Union (EU) Trade & Technology Council (TTC) Working Group 2 (WG2) on Green & Clean Energy Technologies," from 10th - 11th October 2023 at MNRE. Further details on the workshop are available on the MNRE website.

iii IEA and MNRE hosted a half-day workshop on 7th November, 2023, to explore possibilities of joining and engaging with representatives of the Technology Collaboration Programme (TCPs) on topics such as hydrogen, solar, wind, geothermal, bioenergy, ocean energy, energy storage, and hydropower suitable TCPs in future. Further details on the workshop are available on the MNRE website.

iv Bilateral Project on "Innovative Solar" Applications (IN-Solar) with GIZ: Under Indo-German technical cooperation, the Government of India (MNRE) and the Government of Germany had signed an Implementation Agreement with GIZ to implement the project titled "Innovative Solar" (IN-Solar). Under this project, GIZ has initiated a project titled I-SUN (India-Solar Usage in New Applications). The main objective of this project is to create improved conditions for the use of innovative, low-competition areas for the use of land for the expansion of photovoltaics.

Under the IN-Solar project, the following activities are being carried out: (i) 7 New and Innovative Solar PV applications shortlisted for further proliferation; (ii) Assessing potential of New and Innovative Solar Applications (NISA) such as floating solar, agri PV, canal-top PV, urban-PV, rail-PV, road-PV, building-integrated PV ; (iii) The MNRE and GIZ hosted a Full-Day Workshop on "AgriPV in India- Scope and Prospects" on 23rd June, 2023 to share project progress and findings with stakeholders. (iv) Under the project, the Delhi Metro Rail Corporation (DMRC) has been demonstrating a project on Rail PV by using vertical bifacial panels.

7.11 R&D Projects Under Implementation

Given below is a list of R&D projects under implementation during FY 2023-24:

S.No.	Title of the Project	Name of the Pi & Institution
1	National Centre for Photovoltaic Research and Education (NCPRE) Phase-II	Indian Institute of Technology Mumbai
2	National Primary Standard facility for cell calibration	National Physical Laboratory (NPL), Delhi
3	Development of high efficiency (21%/ 19%) PERC type of c-Si/mc-Si solar cell	BHEL-ASSCP, Gurugram and National Institute of Solar Energy, Gurugram
4	Flexible Perovskite Solar Cells and Intermediate Module	Indian Institute of Technology Bombay, Powai, Mumbai

Wind Energy

S.No.	Title of the Project	Name of the Pi & Institution
1	Integrated Wind and Solar Resource Assessment	National Institute of Wind Energy Chennai
2	Met-Ocean Measurements (Wind, Wave, Tide, Current, Water Level, etc.,) at the Gulf of Khambhat and the Gulf of Mannar	National Institute of Wind Energy Chennai

Waste to energy

S.No.	Title of the Project	Name of the Pi & Institution
1	Biomass Gasification through Plasma Pyrolysis Technology for Chemicals Production	IIT Roorkee
2	Densification and co-firing of agro-waste for power generation through gasification	SSS-NIBE

Hydrogen energy

S.No.	Title of the Project	Name of the Pi & Institution
1	Design & development of 20kW Low-Temperature Polymer Electrolyte Membrane Fuel Cell (LTPEMFC) with high indigenous content	ARCI-CFCT, Chennai
2	Setting up of a Centre of Excellence on Hydrogen Energy at the National Institute of Solar Energy (NISE), Gwal Pahari, Haryana	NISE Gurgaon
3	Green Hydrogen Mobility Projects at Leh	NTPC

Small Hydro

1	Centre of Excellence for Small Hydropower, IIT Roorkee	IIT Roorkee

7.12 ENERGY STORAGE

Renewable Energy sources are variable and intermittent in nature and as integration of high volumes of Renewable into Grid, there would be a challenge in terms of grid security, stability & safety. Grid scale Energy Storage Systems (ESS) would help in smoothening the renewable generation output and thereby improving the power quality, helping grid stability. This will also result in reduction of transmission network congestion and making better use of network infrastructure. The Solar Energy Corporation of India Ltd (SECI), a CPSU under the Ministry, is promoting ESS coupled with renewable energy projects. Details (till 31.12.2023) are given below:

7.12.1 In Developer Mode

I 1200 MW ISTS-connected RE projects with Peak Power Supply (ISTS-VII). Letter of Award (LoA) was issued in Feb 2020, the projects are currently under implementation.

ii 400 MW Round-the-Clock (RTC) Supply of RE Power (RTC-I) LoA was issued in June 2020, the projects are currently under implementation.

iii 1200 MW ISTS-Connected RE Projects with assured Peak Power Supply (Tranche VI). LoA was issued in April 2023, the projects are currently under implementation.

iv MW Firm and Dispatchable Power from ISTS-connected Renewable Energy (RE) Power Projects to Punjab (SECI-FDRE-I) (Bidding in Process

v 1500 MW Firm and Dispatchable Power from ISTS-connected Renewable Energy (RE) Power Projects to Punjab and Madhya Pradesh (SECI-FDRE-II) (Bidding in Process)

vi 800 MW Firm and Dispatchable Power from ISTS-connected Renewable Energy (RE) Power Projects to Haryana (SECI-RTC-IV) (Bidding in Process)

vii 1260 MW Firm and dispatchable power from ISTS-connected Renewable Energy (RE) Power Projects to Delhi (SECI-FDRE-IV) (Bidding in process)

viii 4 MW Floating SPV Project with 1 MW/2 MWh BESS at Kalpong Dam, Diglipur in the UT of Andaman and Nicobar. The project is under implementation.

7.12.2 In CAPEX Mode

I 100 MW (AC) Solar PV Power Plant (160 MWp DC capacity) along with 40 MW/120 MWh BESS at Rajanandgaon, Chhattisgarh: SECI has awarded the project to an EPC contractor,

ii 1.7 MWp SPV Project with 1.4 MWh BESS in Kavaratti & Agatti Islands, Lakshadweep. The project is under implementation

iii 2 MW SPV Power Plant with 01 MWh BESS at Kaza, Himachal Pradesh, India. The project is under implementation; it was set up through one of SECI's JV companies.

7.12.3 STANDALONE BESS

SECI has also come up with tender for setting up of 500 MW/1000 MWh ISTS-connected standalone Battery Energy Storage System (BESS) project at Fatehgarh-III substation in Rajasthan. LoA was issued in January 2023.

7.13 STANDARDS & QUALITY CONTROL IN RENEWABLE ENERGY SECTOR

7.13.1 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

S.No.	Programme	Product & Standard Title	Stamndards
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
		- Type and Component Certification Scheme	IECRE OD-501
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

7.13.2 Quality Control in SPV Power Projects

7.13.2.1 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 labs, 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. The self-certification of SPV inverters for manufacturers having valid IEC certificates was extended up to 30.06.2023 and further extended up to 31.12.2023 during the year 2023-24. Further, at present, the QCO 2017 stands implemented for SPV inverters up to 100 kW capacity w.e.f. 01.01.2024 and for inverters above 100 kW, the implementation of QCO is extended up to 31.12.2024.

The modification/updation of this Quality Control Order 2017 with revised versions of Indian Standards, BIS Act 2016, BIS (Conformity Assessment) Regulations 2018 in under consideration.

7.13.2.2 BIS Registration of Products

The nos. of registration 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 31.03.2024 is given in Table 7.2. Out of 479 nos. manufacturers who were granted registration for SPV Products, 289 Nos. are domestic manufacturers (60.33%). The MNRE has decided that only SPV Products 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 Products but also domestic manufacture of SPV Products with quality at international level, hence fulfilling the objective of Atmanirbhar Bharat.

Star Labelling/Rating of Solar PV Modules

Ministry of New and Renewable Energy on 17.10.2023 has conveyed its concurrence for launch of Star Labelling Program for Solar Photovoltaic (SPV) modules. The programme was launched on October 20, 2023, by the Shri R. K. Singh, Hon'ble Minister for Power and New & Renewable Energy. The star labelling programme will be implemented by Bureau of Energy Efficiency. Initially, Star Labelling of PV modules shall be for the period from January 1, 2024 till December 31, 2025 in the voluntary regime.

Table 7.2: Registration nos. granted by BIS under MNRE Quality Control Order (CRO) 2017 till 31.03.2024

S.No.	Product Name	No. of Registrations		
		Domestic	Foreign	Totals
1	SPV Modules	224	125	349
2	SPV Inverters	55	65	120
3	Storage Batteries	10	0	10
	Total	**289**	**190**	**479**

CHAPTER 8

Renewable Energy in North Eastern Region States

8.1 Introduction

Special attention is being given to the development of renewable energy in the entire North Eastern Region (NER) through a separate budgetary allocation of 10% under various renewable energy programme for the deployment of grid & off-gridSolar Energy Systems, Wind energy systems, small Hydro Projects and Biogas plantsamong others, in the region.

The total estimated potential of renewable energy in the NER from Solar, SmallHydro, wind and Bio-energy is around 66.88 GW (excluding large hydro), a substantial part of which is suitable for grid-connected applications. State-wise details are shown in Table 8.1.

Table 8.1: State-wise Renewable Energy Potential in NER

S. No.	State/UTs	Wind Power	Small Hydro Power	Biomas Power	Solar	Total excluding large hydro
		(MW) @ 150 m	(MW)	(MW)	(MW)	(MW)
1	Arunachal Pradesh	246	2064.92	18.46	8650	10979.38
2	Assam	459	201.99	321.89	13760	14742.88
3	Manipur	0	99.95	62.31	10630	10792.26
4	Meghalaya	55	230.05	68.54	5860	6213.59
5	Mizoram	0	168.90	2.9	9090	9261.8
6	Nagaland	0	182.18	53.9	7290	7526.08
7	Sikkim	0	266.64	4.73	4940	5211.37
8	Tripura	0	46.86	34.35	2080	2161.21
	Total	**760**	**3261.49**	**567.08**	**62300**	**66888.57**

The State-wise details of Renewable Energy capacity installed as on 31.03.2024, inthe NER are given in Table 8.2.

Table 8.2: State-wise Renewable Power capacity installed in the NER as on 31.03.2024

S. No.	State/UTs	Small Hydro Power	Bio Power	Ground Mounted Solar	Rooftop Solar	Off-grid Solar/ KUSUM	Solar Power Total	Total Capacity excluding Large Hydro
		(MW)	(MW)	(MW)	(MW)	(MW)	(MW)	(MW)
1	Arunachal Pradesh	133.11	0	1.27	4.34	6.18	11.79	156.69
2	Assam	34.11	2	105	41.74	9.44	156.18	348.47
3	Manipur	5.45	0	0.6	6.36	6.08	13.04	31.53
4	Meghalaya	55.03	13.8	0	0.21	4.03	4.24	77.31
5	Mizoram	45.47	0	22	1.96	6.35	30.31	106.09
6	Nagaland	32.67	0	0	1	2.17	3.17	39.01
7	Sikkim	55.11	0	0	5.12	1.92	7.04	69.19
8	Tripura	16.01	0	5	4.78	8.68	18.46	52.93
	Total	**376.96**	**15.8**	**133.87**	**65.51**	**44.85**	**244.23**	**881.22**

8.2 Small Hydro Programme

NE States have fairly good potential to develop small Hydro-power projects. Among the NE States, Arunachal Pradesh has the highest potential followed by Sikkim, Meghalaya and Assam. MNRE has been giving special emphasis to the development of small hydro projects in the NER. Small hydropower projects can provide energy almost uninterrupted without any major maintenance or dependence on weather. Small Hydro Power projects can generate su cient electricity to power domestic households, schools, and clinics in rural areas and trigger entrepreneurship activities. The details are given in Table Nos. 8.3 and 8.4.

Table 8.3: State-wise Small Hydro Potential and total installed in the NER States as on 31.03.2024

S. No.	State	Total potential (MW)	Total installed capacity (MW)
1	Arunachal Pradesh	2064.92	133.11
2	Assam	201.99	34.11
3	Manipur	99.95	5.45
4	Meghalaya	230.05	55.03
5	Mizoram	168.90	45.47
6	Nagaland	182.18	32.67
7	Sikkim	266.64	55.11
8	Tripura	46.86	16.01
	Total	**3261.49**	**376.96**

Table 8.4: Small Hydro Power Projects currently under implementation in NER as on 31.03.2024

S. No.	Name of Project	Capacity (MW)	Implementing Agency
Arunachal Pradesh			
1	PakhanKha SHP	0.50	Department of Hydro Power Development
2	TiruNallah SHP	0.10	Department of Hydro Power Development
3	Fure SHP	0.05	Department of Hydro Power Development
4	Kush SHP	2.00	Department of Hydro Power Development
5	Taksang Chu SHP	3.40	Hydro Power Development of Arunachal Pradesh Ltd.
Meghalya			
6	Riangdo SHP	3.00	Meghalaya Power Generation Corporation Ltd.
Nagaland			
7	Duilumroi SHP	2.40	Department of Power, Govt. of Nagaland

8.3 PM KUSUM Scheme

PM-KUSUM (Pradhan MantriKisanUrja Suraksha EvamUtthaanMahabhiyan) scheme to promote small Grid-Connected Solar or Other Renewable Energy Power Plants, installation of stand-alone solar-powered agricultural pumps and solarisation of existing grid-connected agricultural pumps including feeder-level solarisation (FLS).

For the North Eastern States, Sikkim, Jammu & Kashmir, Ladakh, Himachal Pradesh, Uttarakhand, Lakshadweep, and A&N Islands, the CFA is provided as follows: -

I Under Component A, Procurement Based Incentives @ Rs. 0.40 per unit for five years will be provided to DISCOMs.

ii For all the individual farmers installing/solarising the agriculture pumps up to 7.5HP capacity under both the Component-B and Component-C will be provided with Central Financial Assistance (CFA) of 50% of the benchmark cost or the tender cost, whichever is lower. Further, the CFA will be available for pump capacity up to 15 HP, however, it will be restricted to 10% of total installations in the state. The State Government will provide a subsidy of at least 30%, and the remaining up to 20% is to be provided by bank loan/farmer.

iii Moreover, components- 'B' and 'C' can also be implemented without a State share of 30%. The Central Financial Assistance will continue to remain at 50% and the rest 50% will be borne by the farmer.

iv Under FLS, CFA is calculated considering the cost of the solar power plant as Rs. 3.5 Crore/ MW. Therefore, the CFA of 1.75 Crore/MW will be provided to States.

Table 8.5: Status of installations under PM KUSUM Scheme in the NER as on 31.03.2024

S. No.	State	Component-A (MW)		Component-B (Nos)		Component-C (Nos) Individual pump solarisation	
		Sanction	Installed	Sanction	Installed	Sanction	Installed
1	Arunachal Pradesh	2	-	700	199	-	-
2	Assam	10	-	4000	-	1000	-
3	Manipur	0	-	150	78	-	-
4	Meghalaya	0	-	3035	82	-	-
5	Mizoram	0	-	2700	-	-	-
6	Nagaland	5	-	265	65	-	-
7	Tripura	5	-	10895	2117	2600	50
	Total	**22**	-	**21745**	**2541**	**3600**	**50**

8.4 Solar Parks

Ministry is implementing a Scheme for "Development of Solar Parks and Ultra MegaSolar Power Projects" with an objective to set up at least 50 nos of Solar Parks with an aggregate capacity of 40,000 MW of solar power projects. All the States and Union Territories are eligible for getting benefit under the scheme.

Under the Scheme, Ministry have approved 55nos of Solar Parks in 13 States including one Solar Park of capacity 20MW in Vankal, Champhai District, Mizoram. The Solar Park at Vankal in Mizoram has been successfully commissioned.

8.5 PM-Surya Ghar: MuftBijliYojana

The Government of India has approved the PM Surya Ghar: MuftBijliYojana on 29th February, 2024 to increase the share of solar rooftop capacity and empower residential households to generate their own electricity. The scheme has an outlay of Rs 75,021 crore and is to be implemented till FY 2026-27. The Ministry of New and Renewable Energy has been implementing the Grid Connected Rooftop Solar Phase II Programme since 2019, which was proposed to be implemented till 2025-26 with a budgetary outlay of Rs 11,814 crores.

This scheme stands subsumed within the PM Surya Ghar: MuftBijliYojana. The CFA releases for ongoing projects against allocations made by MNRE to implementation agencies under Phase II shall be governed by the guidelines issued under the Phase II programme and shall not be covered under the PM – Surya Ghar Scheme CFA structure. However, the budgetary releases for phase II programme shall be met through the new scheme outlay.

CFA Structure: The Central Financial Assistance for the residential sector shall be as per the following table:

	Type of Residential Segment	CFA
1	Residential Sector (first 2 kWp of RTS capacity or part thereof)	60 % of benchmark cost of 2 kW
2	Residential Sector (with additional RTS capacity of 1 kWp or part thereof)	40 % of benchmark cost of 2 kW
3	Residential Sector (additional RTS capacity beyond 3 kWp)	No additional CFA
4	Group Housing Societies/ Residential Welfare Associations (GHS/RWA) etc, for common facilities including EV charging up to 500 kWp (@3 kWp per house) with upper limit being inclusive of individual rooftop plants installed by individual residents in the GHS/RWA	As per Sr. no. (2) above

Benchmark Cost

The benchmark cost for 1 kW system is fixed at 50,000/kW for the first 2 kW of RTS capacity and 45,000 for the additional kW with effect from 13th February, 2024. The benchmark for special category States (States/UTs of Uttarakhand, Himachal Pradesh, J&K, Ladakh, States in the North East including Sikkim, UTs of A&N and Lakshadweep) will be Rs 55,000/kW for first 2 kW of RTS capacity and Rs 49,500 for the additional kW of RTS capacity.

Table 8.6: Progress under the Rooftop Solar as on 31.03.2024

S. No.	State/UT	Total Amount Released So far (in Crores)	Capacity installed through CFA including of National Portal (MW)	Cumulative RTS capacity installed with and without CFA (MW)
1	Arunachal Pradesh	0.00	0.00	2.00
2	Assam	7.34	0.77	41.74
3	Manipur	1.13	0.68	5.50
4	Meghalaya	0.00	0.00	0.21
5	Mizoram	0.85	0.63	1.96
6	Nagaland	0.00	0.09	0.19
7	Sikkim	0.00	0.00	5.12
8	Tripura	0.00	0.03	4.78
	Total	9.32	2.20	61.5

8.6 Off Grid Solar PV Programme

O -grid Solar PV Programme is implemented in the NER states through the O - Grid and Decentralized Solar PV Applications Programme, the Ministry provided Central Financial Assistance (CFA) for the deployment of Solar Street Lights, Solar Study Lamps/Lanterns, Solar Home Lighting Systems, and Solar Power Packs to meet the electricity and lighting needs of local communities, institutions, and individuals mainly in rural areas.

Pradhan MantriJanjatiAdivasi Nyaya MahaAbhiyan (PM JANMAN) was launched to focus on eleven critical interventions through Nine Line Ministries for implementation. The Mission, inter-alia, covers the implementation of New Solar Power Scheme (for Particularly Vulnerable Tribal Groups (PVTG) Habitations/Villages) for electrification of one lakh un-electrified households (HHs) in PVTG areas located in 18 States and UT of Andaman & Nicobar Islands including from the states of Manipur & Tripura, by provision of o -grid solar systems where electricity supply through grid is not techno-economically feasible. Based on the demand received, the off-grid solar systems have been sanctioned to 1703 PVTG households (HHS) in the state of Tripura.

NER State-wise cumulative numbers/capacity of o -grid solar applications installed/distributed under the MNRE programs are given in Table 8.7 below.

Table 8.7: State-wise cumulative numbers/capacity of off-grid solar applications in NER

S. No.	Agencies	Solar Home Light (Nos.)	Solar Lamp (Nos.)	Solar Street Light (Nos.)	Solar Power Plant (kW)
1	Arunachal Pradesh	35065	218551	25008	963.2
2	Assam	46879	647761	29538	1605
3	Manipur	24583	69722	32767	1580.5
4	Meghalaya	14874	97360	5800	2004
5	Mizoram	12060	155217	20325	3894.6
6	Nagaland	1045	30766	16045	1506
7	Sikkim	15059	45200	504	850
8	Tripura	32723	364012	15517	867
	Total	**182288**	**1628589**	**145504**	**13270.3**

8.7 Biogas Programme

MNRE is implementing the Biogas Programme under Umbrella National Bioenergy Programme in the NER States for providing clean gaseous fuel mainly for cooking, lighting, decentralized power generation needs of users and production of organic manure for households and dairy, poultry sector, agro/food-based industries in the NER States through State Government Nodal Departments/ State Nodal Agencies. MNRE has allocated targets to the State Nodal Agencies/ Departments for implementing the Biogas Programme in the States of Assam, Arunachal Pradesh, Manipur Meghalaya, Mizoram, Nagaland, Sikkim, and Tripura during the year 2023-24. Under the Biogas Programme, 20% of additional CFA over and above the standard CFA is applicable for all the biogas plants installed in NER.

2. A Biogas Development and Training Centre for all the NER States for providing training and technical support under the Biogas Programme is functional at Department of Mechanical Engineering, Indian Institute of Technology, Guwahati, Assam.

8.8 Wind Resource Assessment Programme:

NIWE in collaboration with RISO DTU Denmark prepared the Indian Wind Atlas for the Country including NER during the year 2010. The estimated wind potential of NER at 50 m level was estimated to 406 MW.

Further, NIWE has also estimated the installable wind power potential at 80 m in NER wherein the estimated potential indicates 600 MW. The State wise details of wind potential both at 50 m and 80 m in NER is given in the Table 8.8 below:

Table 8.8: State wise details of wind potential both at 50 m and 80 m in NER

S. No.	State/UTs	Estimated Potential (MW)*	
		@50m	@80m
1	Arunachal Pradesh	201	236
2	Assam	53	112
3	Manipur	7	56
4	Meghalaya	44	82
5	Nagaland	3	16
6	Sikkim	98	98
	Total	**406**	**600**

*The Wind potential is yet to be validated with actual measurements to take much more informed and better decisions.

As of 31.03.2024, a total of 97 Wind Resource Assessment instrumentation using 25 m and 50 m meteorological masts were carried out at NER and the requisite data collection from all these Wind Resource Assessment stations were completed and closed down subsequently. In addition, Wind Resource Assessment was also carried out by utilizing the Existing Telecom Towers at NER. As of 31.03.2024, a total of 80 Telecom Tower Stations of heights ranging from 25 m to 80 m were employed for this purpose and the requisite data collection from all these Telecom Towers were also completed.

8.9 Human Resource Development (HRD) Programme

HRD Programme of MNRE aims to institutionalize renewable energy education and training to meet the requirement of qualified and trained manpower in the country. HRD Programme supports trainings for manpower including promoting higher studies and research courses by providing Fellowships to students and research scholars in R&D and academic institutions in Renewable Energy. Ministry also provides Support to educational and other training organizations for conducting short-term trainings on various aspects of Renewable Energy with focus on skill development at all levels. Under short-term training programmes of HRD scheme, Ministry is implementing Skill Development Programmes namely Solar PV Technician (Suryamitra), Solar Water Pumping Technician (Varunmitra), Wind Power Plant Technician (Vayumitra) and Small Hydro Power Plant Technician (Jalurjamitra) through NISE, NIWE and IIT Roorkee to train workforce for installation, commissioning, operation and maintenance of renewable energy projects.

The Ministry is creating skilled manpower in various technologies of Renewable Energy in NER. Under the Suryamitra Programme, initiated in 2015, a total of 2110 Suryamitras were trained, under Varunmitra programme, 71 Varunmitras were trained and 29 Jalurjamitras were trained under Jalurjamitra programme launched in March, 2022 in NER. The State-wise progress of trained manpower in NER under these Programmes are given in Table 8.9.

Table 8.9: State-wise progress of trained manpower in NER under HRD Programme as on 31.03.2024

S. No.	State	Manpower trained		
		Suryamitras	Jalurjamitras	Varunmitras
1	Arunachal Pradesh	60	29	-
2	Assam	1632	-	71
3	Manipur	150	-	-
4	Meghalaya	30	-	-
5	Mizoram	0	-	-
6	Nagaland	60	-	-
7	Sikkim	0	-	-
8	Tripura	178	-	-
	Total	2110	29	71
	Grand Total	**2210**		

CHAPTER 9

PRODUCTION LINKED INCENTIVE (PLI) SCHEME: 'NATIONAL PROGRAMME ON HIGH EFFICIENCY SOLAR PV MODULES'

8.1 Ministry of New and Renewable Energy, Government of India is implementing the Production Linked Incentive (PLI) Scheme for National Programme on High Efficiency Solar PV Modules, for achieving manufacturing capacity of Giga Watt (GW) scale in High Efficiency Solar PV modules with an outlay of Rs. 24,000 crores. This Scheme has provision for Production Linked Incentive (PLI) to the selected solar PV module manufacturers for five years post commissioning, on manufacture and sale of High Efficiency Solar PV modules.

9.2 Aims and Objectives

The scheme aims to build an ecosystem formanufacturing of high efficiency solar PV modules in India and thus reduce import dependence in the area of Renewable Energy. The objectives of the scheme include the following:

I To build up solar PV manufacturing capacity of high efficiency modules.

ii To bring cutting-edge technology to India for manufacturing high efficiency modules. The scheme will be technology agnostic in that it will allow all technologies. However, technologies which yield better module performance will be incentivized.

iii To promote setting up of integrated plants for better quality control and competitiveness.

iv To develop an ecosystem for sourcing of local material in solar manufacturing

v Employment generation and technological self-sufficiency.

9.3 The PLI Scheme is being implemented in two tranches as follows:

9.3.1. Tranche-I:

i The Union Cabinet approved the Production Linked Incentive (PLI) Scheme for National Programme on High Efficiency Solar PV Modules, for achieving manufacturing capacity of Giga Watt (GW) scale in High Efficiency Solar PV Modules on 7th April, 2021. Ministry of New & Renewable Energy (MNRE) issued the Scheme Guidelines for Production Linked Incentive Scheme on 'National Programme on High Efficiency Solar PV Modules' on 28th April, 2021, with an outlay of Rs. 4,500 crores.

ii Under this tranche, Indian Renewable Energy Development Agency Limited (IREDA), the implementing agency on behalf of MNRE for the PLI Scheme (Tranche-I), issued the Bid Documents for selection of manufacturers for setting up manufacturing capacities for High Efficiency Solar PV Modules. Letters of Award were issued by IREDAin November and December, 2021 to three successful bidders for setting up of 8,737 MW capacity of fully integrated Solar PV Module manufacturing units within PLI scheme outlay of Rs. 4,500 crores. The aforesaid 8,737 MW solar PV manufacturing capacity is scheduled for commissioning by around end of year 2024.

9.3.2. Tranche-II:

I Subsequent to the Union Cabinet approval dated 21.09.2022, Ministry of New & Renewable Energy, on 30.09.2022, has issued Scheme Guidelines for implementation of Tranche-II of the PLI Scheme for High Efficiency Solar PV Modules, with an outlay of Rs. 19,500 crores.

ii Under this tranche, Solar Energy Corporation of India (SECI), the implementing agency on behalf of MNRE for the PLI Scheme (Tranche-II), issued the tender document for selection of Solar PV manufacturers under Tranche-II of PLI Scheme for High Efficiency Solar PV Modules. Letters of Award (LoAs) have been issued by SECI to 11 bidders in April 2023 for setting up 39,600 MW of fully/partially integrated solar PV module manufacturing. The aforesaid 39,600 MW capacity is scheduled for commissioning from October, 2024 to April, 2026, depending upon the extent of integration involved.

9.4. Expected Outcome/Benefits

The outcomes/benefits expected from the scheme are as follows:

I It is estimated that about 48,337 MW per annum manufacturing capacity of fully and partially integrated, solar PV modules would be installed.

ii The scheme will bring direct investment of around Rs.1,11,000 crore.

iii Creation of manufacturing capacity for Balance of Materials like EVA, Solar glass, Backsheet, etc.

iv Direct employment of about 44,000 persons.

v Impetus to Research and Development to achieve higher efficiencies in Solar PV Modules.