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Strengthening National MRV Systems – Options and approaches for India

MRV Framework for Utility –Scale Solar Policies and Actions

Initiative for Climate Action Transparency

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MRV Framework for Utility-Scale Solar Policies and Actions

Initiative for Climate Action Transparency: ICAT
MRV Framework for Energy Conservation Building Code for Large Commercial Buildings

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Cover photo: World's largest Solar Park- "Shakti Sthala", Pavagada Solar Park, Karnataka, India.
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Source: https://citytoday.news/worlds-largest-solar-park-launched-in-pavagada-by-cm-siddarmaiah/

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LIST OF ACRONYMS

AD : Accelerated depreciation
AHEC: Alternate Hydro Energy Centre
BM: Build margin
BS: Baseline scenario
CDM: Clean Development Mechanism
CEA: Central Electricity Authority
CERC: Central Electricity Regulatory Commission
CFA: Central Financial Allocation
CH_4: Methane
CIFF: The Children's Investment Fund Foundation
CM: Combined margin
CO_2: Carbon dioxide
CoP: Conference of the Parties
CTS: Current trajectory scenario
DCR: Domestic content requirement
DISCOMs: Distribution companies
GBI: Generation-based incentive
GDP: Gross domestic product
GHG: Greenhouse gases emissions
GST: Goods and Services Tax
GW: Gigawatt
ICAT: Initiative for Climate Action Transparency
IEX: India Energy Exchange
IREDA: Indian Renewable Energy Development Agency
JNNSM: Jawaharlal Nehru National Solar Mission
kW: kilowatt
kWh/m²/d: kilowatt-hour per metre square per day
kWh/y: kilowatt-hour per year
LoI: Letter of Intent
MNRE: Ministry of New and Renewable Energy
MoEFCC: Ministry of Environment, Forest and Climate Change
MoF: Ministry of Finance
MoP: Ministry of Power
MRV: Monitoring, Reporting and Verification
$MtCO_2$/y: Million tonnes of carbon dioxide per year
$MtCO_{2e}$: Million tonnes of carbon dioxide equivalent
MW: Megawatt
N_2O: Nitrous oxide
NAPCC: National Action Plan on Climate Change
NCEF: National Clean Energy Fund
NDC: Nationally Determined Commitments

NEP: National Electricity Policy
NIWE: National Institute for Wind Energy
NLDC: National Load Dispatch Centre
NSIE: National Institute for Solar Energy
NSM: National Solar Mission
NTP: National Tariff Policy
NTPC: National Thermal Power Corporation Limited
NVVN: NTPC Vidyut Vyapar Nigam
OE: Obligated entities
OM: Operating margin
PA: Paris Agreement
PGCIL: Power Grid Corporation of India Limited
PS: Policy scenario
PSA: Power Sale Agreements
PSU: Public Sector Unit
PXIL: Power Exchange of India Ltd.
RE: Renewable energy
REC: Renewable Energy Certificate
REMC: Renewable Energy Management Committee
RGO: Renewable Generation Obligation
RPO: Renewable Purchase Obligations
SCD: Scheduled Commissioning Date
SECI: Solar Energy Corporation of India
SERC: State Electricity Regulatory Commission
SLDC: State Load Dispatch Centres
SNA: State Nodal Agency
SPPD: Solar Power Park Developer
SSS-NIRE: Sardar Swaran Singh National Institute for Renewable Energy
tCO_2/MWh: Tonnes of carbon dioxide per megawatt-hour
tCO_{2e}: Tonnes of carbon dioxide equivalent
TERI: The Energy and Resources Institute
UMPP: Ultra-mega power plant
UNFCCC: United Nations Framework Convention on Climate Change
UNOPS: United Nations Office for Project Services
VGF: Viability Gap Funding

EXECUTIVE SUMMARY

The report proposes a framework for monitoring, reporting, and verification (MRV) of GHG emissions from policies and actions related to development of utility scale solar power in India, which will help track India's NDC commitments submitted to the UNFCCC. The report comprises six chapters that are as follows:

The introductory chapter (Chapter 1) covers background of India's Renewable Energy (RE) power sector, RE commitments with timelines, and installation status (86 GW as on 29th February, 2020). The chapter also highlights the need for MRV approaches to track the progress of targeted policies. The Government of India is aspiring to handhold the rapid upscaling of non-fossil based capacity installation through several policy measures including financial schemes, capacity building, and other measures. The non-fossil energy sector comprising solar, wind, biomass, large and small hydro has grown significantly in the last decade under the supervision of the Ministry of New and Renewable Energy (MNRE), Government of India. Solar energy with a major share in the current commitment at 100 GW out of total commitment of 175 GW installation by 2022, will play a crucial role in steering India's clean energy capacity addition and meeting country's Nationally Determined Commitments (NDCs). In the NDC, India has indicated to achieve 40% of the total installed power on non-fossil fuel based by 2030. In line with the decision of the Parties to monitor the progress on NDC commitments, it is important to develop effective MRV approach and identify the gaps and barriers hindering the NDC targets.

Chapter 2 presents key policies driving the RE capacity additions, institutional framework led by MNRE and comprising key relevant Government agencies, public sector units (PSUs), regulatory agencies, and their roles. India's renewable energy capacity landscape is integrated under the two key initiatives — the Electricity Act, 2003 and the National Action Plan on Climate Change (NAPCC), 2008. The succeeding policies including National Tariff Policy (2006) and New Tariff Policy (2016) were brought out to promote the sustainable growth of renewable energy capacity by providing the required infrastructural, financial, and capacity supports. India with its large and diverse geographical landscape, it is imperative to have a multi-level stakeholder engagement at national, state and regional level for steering the deployment of renewable energy capacity addition. Under the guidance and strategic leadership of the MNRE, Government of India has established several government agencies, institutions, and public sector units to help build renewable energy capacity in the country. The key agencies and institutions involved in development of renewable energy in India include the MNRE, the Solar Energy Corporation of India (SECI), the Indian Renewable Energy Development Agency (IREDA), the National Institute for Solar Energy (NISE), the National Institute for Wind Energy (NIWE), Sardar Swaran Singh National Institute for Renewable Energy (SSS-NIRE), Alternate Hydro Energy Centre (AHEC), and supporting institutions include the Ministry of Power (MoP), the Central Electricity Regulatory Commission (CERC), the State Electricity Regulatory Commission (SERC), the Power Grid Corporation of India Ltd/National Load Dispatch Centre (PGCIL/NLDC), the State Load Dispatch Centers (SLDC), the Central Electricity Authority (CEA), NTPC Vidyut Vyapar Nigam (NVVN), India Energy Exchange (IEX), and the Power Exchange of India Ltd (PXIL).

Chapter 3 indicates the objectives, scope, and an overview of approach of the study.

The study aims to develop an effective MRV framework for evaluating impacts of targeted policies /actions on mitigating GHG emissions. The two key broad objectives are as follows:

- Contribute to the achievement of the country objectives under India's Nationally Determined Contribution (NDC) by establishing the follow-up framework to the implementation of the national targets on solar and the achievement of its objectives.

- Respond to the reporting obligations under the Conference of the Parties (COP) of the United Nations Framework Convention on Climate Change (UNFCCC).

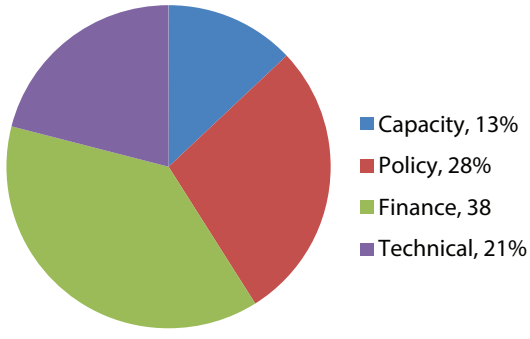
The two key schemes; 'The Viability Gap Funding (VGF) 750 MW' scheme and 'Scheme for developing Solar Parks and Ultra-Mega Solar Parks' were selected for the proposed assessment. The proposed two schemes jointly aim to build a capacity of 40,750 MW by 2022 (71% of the overall target). Adapting to the ICAT guidance, the study uses the following three tiers to develop the MRV framework on mitigation of GHG emissions:

(i) Estimating mitigation potential; (ii) assessing GHG mitigation impacts; (iii) monitoring and reporting.

Chapter 4 that explores mitigation potential of the selected schemes first covers the characteristics of both the schemes. The 750 MW VGF Scheme aims to commission 750 MW capacity of solar, enabling scaling up of projects alongside cost reduction and help meet Renewable Purchase Obligations (RPOs) of the Obligated Entities (OEs). Currently, the scheme has successfully implemented 680 MW during its implementation period 2013–2022.

The second scheme under the proposed study; 'Scheme for Developing Solar Parks and Ultra-Mega Solar Parks', aims to install a number of solar parks across various states in the country, each with a capacity of Solar Projects generally above 500 MW. The scheme targets to achieve 40 GW of solar capacity by 2022. With its inception from 2014, the scheme has progressed and around 37 solar parks with a total capacity of 26 GW have been installed till date. Out of which a total of 6280 MW capacity has been awarded and around 5680 MW capacity has been commissioned (as of January 2020). Identification of GHG impacts is carried out by mapping cause-effect relationship across the life cycle of the electricity generation from the selected schemes. GHG assessment boundary considers impact on emissions due to substitution from fossil fuel to solar power, covering life cycles of both types of generations.

Chapter 5 summarizes the results of barrier analysis of the Solar Park Scheme and estimation of ex-ante and ex-post GHG reductions of Solar Park Scheme and VGF scheme, respectively. The barriers affecting the implementation of solar power projects under the two proposed schemes were investigated. In case of the 'VGF 750 MW scheme' with a total implementation target of 750 MW, 680 MW has been commissioned within a period of 5 years from its launch in October, 2013. One of the key barriers, impeding the due 70 MW was delays in getting land use change or delays in setting up external evacuation system. The second scheme—'Solar Park Scheme', which is currently under implementation phase, was evaluated for barriers with more structured approach adapting to ICAT Renewable Energy guidance. The key barrier categories: (i) financial; (ii) technical; (iii) capacity; and (iv) policy were identified as primary barriers hindering the implementation of solar parks. The structured questionnaires were used to interview sector experts associated with relevant stakeholders for comprehending their perspectives and ranking of the proposed barriers. The interviews and consultation indicated that major barriers for solar park implementation were financial and policy barriers (around 66%). Using appropriate CDM methodologies, approach both for ex-ante (expected emissions reductions over the assessment period) and ex-post (actual emissions reductions) assessment have been given. The ex-ante GHG reduction potential analysis of solar park scheme for the following three scenarios was conducted:



Expert rating of the different barriers that hinder solar park development in India

Scenario	Avoided Emission, year 2022 ($MtCO_2e$)	Scenario emissions, year 2022 ($MtCO_2e$)
Baseline scenario (absence of planned solar park scheme)	-	1,219
Solar park policy scenario (full implementation)	10.23	1,209
Current trajectory scenario (implementation of solar park scheme under current implementation barriers)	3.04	1,216

The ex-post GHG analysis for Solar parks scheme indicated that around 2,151,584 tCO2e was avoided for the year 2019-2020 from 5680 MW commissioned capacity. Further, ex-post GHG analysis for VGF 750 MW scheme showed a reduction to the tune of 252,280 tCO2e from 680 MW capacity installed between 2013 and 2018.

Chapter 6 includes key parameters on which data needs to be collected for the assessment framework; existing institutional framework has been discussed and proposal has been made for an appropriate institutional structure for the assessment. The study indicated that the data required for GHG estimation in RE sector is widely dispersed and collected at multiple sources. The data collection and collation is a key challenge to monitor the progress of the installed capacity under various schemes and policies. Further, in addition to the existing monitoring committee for solar park scheme, the study suggests creation of a Solar Parks Steering Committee headed by the Ministry of Environment, Forest and Climate Change (MoEFCC), hosted by the MNRE and supported by inventory teams at different levels; National level, State level, and Park project level. A Technical Consultative Committee has also been proposed.

1. Introduction: Need for MRV in Indian Renewable Energy Sector

With the adoption of the Paris Agreement (PA) in 2015, governments around the world are increasingly focused on implementing policies and actions that achieve greenhouse gas (GHG) mitigation objectives. Under the Paris Agreement, countries have submitted their Nationally Determined Contributions (NDCs) with an objective to limit the global warming to well below 2°C while pursuing efforts to limit the increase to 1.5°C. As committed in the NDCs, countries are working towards reducing GHG emissions from the key emitting sectors including energy and industry. Within the energy sector, electricity generation accounts for approximately 40% of global GHG emissions.

India has a diverse power generation portfolio ranging from coal, natural gas, nuclear, and hydro to solar, wind, biomass, and waste. As per Central Electricity Authority (CEA), net generation of 105,016 billion units (BU) was recorded for the period of April 2019 to December 2019[1] as compared to 771 billion units in 2009–10.[2] This shows an unprecedented growth in the added capacity alongside rising demand. The total installed capacity in the country until February 2020[3] was around 369 GW, where the private sector accounted for almost 45% at 173 GW followed by central sector at 103 GW and state sector at 93 GW.[4] Out of this, the total share of renewable energy (RE) sources in the mix has also seen a rapid rise in capacity addition through investment and policy development which stands at 86 GW, with ground mounted solar power at around 32 GW (as on 29th February 2020) implying the importance of RE in India's broad energy policy.

Renewable Energy development in India comes under the purview of the MNRE. India is one of the few countries in the developing world which has pioneered the development of RE and had a dedicated ministry for non-conventional energy as far back as in the early 1980s. In 2019, India had the 3rd largest capacity for solar and 4th largest capacity for wind globally (REN21).

As countries mainstream climate change in their economic development process, the commitment shown towards decarbonizing through RE by governments using multiple legislative, policy and technical initiatives becomes even more crucial. Apart from the role of central and state government policies, it also has a combination of funding mechanisms, institutional effectiveness and proper co-ordination frameworks which gives direction to the overall development of RE.

India has long experience with the exploitation of RE, with the MNRE having been established as early as in 1992. However, the sector received a real boost in 2010 and then again in 2015, with the adoption respectively of the Jawaharlal Nehru National Solar Mission (JNNSM) and the 175 gigawatt (GW) target for renewable energy capacity by 2022. The national target of achieving 175 GW of installed capacity in renewable energy by 2022 may be highly ambitious, but its achievement can meet multiple climate and developmental objectives, such as, mitigating GHG emissions, energy access, clean energy development, and economic opportunities through jobs and investments. Solar energy takes the major share in this target with 100 GW, bifurcated into 60 GW of utility scale solar and 40 GW of rooftop solar. These steps symbolize a crucial move towards a decarbonized economy which is also reflected in India's NDCs targeting to achieve a 40% cumulative installed capacity from non-fossil fuel sources. Hence, the RE sector holds an important place in terms of how the relative share of resultant mitigation efforts may change and how it may influence India's NDC targets in future.

Further, the decarbonization process depends on how efficiently and effectively the related

[1] As per generation data from Central Electricity Authority, Ministry of Power, for the month of January 2020 available online at: http://www.cea.nic.in/reports/monthly/executive-summary/2020/exe_summary-01.pdf last accessed on March 18, 2020.

[2] As per National Electricity Plan (Volume I) Generation. Published by Central Electricity Authority (CEA) in January 2018, available online at: http://www.cea.nic.in/reports/committee/nep/nep_jan_2018.pdf; last accessed on March 6, 2020.

[3] As per monthly installed data from Central Electricity Authority for the month of February 2020. Available online at: http://www.cea.nic.in/reports/monthly/installedcapacity/2020/installed_capacity-02.pdf, last accessed on March 18, 2020

[4] As per data from Ministry of Power, available online at: https://powermin.nic.in/en/content/power-sector-glance-all-india; last accessed on March 6, 2020.

targets are met which requires measurement of both emissions as well as emissions reductions and it should be done with as much precision as possible. Hence, there exists a need to put in an assessment framework which enables policymakers to review the progress of goals. In order to do so, data capture, is the sound basis for any MRV system. The MRV system in this case is designed for the collection and aggregation of the necessary data for calculation, measurement, reporting and verification of the emissions reductions (ER) as a consequence of the policies and actions implemented by a country to mitigate climate change.

An MRV system helps in building domestic capacities to ensure sustainability of reporting processes. An effective MRV informs domestic and international stakeholders and policymakers on progress achieved, and can help identify need for technical and financial support. An MRV framework that can effectively measure the impact of mitigation actions in terms of GHG emission reduction may also help policymakers to identify successful policies.

Currently, RE sector in India lacks a mandated system for comprehensive data collection, and hence evaluation of mitigation impacts in terms of avoided GHG emissions becomes a challenging task. As RE sector in India is observing diverse trends of development across different regions, there is a need to identify various factors that determine the RE capacity deployment patterns and subsequently impact the energy generation and emission reduction.

In this context, there is an increasing need to assess and communicate the impacts of renewable energy policies and actions to ensure they are effective in delivering GHG mitigation. An MRV system can prove to be a starting point for developing a streamlined GHG emission inventory at different levels that is relevant for different actors within and outside the RE sector.

Therefore, there is a need to develop MRV approaches and methodologies that could be useful to track progress of RE policies and schemes in India. Given the current national thrust towards solar energy, particularly utility scale with a target of achieving 60 GW by 2022, the focus of this work is to develop an MRV framework for the schemes that contribute to achieve the target of utility scale solar energy.

The Table 1 below highlights the various RE power capacities achieved as of February 2020.

Table 1: Programme/Scheme-wise Physical Progress in 2019-20 and Cumulative upto February, 2020

Sector	FY- 2019-2020		Cumulative Achievements
	Target	Achievement (April-February 2020)	(as on 29.02.2020)
I. Grid interactive power (Capacities in MWp)			
Wind power	3,000.00	2,043.28	37,669.25
Solar power - ground mounted	7,500.00	5,596.40	31,980.70
Solar power - rooftop	1,000.00	628.59	2,424.94
Small hydro power	50.00	90.00	4,683.16
Biomass (bagasse) cogeneration)	150.00	83.00	9,186.50
Biomass (non-bagasse) cogeneration)/ captive power	100.00	0.00	674.81
Waste to power	2.00	1.50	139.80
Total	11,802.00	8,442.77	86,759.16
II. Off-grid/ CAPTIVE power (Capacities in MWEQ)			
Waste to energy	10.00	12.41	191.13
SPV systems	400.00	54.86	970.47
Total	410.00	67.27	1,161.60
Iii. Other Renewable Technologies (Capacity in Nos.)			
Biomass plants	0.76	0.20	50.92
Source: MNRE[5]			

[5] As per the data published by Ministry of New & Renewable Energy (MNRE), accessed at https://mnre.gov.in/the-ministry/physical-progress on March 18, 2020.

2. Understanding RE Policy Landscape in India and Selection of Policy / Scheme for MRV Framework Development

2.1 Enabling Policies Promoting RE in India

Renewable Energy sources in India are anchored through umbrella act such as the Electricity Act, 2003 and the National Action Plan on Climate Change (NAPCC), 2008. The Electricity Act, 2003[1] provides for policy formulation by the Government of India and mandated State Electricity Regulatory Commissions (SERCs) to take steps to promote renewable sources of energy within their area of jurisdiction. Further, the Act has explicitly stated the formulation of National Electricity Policy (NEP) brought out in 2005, National Tariff Policy (NTP) notified in 2016, for developing power systems to ensure optimal utilization of all resources including renewable sources of energy. NEP also stated that the purchase of renewable power by the State Electricity Distribution Companies (DISCOMs) should be through competitive bidding. Under the following sections of the Electricity Act, an enabling environment was created for promotion of RE in the country:

- **Section 61(h). (Tariff regulations)-** The promotion of co-generation and generation of electricity from renewable sources of energy
- **Section 63. (Determination of tariff by bidding process)-** The Appropriate Commission shall adopt the tariff if such tariff has been determined through transparent process of bidding in accordance with the guidelines issued by the Central Government.
- **Under Section 86. (1) (e) (Functions of State Commission)-** Promote co-generation and generation of electricity from renewable sources of energy by providing suitable measures for connectivity with the grid and sale of electricity to any person, and also specify, for purchase of electricity from such sources, a percentage of the total consumption of electricity in the area of a distribution licensee.
- **Section 62.** - Central Electricity Regulatory Commission (CERC) released (Terms and Conditions for Tariff determination from Renewable Energy Sources) Regulations- These regulations shall apply in all cases where tariff, for a generating station or a unit thereof based on renewable sources of energy, is to be determined by the Commission under Section 62 read with Section 79 of the Act.

National Tariff Policy, 2006: Introduction of NTP in 2006 triggered fixation by SERCs of a minimum percentage of Renewable Purchase Obligation (RPO) from RE sources as targets for state distribution companies and other obligated entities taking into account availability of such resources in the region and its impact on retail tariffs and procurement by distribution companies at preferential tariffs determined by the SERCs. The recent amendments in NTP in 2016 mention promotion of RE as a crucial objective of the policy.

National Action Plan on Climate Change (NAPCC): It was launched in 2008 by the Government of India to achieve a sustainable development path by addressing the economic and environmental objectives. Eight missions form the core of NAPCC focused on promoting understanding of climate change, adaptation and mitigation, energy efficiency, and natural resource conservation. The National Solar Mission (NSM) was one of the key missions under NAPCC that was launched for significantly increasing the share of solar energy in the total energy mix of India. It was also envisaged to constitute a major contribution by India to the global effort to meet the challenges of climate change. The Mission has set the ambitious target

[1] The Electricity Act, 2003 published by the Ministry of Law and Justice (Legislative Department) on May 26, 2003, available online at: http://www.cercind.gov.in/Act-with-amendment.pdf; last accessed on March 6, 2020.

of deploying 20,000 MW of grid connected solar power by 2022 and aims at reducing the cost of solar power generation in the country through: (i) long-term policy; (ii) large-scale deployment goals; (iii) aggressive R&D; and (iv) domestic production of critical raw materials, components and products, with a view to achieve grid tariff parity by 2022. The solar mission was further divided into phase-I (2010–2013), phase-II (2013–17), and phase-III (2017–2022) for deployment of solar power in the country. Further, Government has revised the target of Grid Connected Solar Power Projects from 20,000 MW by the year 2021–22 to 100,000 MW by the year 2021–22 under the NSM in 2015. The target of 100,000 MW will comprise of 40,000 MW solar rooftop and 60,000 MW large- and medium-scale grid connected solar power projects, of which 40,000 MW is to be installed under Solar Parks scheme.

The New Tariff Policy 2016: Development of RE has been given a special consideration. New tariff policy pursues the following initiatives that will help in capacity addition and promote interstate transaction of RE power:

- SERCs to fix RPO trajectory to reach 17% of the RE in the total energy mix by 2022 which includes 8% from solar power.
- The policy also specifies Renewable Generation Obligation (RGO) which is applicable to the new coal/lignite-based thermal plants to install RE capacity which will be at least 10% of their total capacity. The renewable electricity can be sold by bundling with conventional electricity.
- To promote RE interstate exchange of power, the policy waived off inter-state transmission charges and losses for solar and wind power.

2.2 Institutional Framework for RE in India

The aim of this section is to highlight the institutional capacity, relevant for existing and planned MRV arrangements, in place to track the policies of the RE sector in India. It also provides an overview of the data sources provided by government institutions which can be used to monitor the progress and evaluate the success of the various policies and programmes through relevant parameters.

The institutions include executive bodies such as the Ministry of New and Renewable Energy (MNRE), Ministry of Power (MoP); regulatory commissions such as State and Central Electricity Regulatory Commissions (SERC, CERC); autonomous State and Central PSUs such as Power Grid Corporation of India Ltd (PGCIL), State Load Dispatch Centre (SLDC), Central Electricity Authority (CEA); financial institutions such as Indian Renewable Energy Development Agency (IREDA); RE market trading platforms such as India Energy Exchange (IEX) and Power Exchange of India Ltd (PXIL); autonomous R&D agencies under various ministries such as the National Institute for Solar Energy (NISE), Centre for Wind Energy Technology (C-WET), etc. Building upon the existing institutional data sources, an MRV framework can be established for different sub-sectors in the RE sector (such as solar, wind, etc.) to ascertain GHG impacts of the sub-sectoral policies/schemes. In addition to this, data collection mechanisms as referred in the various official reports such as 'United Nations Human Development Report', 'Economic Survey of India' presented by the Ministry of Finance, etc., as well as from Annual Reports on Grid Emission Factor and Renewable capacity addition released by the CEA[2] can be useful for establishing an integrated and robust MRV system.

The broad mandate of the MNRE is to develop national RE laws, develop national renewable electricity tariff policies, provide financial incentives for investors and manufacturers, set technical standards for RE, conduct resource potential mapping, promote effective use of technology, manage databases, and periodically review policies and programmes to evaluate their efficiency. The state government also plays an active role in developing state-level RE policies focussed on implementation, energy distribution and access, as well as by providing adequate fiscal and other incentives to investors and developers in terms of taxes, ease of availability of land, laws related to labour, etc.

The RE tariff at the central and state level is fixed by the Central Electricity Regulatory Commission (CERC) and State Electricity Regulatory Commission (SERC), respectively. It may be noted that only utility-scale RE is currently regulated. Off-grid RE is in a relatively unorganized sector and hence not regulated under the current framework. The CERC's mandate is to set benchmark and guidelines for preferential feed-in tariffs extended to RE sources, and to set regulations for inter-state trade of electricity through open access mechanism. The SERC's mandate is to

2 http://www.cea.nic.in/tpeandce.html

determine the actual feed-in tariff rates that will be implemented at the state level, set Renewable Purchase Obligation (RPO) targets for different RE sources based on resource availability, issue regulation on open access, and third-party sale.

The CERC and SERCs have issued various regulations including for solar RPOs, Renewable Energy Certificates (REC) trading framework, tariffs, grid connectivity, and forecasting, etc., for promoting solar energy. The Electricity Act, 2003 is also proposed to be amended to accelerate private participation in the RE value chain.

Trading platforms such as IEX and PXIL that enable trading of RECs among DISCOMs in order to facilitate the meeting of their RPO targets, can provide data on the state-wise capacity of RE on a real time basis. This can be tracked and compared with the stated targets.

Public Sector Undertakings (PSUs) perform a variety of functions in the RE supply chain. PSUs at the central and state level are tasked with electricity transmission and distribution that include PGCIL, NLDCs, and SLDCs. The Solar Energy Corporation of India (SECI) facilitates setting up RE power plants and enterprises such as NTPC Vidyut Vyapar Nigam (NVVN) help unit price reduction of solar power through bundling with cheaper coal power. These organizations can also serve as useful sources of relevant technical data in order to evaluate the implementation of policies.

Various institutions dedicated to Research and Development (R&D) have been established by the central government to provide the necessary technical capacity that will help realize its ambitious targets. These include the National Solar Energy Institute (NISE, formerly Solar Energy Centre), Centre for Wind Energy Technology (C-WET), Sardar Swaran Singh National Institute for Renewable Energy (SSS-NIRE) as the nodal R&D agency for biomass energy, and Alternate Hydro Energy Centre (AHEC) for R&D in small hydro power. These institutes provide technical support through resource potential mapping of various RE sources. This helps in identifying suitable locations for RE power plants and optimize the output.

Table 2 highlights the role of key organizations in policymaking, implementation and R&D with respect to RE. These agencies can play key role in domestic MRV systems for the sector.

Table 2: Key Institutions and their role in RE policy

Institution	Role in RE Policy Planning and Implementation
Ministry of New and Renewable Energy (MNRE)	◆ Apex body; plans , formulates and coordinates all RE policies ◆ Monitors RE capacity addition, electricity generation, RPO compliance, Feed-in-tariff (FiT), Generation-Based Incentive(GBI) and Accelerated Depreciation (AD), Open Access and other incentives ◆ Coordinates Central Financial Allocation (CFA) for off-grid RE programmes
Ministry of Power (MoP)	◆ Coordinates between MNRE and NTPC (National Thermal Power Corporation Limited) to bundle cheaper coal power with solar power to accelerate grid parity
Central Electricity Regulatory Commission (CERC)	◆ Issues benchmark FiT for RE sources at national level ◆ Issues benchmark ratio for bundling coal and solar power under Bundling Scheme
State Electricity Regulatory Commission (SERC)	◆ Sets FiT and GBI rates at state level ◆ Enforces RPO compliance at state level
Power Grid Corporation of India Ltd./National Load Dispatch Centre (PGCIL/NLDC)	◆ Supervision over Regional/State Load Dispatch Centres for all types of power
State Load Dispatch Centre (SLDC)	◆ Monitoring of source-wise and Discom-wise power generation data on real-time basis
Central Electricity Authority (CEA)	◆ Grid Emission Factor estimation on annual basis ◆ Monitoring total installed RE capacity

Institution	Role in RE Policy Planning and Implementation
NTPC Vidyut Vyapar Nigam (NVVN)	◆ Facilitates bundling of coal and solar power to accelerate grid parity
Solar Energy Corporation of India (SECI)	◆ Implementing agency for JNNSM and other related schemes
Indian Renewable Energy Development Agency (IREDA)	◆ Provides financial support for RE projects, funding for GBI, AD, and other incentives for RE
India Energy Exchange (IEX) and Power Exchange of India Ltd (PXIL)	◆ Platform to enable trading of RECs
National Institute for Solar Energy (NISE)	◆ R&D institute for solar energy capacity building
National Institute for Wind Energy (NIWE)	◆ R&D institute for wind energy capacity building
Sardar Swaran Singh National Institute for Renewable Energy (SSS-NIRE)	◆ R&D institute for biomass energy capacity building
Alternate Hydro Energy Centre (AHEC)	◆ R&D institute for small hydro energy capacity building

These institutions also serve as depository of RE-related data in line with their role. Table 3 below provides a brief summary of the databases released by some of these institutions which can serve as progress indicators for the RE sector and included in the MRV systems.

Table 3: Databases to track Renewable Energy Policy Implementation in India

Name of the Database	Type of Information	Source	Reference
All India RE Regulatory and Policy Database (2013)	◆ Feed-in Tariff by state and RE source ◆ RPO Targets from 2011–12 to 2021–22 by state (non-solar) ◆ Open Access policy by state	MNRE	MNRE. 2013. All India Renewable Energy Regulatory and Policy Database (2013)
State-wise Solar RPO Targets	Solar RPO Targets by state from 2011–12 to 2021–22	MNRE	MNRE. 2011. State-wise Solar RPO Targets. Available at ‹http://mnre.gov.in/file-manager/UserFiles/Solar%20RPO/state-wise-solar-RPO-targets.pdf›
REC (Renewable Energy Certificate) Registry of India	State-wise and source-wise REC accredited status	REC Registry	REC Registry of India. State-wise and source-wise REC accredited status. Available at ‹https://www.recregistryindia.nic.in/index.php/general/publics/State_Source_Wise_Accr_Status›
Real-time Electricity Generation	Scheduled and dispatched electricity by RE source updated on daily basis	State Load Dispatch Centres	SLDC. Realtime data. Available at ‹ https://www.sldcguj.com/RealTimeData/RealTimeUser.php ›

Name of the Database	Type of Information	Source	Reference
Grid Emission Factor and Annual GHG emissions from power sector	Central Electricity Authority's Annual CO2 Baseline Database	Central Electricity Authority	CEA. 2014. Annual CO2 Baseline Database for Indian Power Sector, v.9 Available at ‹http://www.cea.nic.in/reports/planning/cdm_co2/user_guide_ver9.pdf›
MNRE Physical Progress (Achievements)	Capacity targets and achievements for biomass power and gasification, bagasse and other RE sources	MNRE	MNRE. Physical Progress (Achievements). Available at ‹http://mnre.gov.in/mission-and-vision-2/achievements/›
Financial Outlay for Each Phase as indicator of allocation of budgetary resources to RE	Rs. (crore) allotted per phase	MNRE	12th FYP. 2011. Report of Sub-Group on Climate Change. Available at ‹http://planningcommission.gov.in/aboutus/committee/wrkgrp12/enf/wgsub_climate.pdf›
National Portal for RPO	Web Portal for RPO monitoring and Compliance in India	MNRE. MOP. CERC. Central Agency/ NLDC. SERCs. State Agencies.	https://rpo.gov.in/

2.3 An Overview of Utility Scale Solar Development and Selection of Policy/Scheme for MRV

Considering the importance given by the government to the utility scale solar sub-sector within the RE, and its projected role in contributing to India's NDC commitments, it was selected for assessment and development of MRV framework.

Utility scale solar power development: As a tropical country, solar power is poised to be a viable source for energy generation with high potential for GHG mitigation as most regions in India receive 4–7 kWh/m²/d of solar radiation with 250–300 sunny days in a year. India has one of the highest potential for solar power in the world (~750 GW), which had not been exploited until the JNNSM was launched in 2010 as part of NAPCC by the MNRE. Before the launch of the JNNSM, India's solar power capacity was only 17.8 MW in 2010. This has increased to 33, 730 MW as on June 2018. The policy initiatives have been fuelled by falling interest rates and tariff. The mission (JNNSM) has three-phased[3] approach until the end of 2022. JNNSM implementation has also helped energy security of the country with steep growth in the installed solar capacity over the last few years. Prior to the mission, under the 2010 RE plan, the Government of India had aimed to achieve an installed solar capacity of 20 GW by 2022. In 2015, the plan was revised and JNNSM was brought in, revising the RE target to 100 GW from 20 GW. Some key schemes and programmes under the JNNSM are listed in Annexure 1.

Figure 1 shows the scheme-wise capacity installed capacity until September 2019. From Figure 1, it can be seen that majority of commissioned or the operating solar capacity comes from solar parks scheme contributing around 5 GW until September 2019. The figure also depicts the other contributing schemes under the utility scale, one of which is known as 'Viability Gap Funding (VGF) Scheme'. This scheme was implemented in JNNSM Phase 2 Batch 1 and has resulted in deployment of 680 MW (from the year 2013 to 2018) operating solar capacity in seven states making this scheme as one of the major early contributor to the total solar capacity in India.

Supporting mechanisms for solar deployment in India: These broadly include the following:

- **Fiscal incentives:** All solar projects have been historically eligible to avail depreciation of

[3] Phase-I (2010–13), Phase-II (2013–17), Phase-III (2017–22)

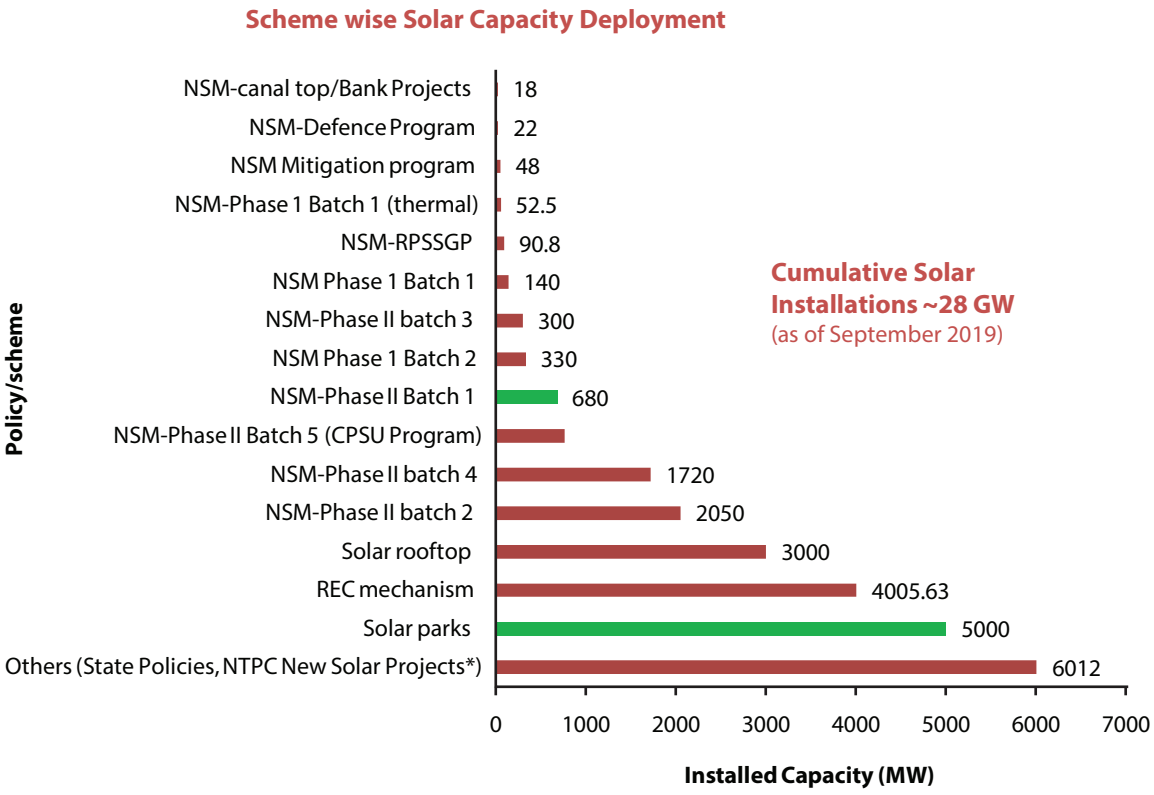


Figure 1: Scheme-wise Solar Capacity Deployment as of September 2019

80% of asset value but this rate has been reduced to 40% from April 2017 onwards. A 10-year income tax holiday had been offered to solar projects but this incentive was withdrawn in April 2017.

- **Auction/Bidding:** Currently, utility scale solar deployment in India is majorly conducted through auction/bidding. Selection of grid connected projects for Phase-II is being done through different schemes such as Bundling, and Viability Gap Funding (VGF). Solar parks scheme has also been implemented through auctions. However, capacity allocation could be altered depending upon the availability of resources in the state/region. In August 2017, the MoP has also released Solar Guidelines for Tariff-Based Competitive Bidding Process for Procurement of Power from Grid Connected Solar PV Power Projects.[4]
- **Solar RPO and RECs:** According to the JNNSM, the renewable purchase obligation (RPO) for solar energy in states started with 0.25% in the phase-I and is expected to go up to 3% by 2022. This could be complemented with a solar specific REC mechanism to allow utilities and solar power generation companies to buy and sell certificates to meet their solar power purchase obligations. CERC and SERCs have issued various regulations including solar RPOs, REC framework, solar tariff, grid connectivity for solar plants, power forecasting, etc., for promoting solar energy. Many States have come up with their own Solar Policy also.

The auction/bidding mechanism thus plays an important role in development of utility scale solar. The assessment presented in this report therefore focuses only on tracking the target under for utility scale solar park deployment.

4 http://mnre.gov.in/file-manager/grid-solar/Guidelines_for_Tariff_Based_Competitive_Bidding_Process.pdf

3. Objective and Approach

Broader objective of this project is to assess the existing policies/schemes in the RE sector and develop an MRV framework for evaluating impacts of selected policies/schemes on mitigating GHG emissions. As already mentioned, the scope of this project is limited to utility scale solar sub-sector because of its potential for large contribution to the national RE target of deploying 175 GW by 2022 (100 GW solar out of a total RE target), as defined in the JNNSM. The proposed MRV framework will help track progress of solar power targets for the selected sub-sector under the selected schemes, and resultant GHG emissions reductions achieved.

The MRV framework so developed to track the Indian Solar Energy targets under selected schemes will thus be used for the following purposes:

- Establish a follow-up mechanism for the implementation of the national targets on solar power.
- Respond to the reporting obligations under the Conference of the Parties (COP) of the United Nations Framework Convention on Climate Change (UNFCCC).
- Contribute to the achievement of the country commitments under India's NDC to the UNFCCC.

At a second level, the MRV framework can also be expected to contribute to the related sector as follows:

- Support dialogue between different stakeholders (government authorities, solar developers, international organizations, academicians, etc.) with the idea of establishing technical cooperation, training development opportunities as well as financial facilitations in support of the solar energy development in India.
- Support in reinforcing institutional infrastructure towards improved reporting on different aspects of activities undertaken under for solar deployment, in order to strengthen national capacities on management of information (emissions factor determinations, GHG emissions reductions estimation methodologies, etc.); that are important for GHG mitigation.

The proposed MRV framework provides a step-wise approach to track the progress of targets (in terms of GHG mitigation) in the utility scale solar sub-sector, using ex-ante and ex-post methods. The methodological steps have been adapted from the ICAT Renewable Energy guidance published in June 2019, and supplemented through relevant UNFCCC approved CDM methodologies.

3.1 Schemes Selected for Assessment and Rationale

Within utility scale solar, two schemes were selected and MRV framework developed to track the progress under these schemes. The schemes were selected based on the past capacity installation trends (as depicted in Figure 1 of the previous section) and their overall contribution in the utility-scale solar national target of deploying 60 GW by 2022. The two key schemes selected include: (i) the Viability Gap Funding (VGF) 750 MW scheme, and (ii) Scheme for developing Solar Parks and Ultra-Mega Solar Parks. These schemes primarily use auction mechanism. The VGF 750 MW scheme saw maximum installations until 2019, whereas the Solar Park scheme has a wider reach with solar development being carried out in 21 states. These are referred as Scheme 1 and Scheme 2 in the assessment that follows, and defined as below:

- **Scheme 1**: VGF 750 MW, introduced as a public–private partnership model to increase investments in the solar sector during JNNSM phase 2, Batch 1.
- **Scheme 2**: Scheme for developing Solar Parks and Ultra-Mega Solar Parks, introduced in 2016 aims at deployment of large-scale solar

utility corresponding to 40 GW by 2022 solar in various states of India.

These two schemes translate to 71% (40,750 MW) of utility scale solar target until 2022. India has other overarching national missions that enable positive environments for up-scaling renewables. Also, experience from the past programmes has helped develop proper platforms for auctions and setting up of solar projects in the country. The schemes were centrally auctioned and have provisions for fiscal incentives. Detailed descriptions of each scheme are presented in subsequent sections.

A summary of the schemes and targets are presented in Figure 2 below:

3.2 Overview of Approach

The identified schemes contribute to climate mitigation (impact) through achievement of their targets. Ultimate outcome is in terms of GHG reduction, which can be calculated using data on achievement (electricity generation from installed capacity) and other data. This report is organized in a step-by-step approach to access the GHG impacts from the two selected solar auction schemes as indicated in Figure 3. The ICAT Renewable Energy guidance (June, 2019) and experts' consultations were used for devising the methodology to measure the mitigation impacts from the two selected schemes for solar power development; VGF scheme and Solar Parks Scheme, and for developing a monitoring and reporting plan for the same.

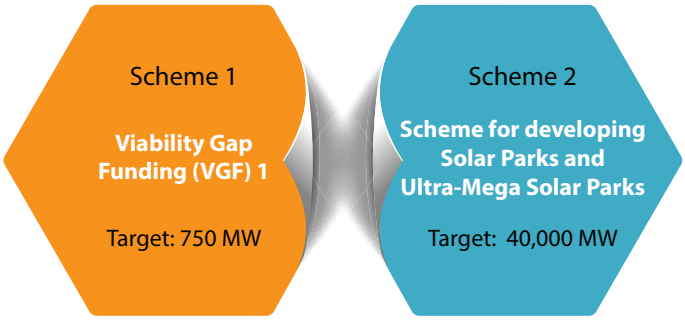


Figure 2: Breakup of scheme-wise target

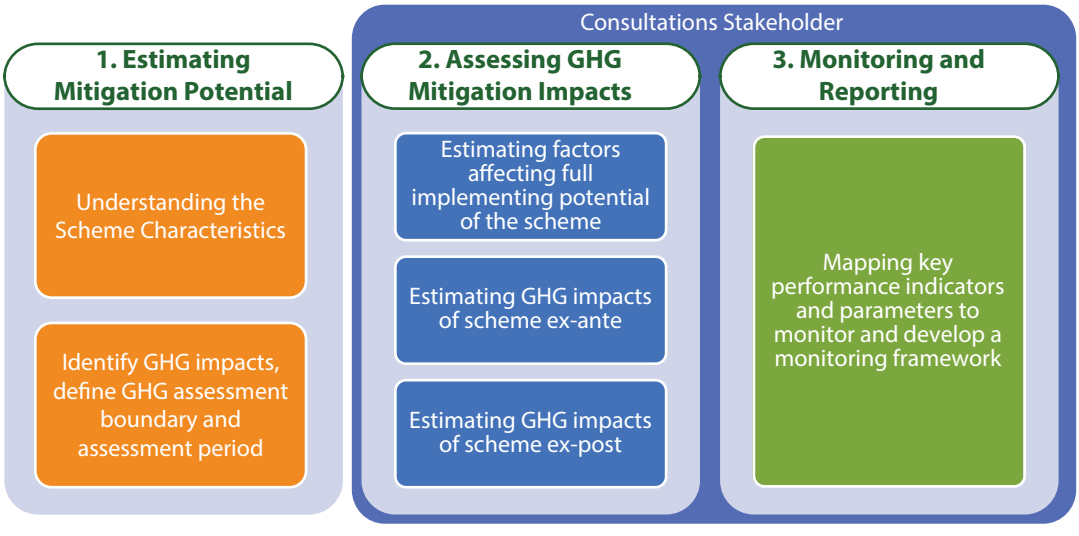


Figure 3: Approach for the study

4. Estimating Mitigation Potential

As described in the previous chapter, the VGF scheme and Solar parks scheme are playing a vital role in achieving India's ambitious solar deployment target of 100 GW by 2022, which is expected to be scaled up further thereafter. These two schemes cover 71% of utility scale solar target until 2022. The schemes contribute to India's NDC goals, particularly to the following quantitative targets:

- Achieving about 40 per cent cumulative electric power installed capacity from non-fossil fuel-based energy resources by 2030 (conditional[1,2])
- Reducing the emissions intensity of its GDP by 33 to 35 per cent by 2030 from 2005 level

In this section, we highlight the design characteristics of the schemes and factors affecting their implementation potential.

4.1 Understanding the Scheme Characteristics

4.1.1 Scheme 1: Viability Gap Funding – 750 MW VGF Scheme under JNNSM Phase-II, Batch-I

This was the first scheme with VGF support from the National Clean Energy Fund (NCEF). The key objectives of the scheme were to enable scaling up of projects alongside cost reduction and fulfilment of RPOs of the obligated entities (OEs).

The scheme characteristics are given in Table 4.

Table 4: Viability Gap Funding Scheme 750 MW - Characteristics

Scheme 1: Solar VGF 750 MW scheme	
Type/Nature	Auction type Scheme
Technology	Solar PV
Target/Goals (Maximum Implementation Potential)	750 MW
Implementation Period	2013–2022
Status of the Scheme	Implemented: 680 MW[2]
Potential GHG Impact	Utility scale solar energy to displace conventional energy sources. Avoided emissions as RE is carbon-neutral
Potential co-benefits	Energy security, energy access, sustainable development
Scheme Document	Guidelines for Selection of 750 MW Grid Connected Solar Power Projects Under Batch-I, Phase-II of JNNSM. Available at: https://mnre.gov.in/file-manager/UserFiles/finalVGF_750MW_Guidelines_for-grid-solar-power-projects.pdf

1 With the help of transfer of technology and low cost international finance including from Green Climate Fund (GCF). Source: India's Nationally Determined Contribution (NDCs) submitted to UNFCCC on 1st October 2015, available online at: http://www.moef.gov.in/sites/default/files/INDIA%20INDC%20TO%20UNFCCC.pdf

2 As per the annual report 2017-18 released by the Ministry of New and Renewable energy (MNRE), around 680 MW of the capacity is already commissioned under this scheme in 7 States (Rajasthan, Gujarat, Maharashtra, Madhya Pradesh, Karnataka, Tamil Nadu, and Odisha).

Scheme 1: Solar VGF 750 MW scheme	
Domestic Content Requirement (DCR)	375 MW
No DCR Restriction	375 MW
Installation and Commissioning Period	13 months from PPA signing date
Implementation Agency	Solar Energy Corporation of India (SECI)
Minimum Project Capacity	10 MW
Maximum Project capacity	50 MW
VGF details	
VGF Support	Support from National Clean Energy Fund (NCEF)
Upper Limit for VGF	30% of the project cost or Rs. 2.5 crore/MW, whichever is lower
PPA Longevity	
PPA period agreed for Purchase by SECI	25 years at pre-determined fixed price of Rs. 5.45 per kWh
Power sell by SECI to the Discoms	At Rs. 5.50 per kWh
Accelerated Depreciation	In this case, the tariff will get reduced to Rs. 4.75 per kWh
Qualification Requirements	
Equity Requirements	The selected project developer has to demonstrate/infuse capital in the form of Equity for an amount of at least Rs.1.5 crore/MW.
Technology type	The selection of projects would be technology agnostic and crystalline silicon or thin film or CPV, with or without trackers can be installed.
Technical Criteria	Only commercially established and operational technologies to minimize the technology risk.
Connectivity with the Grid	Designed for inter-connection with the transmission network of STU/ CTU/Pooling substation of Solar Park or any other transmission utility at voltage level of 33 kV or above. Responsibility for connectivity lies with the project developer.
Clearances required from the State Government and other local bodies	The projects developers are required to obtain necessary clearances as required for setting up the Solar PV Power Projects.
Domestic Content Requirement	The developers at the time of bidding may opt for either 'DCR' or 'Open' or both the categories capacity of 375 MW will be kept for bidding with Domestic Content Requirement (DCR). Each Bid/Application can be for a maximum of five projects at different locations with aggregate capacity not exceeding 100 MW.
Implementation Process	
Selection criteria of Projects under the VGF scheme	Pre-feasibility report of the project covering its salient technical details including technology proposed to be deployed and configuration of the project. Letter from the STU/CTU/Transmission utility confirming technical feasibility of connectivity of plant to grid substation, preliminary estimate of project cost. Financial capability statement of the bidder/bidding consortium. Technical capability statement of the bidder/bidding consortium. Undertaking that the project shall adhere to the technical parameters.
Selection of the winner	The opened financial bids will be arranged in ascending order of per MW VGF required. The lowest financial bid received will be marked L1. Selection of projects for allotment will start from L1 and go up to the level where the specified maximum MW capacity to be allocated under the chosen Category is reached.

Scheme 1: Solar VGF 750 MW scheme	
Implementation arrangement	Implemented through SECI in close association with NTPC Vidyut Vyapar Nigam Limited (NVVN). SECI shall issue Letter of Intent (LoI) to successful bidders and sign Power Purchase Agreements (PPAs) with them for purchase of the solar power, valid for a period of 25 years. SECI shall accordingly also sign back-to-back Power Sale Agreements (PSAs) with interested State Utilities/ DISCOMs for sale of solar power to them, which shall also be valid for a period of 25 years.
Commissioning Schedule and Penalty for Delay in Commissioning	The maximum time period allowed for commissioning of the full Project Capacity with encashment of Performance Bank Guarantee and reduction in the fixed tariff shall be limited to 24 months from the date of signing of PPA. In case, the Commissioning of the Project is delayed beyond 24 months from the date of signing of PPA, the PPA capacity shall stand reduced/amended to the Project Capacity Commissioned and the PPA for the balance capacity will stand terminated and shall be reduced from the selected Project Capacity.

4.1.2 Scheme 2: Scheme for developing Solar Parks and Ultra-Mega Solar Parks

The MNRE had drawn a scheme to set up a number of solar parks across various states in the country, each with a capacity of solar projects generally above 500 MW. The scheme proposes to provide support by the Government of India to establish solar parks through creation of infrastructure necessary for setting up new solar power projects. The support includes allocation of land, transmission and evacuation lines, access roads, availability of water and others, in a focused manner.

India has pioneered the concept of the Ultra-Mega Power Plant (UMPP) in a single solar industrial park, and the MNRE initially set a target for 40 industrial solar parks with a combined capacity of 20 GW. In 2017, the MNRE doubled this target to have an installed capacity of 40 GW by 2022.[3] The UMPP concept involves a state government or local distribution company who facilitates a single central grid connection and takes on the procurement and time-delay risks relating to land acquisition. This approach has been instrumental in driving economies of scale and attracting global capital flows into India over the last two years, with an immediate impact on solar tariff, which fell to a record low of Rs. 2.44/kWh in mid-2017. During 2016/17, India commissioned two of the four largest solar projects in the world,[4] one each in Tamil Nadu and Andhra Pradesh, two of the best solar radiation sites in the country.

The scheme characteristics are given in Table 5.

Table 5: Solar Park Scheme - characteristics

Scheme 2: Scheme for developing Solar Parks and Ultra Mega Solar Parks	
Type/Nature of Policy	Auction type scheme
Technology	Solar PV
Targets/Goals (Maximum implementation potential)	40,000 MW solar energy deployment by 2022
Potential GHG impact	Utility scale solar energy to displace conventional energy sources. Avoided emissions as RE is carbon-neutral
Potential co-benefits	Energy security, energy access, sustainable development

[3] As per the notification published by the Ministry of New & Renewable Energy (National Solar Mission Division), Government of India on 21st March 2017, available on-line at: http://static.infraline.com/infralineWiFrame/admindocs/77746110Scheme-for-enhancement-of-capacity-to-40GW-Solar-Parks.pdf; last accessed on March 6, 2020.

Scheme 2: Scheme for developing Solar Parks and Ultra Mega Solar Parks	
Implementation period	2014–2022
Implementation Status	Ongoing (as of January 2020): 37 solar parks round 20 states sanctioned with a total of 26 GW capacity at different stages. (A total of 6280 MW capacity awarded with 5680 MW capacity commissioned)
Nodal agency	SECI, MNRE
Scheme Document	Implementation of a Scheme for Development of Solar Parks and Ultra Mega Solar Power Projects in the country commencing from 2014–15 and onwards (i.e., from the year 2014–15 to 2018–19). Available at: https://mnre.gov.in/sites/default/files/schemes/Scheme-for%20development-of-Solar-Park-%26-Ultra-Mega-Solar-Power-Project-2014-2019.pdf Recent Modifications: 23th March 2017: Scheme for Enhancement of capacity from 20,000 MW to 40,000 MW for "Development of Solar Parks and Ultra Solar Power Projects" Available at: http://static.infraline.com/infralineWiFrame/admindocs/77746110Scheme-for-enhancement-of-capacity-to-40GW-Solar-Parks.pdf 9th March 2019: Modification in scheme for Development of Solar Parks and Ultra Mega Solar Parks Scheme. Available at: https://mnre.gov.in/sites/default/files/uploads/15%20OM%20Modification%20Solarpark%20Scheme%2009-03-2019.pdf 19th July 2019: Modification in scheme for Development of Solar Parks and Ultra Mega Solar Parks Scheme. Available at: http://static.infraline.com/infralineWiFrame/admindocs/13264069Corregendum%20of%20OM%20dated%2005-02-2019-min.pdf
Eligibility	All the states and union territories are eligible for benefits under the scheme
Capacity of solar park	Minimum capacity - 500 MW, Maximum capacity of 1000 MW. Smaller parks of 100 MW and above for North Eastern States, HP, Uttarakhand and J&K
Implementation agency	Solar Energy Corporation of India (SECI)
Policy interaction	Viability Gap Funding 2000 MW scheme under JNNSM phase II, Batch-III – The Solar Projects of 2000 MW Capacity under the State Specific VGF Scheme will be set up in the Solar Parks of various states, to be developed through coordinated efforts of Central and State Agencies. As implementation of solar parks have begun recently, it is possible that Solar Parks in some of the States do not become available soon. For such States, Solar Projects would be allowed to be located outside solar parks with land being provided either by the State Government, or arranged by the Solar Power Developers (SPDs).
Qualification Requirements	
Financial model	Allotment of plot: SECI sells/lease out the plots to prospective project developers identified by state government. SECI to handle funds to be made available under the scheme on behalf of GOI. The states, to designate an agency for the development of solar parks to be developed.
Financial requirements from project developers	The Allotment Price per metre square (inclusive of all applicable taxes, duties, cess, etc.) is paid by the plot applicant. The allotment price is reviewed annually Registration for the plot: A one-time registration fee (per project or per MW) is collected by inviting applications from the prospective buyers when the scheme is finalized, land identified and marked. An advance is collected from the prospective buyers when 50% of the land is acquired. This advance is 10% of the sale price or lease amount. Another instalment of 25% of the price of land or lease amount is taken when full land is acquired.

Scheme 2: Scheme for developing Solar Parks and Ultra Mega Solar Parks	
Land acquisition/ site selection	Land for the setting up of the solar park is identified and made available by the State Government. States identify sites receiving good solar radiation and sites which are closer to CTU (i.e., power grid), preferably locations with spare solar installed capacity and water availability. Land should also be non-agricultural.
Transmission and evacuation	State designated Solar Power Park Developers are the immediate implementing authority for developing infrastructure (pooling substations, land development, common facilities) required to initiate and sustain the solar parks. SPPDs will be regulated in turn by SECI. SECI will also work in collaboration with the Power Grid Corporation of India Limited (PGCIL) for construction of transmission lines and grid connectivity and ensure that there is no mismatch in commissioning of solar projects and that of transmission lines. SECI constructs 66 kV pooling stations and draw transmission lines from pooling stations to substations. CTU/STU constructs 220 kV/400 kV sub-station. STU to create sub-station nearby Solar Park if substantial power is purchased by State Government, otherwise CTU shall make transmission arrangements for dispatch of power to load centres. SPD shall draw transmission lines from respective project to the pooling station. If the cost of transmission/evacuation infrastructure is high, separate proposal for funding through NCEF/External Funds/Green Corridor Project would be necessary.
Power to remove difficulties	If there is need for any amendment to the Scheme due to implementation problems, the MNRE will be competent to make such amendments with the approval of Minister-in-charge.
MNRE Support	Grant upto Rs. 25 lakhs for preparing DPR, conducting surveys, etc. Grant at the rate of up to Rs.20 lakhs/MW or 30% of the project cost including grid-connectivity cost, whichever is lower
PPA Longevity	
Power purchase arrangement	The selected solar power developer for solar park shall enter into Power Purchase Agreements (PPAs) with the beneficiary of solar power, viz., the State Utilities/Discoms who are willing to buy power under any State Scheme, or go for any third-party sale.
PPA period	30 years from the date of the Scheduled Commissioning Date (SCD)
State government's role	State to waive off wheeling charges. It will be mandatory for the Discoms to buy one non-solar Renewable Energy Certificate (REC) or proportionate solar REC so as to match the expenditure on non-solar REC for every 40,000 units of solar power purchased by them.
Implementation Arrangement	
Activities to be undertaken by the SECI or SPV	Develop, plan, execute, implement, finance, operate, and maintain the Solar Power Park. Identify potential site and to acquire/possess land at potential sites for Solar Power Park. Carry out site-related studies/investigations. Obtain statutory and non-statutory clearances and to make area development plan within Solar Power Park. Design a plan for sharing development cost between the developers and the park. Create necessary infrastructure, such as water, transmission lines, roads, drainage, etc., to facilitate Solar Power Project developer for faster implementation of Solar Power Projects. Frame out transparent plot allotment policy and specify procedures pursuant to the relevant State policies and their amendments thereof. Provide directives for technology-specific land requirements. Engage the services of national/global experts/consultants to promote Solar Power Park-related activities. Facilitate the State Government to establish educational institutions/training facilities within Solar Power Park for development of manpower skill related to Solar Power. Any other activities related to Solar Power Park as per the directives from the MNRE and the State Government. Environmental clearances before allocating the land to prospective developers.

4.2 Assessing Barriers Affecting Full Implementation of Schemes

Barriers are defined as obstacles or restrictions that hinder or even prevent the achievement of the intended impacts of any policy/scheme. Targets set for any scheme are indicative of the potential for GHG impacts in case scheme is successfully implemented. In the case of the two solar schemes, full potential for GHG emissions reduction can only be achieved if targeted capacity addition is achieved.

The ICAT Renewable Energy Guidance (June 2019) recommends to identify key barriers that can hinder RE deployment, enduring technical, regulatory, institutional, market, financial, infrastructure, awareness, and public acceptance barriers. The aim of this step is to identify key barriers that may affect the full implementation potential of the selected schemes to present a realistic analysis of its mitigation impacts. To understand the complexity of the barriers within VGF 750 MW and Solar parks scheme, an extensive secondary research and stakeholder's consultation was conducted.

i. **Scheme 1: VGF 750 MW scheme:** As mentioned in the section 3.1 (Chapter 3), the total implementation potential of the scheme is 750 MW. As per the *Annual Report 2017–18* released by the MNRE,[5] around 680 MW of the capacity is already commissioned under this scheme in seven States (Rajasthan, Gujarat, Maharashtra, Madhya Pradesh, Karnataka, Tamil Nadu and Odisha).
This capacity (680 MW) could be successfully commissioned within a period of 5 years from the launch, i.e., October 2013, and 70 MW of the capacity had not been commissioned until then. As mentioned in secondary literature and supported by experts' interview, it was inferred that the remaining capacity could not be deployed on account of policy uncertainties, a lack of awareness on the VGF scheme, and process of availing funds under the scheme. Experts mentioned that the key hindrance was seen as the delay in getting land use change or delays in setting up external evacuation system, both of which are not directly in control of the project developers.

ii. **Scheme 2: Solar Parks Scheme**: The total implementation potential of the scheme is 40,000 MW. Till date, 45 solar parks in 20 states have been approved with a total capacity of 26,450 MW, which are under different stages of development. Out of this, around 5160 MW is operational to date.[6] With a significant capacity remaining to be operational under the scheme, the key barriers that may influence the implementation potential of the scheme are identified as follows:

- Financial Barriers:
  - » High upfront fees as development charges along with sizable recurring cost
  - » Changes in financial parameters post competitive bidding such as Goods and Services Tax (GST) and safeguard duties
  - » Insufficient payment security to cover long payment delays by procurers
  - » Penalties due to delay in Infrastructure development, such as land possession and evacuation facilities
  - » High upfront cost of the plants
- Technical Barriers:
  - » Compliance to quality control standards
  - » Poor quality of land surface
  - » Non-availability of reliable solar radiation data
  - » Non-availability of water for cleaning of solar panels
  - » A lack of transmission/evacuation facilities across states
  - » A lack of grid ability to absorb renewable energy
  - » A lack of land availability
  - » High transmission costs as solar power may be generated far from the load
- Capacity Barriers:
  - » Limited institutional capacity and coordination
  - » A lack of skilled technicians at all levels for project designing and installation
  - » A lack of awareness on new and more efficient technologies
  - » A lack of indigenous production capacity

[4] 5 largest solar farms in the World, a blog by Justine Summers, Origin Energy Limited published on 24th October 2018, available online at: https://www.originenergy.com.au/blog/lifestyle/5-largest-solar-farms-in-the-world.html; last accessed on March 6, 2020.

[5] Available online at: https://mnre.gov.in/file-manager/annual-report/2017-2018/EN/index.html; last accessed on March 9, 2020.

[6] Available online at: https://bridgetoindia.com/report/solar-park-development-in-india/#modal; last accessed on March 9, 2020.

- Policy Barriers:
  - » Policy uncertainty and frequent changes
  - » Issues around land procurement

4.3 Evaluation of Severity of Barriers

To ascertain the impact of above-mentioned barriers on achieving the full implementation potential of the solar parks scheme (i.e., 40,000 MW), significance of each barrier was analysed. The more a barrier hinders the achievement of full implementation potential of the scheme, the higher their significance was during the assessment period. The relative significance was rated, i.e., which of the barriers are more important compared with the others and which are not so important when considering their impact on the scheme's mitigation potential. The severity rating of barriers were exercised with reference to *ICAT Renewable Energy Guidance (2019)*, based on the document study, expert judgement, and stakeholders' consultation. The guidance document suggests two distinct methods, viz., (i) simultaneous rating; (ii) pairwise comparison to rate the barriers. The two methods involve survey of experts, through series of interviews with relevant stakeholders (minimum of 5 interviews with relevant experts). The simultaneous rating method purposes the experts to give a total score out of 100 to each individual barrier according to the barrier's significance and the ratings of the individual experts will be then summarized as averages for ranking. The pairwise comparison is comparatively more cohesive to the former method, where the barriers are compared with one another qualitatively, leading to quantitative rating matrix.

The ranking of barriers severity was exercised by the following four steps:

- **Step 1**: Development of structured questionnaire (Annexure 2), encompassing all identified barriers
- **Step 2**: Identification of key stakeholders (Representation of stakeholders consulted is tabulated in Table 8)
- **Step 3**: Consultation with stakeholders (one to one, email) to compile their perceptions against the identified barriers. Each expert was asked to rate the significance of the barriers using a predefined scale, giving the individual barriers a score from 25 to 100, with 25 indicating low impact and 100 indicating very high impact.

Table 6: Representation of stakeholder's consultation

No.	Stakeholder representation	No. of consultations
1	Consultancy	3
2	Project developers	1
3	Industry	1
4	Association	1
5	Government agencies	2
6	Think tanks	1
7	International organization	2
Total		**11**

- Step 4: Assessment of conducted surveys to rank the severity of barriers through pairwise comparison method.

Inference:

- Results from the interviews indicate most of the experts emphasized that overall financial and policy barriers contribute significantly in hindering the deployment of solar plants, rating them as 38% and 28%, respectively (weights in total). Technical barriers came next with a weight of 21% while the capacity barrier category was given a weight of 13%. Most experts stressed that the solar parks scheme reaching its full implementation potential will hinge largely upon policy and financial barriers.

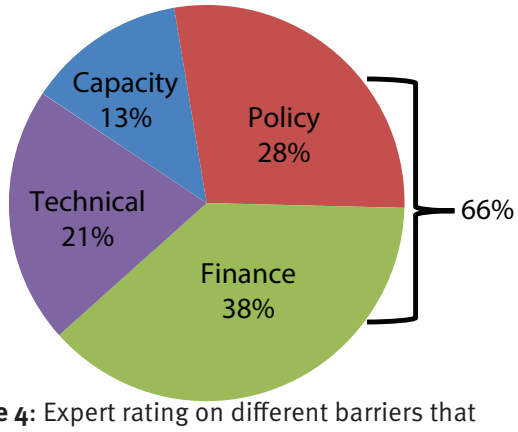


Figure 4: Expert rating on different barriers that hinders solar parks development in India

- Further, within the policy category, the experts considered the 'Policy uncertainty & frequent changes' to be the most significant barrier. Within finance category, the barrier 'Insufficient payment security to cover long payment delays by procurers' was given a weight of 17%. The 'high upfront fees as development charges

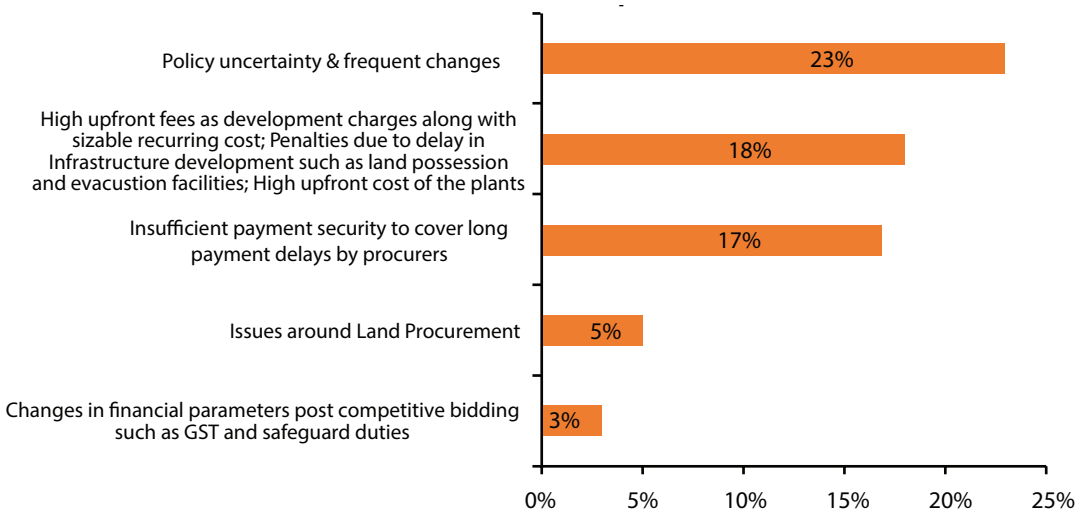


Figure 5: Expert rating on different financial and policy related barriers for Solar Parks Development in India

along with sizable recurring cost', 'Penalties due to delay in infrastructure development such as land possession and evacuation facilities', and 'High upfront cost of the plants' barriers altogether were weighted 18% in total.

- From the above consolidation, it is understood that the barriers within financial and policy category together translate to about 66% (two-thirds) hindrance/obstacle from a total of 19 barriers charted above. This means that in the current implementation landscape, financial and policy-related barriers will result in reduction of solar parks installation. This was reaffirmed by stakeholders when asked about estimates on the overall installed solar parks capacity in 2022, where it accorded that the operating solar parks capacity in 2022 would be between 10 GW and 20 GW depicting a decline in implementation potential of the scheme by 2022.

5. Identifying GHG Impacts, Defining the GHG Boundary and Assessment Period

The national thrust towards solar energy is intended to have a plausible role in India's journey towards decarbonizing electricity system. In general, mitigation potential from any RE scheme is through RE capacity addition, which can reduce emissions by replacing existing fossil fuel power plants, and/or avoided emissions from new fossil fuel power plants that would have been built in absence of the scheme.

This section begins with mapping of the potential mitigation impacts through cause-effect relationship, both for VGF and solar parks scheme. Thereafter, assessment boundary and assessment period are defined and discussed for the schemes, which are used for quantifying the mitigation impacts from the schemes (in Chapter 6).

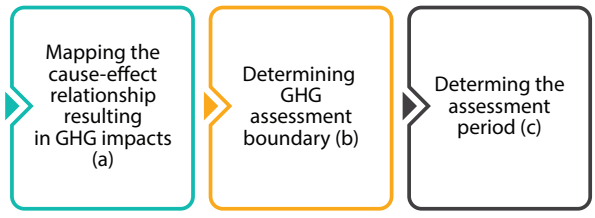


Figure 6: Approach for defining GHG assessment boundary and period

5.1 GHG impacts: mapping the cause-effect relationship

We consider all GHG impacts across the lifecycle of electricity generation from solar park scheme and solar VGF Scheme as elucidated in Table 7.

Table 7: GHG impacts of selected policies

Type of GHG impact	Scheme	
	Scheme for development of solar parks	Viability Gap Funding (VGF) scheme
		750 MW Scheme
Positive impact	Avoided emissions owing to addition of solar plants instead of obtaining the same capacities through establishment of thermal power plants; increased awareness and demand for solar power in the country.	
Negative impact	Increased emissions from the deployment and manufacturing of solar modules.	Increased emissions from the deployment and manufacturing of solar modules due to DCR conditions in the scheme.
Intended impact	Avoided emissions owing to addition of solar plants instead of obtaining the same capacities through establishment of thermal power plants.	
Unintended impact	Increased GHG emissions in jurisdictions where solar power plant equipment are manufactured (in case of imported solar plant equipment) Increased GHG emissions in other jurisdictions; increased GHG emissions from manufacturing of equipment for solar.	
In-jurisdiction impact	Increased GHG emissions from manufacturing of equipment for solar power plants; avoided emissions owing to addition of solar plants instead of obtaining the same capacities through establishment of thermal power plants.	
Out-of-jurisdiction impact	Reduced GHG emissions from local manufacturing of equipment for fossil fuel power plants. However, it is difficult to quantify this impact.	
Short-term impact	Fraction of energy generation in the overall energy mix from clean sources; reduced GHG emissions and electricity load from operating fossil fuel power plants on the electricity grid	
Long-term impact	Increased clean energy access; gradual substitution of thermal power by solar power. Reduction of overall emissions intensity.	

The causal diagram (Figure 7) provides the visual description of various effects of the schemes and relates them to both direct and indirect effects. The diagram helps in tracing the process by which the schemes lead to GHG impacts through a series of interlinked and sequential stages of cause-and-effect relationships.

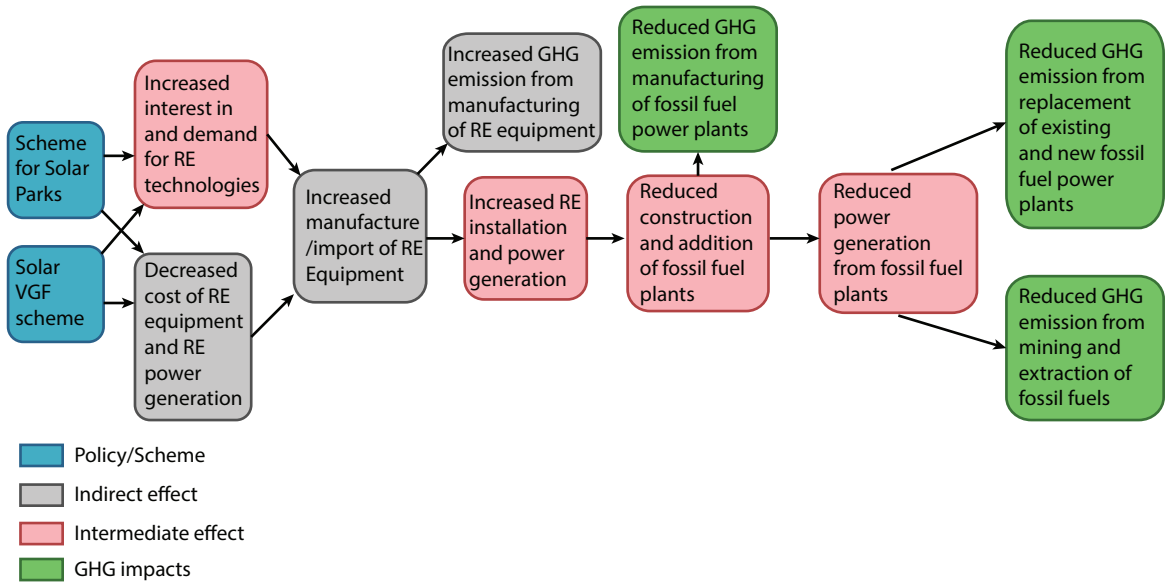


Figure 7: Casual chain for illustrating GHG impacts

Source: Own elaboration

5.2 GHG assessment boundary

The GHG assessment boundary defines the scope of the assessment for the solar parks and VGF schemes in terms of the range of GHG impacts.It is indicated in Table 8.

Table 8: GHG assessment boundary

GHG impact	GHG	Likelihood	Relative magnitude	Included in the assessment (Yes/No)	Explanation
	CO_2/ CH_4/ N_2O	Very likely/ likely/ possible	Major/ Minor		
Avoided emissions owing to generation of power from solar plants instead of from fossil fuel plants as a result of replacement (existing and new capacities)	CO_2	Very likely	Major	Yes	The main GHG impact of solar park scheme and solar VGF Scheme
Reduced emissions from mining of fossil fuels	CH_4	Possible	Minor	No	CEA already provides India-specific emission factor for the use of thermal energy, hence accounted for
Increased emissions from the manufacturing of RE equipment	CO_2, CH_4, N_2O	Possible	Major	No	Could be significant for solar VGF scheme as it includes DCR conditions
Reduced emissions from not constructing new fossil fuel power plants	CO_2, CH_4, N_2O	Possible	Minor	No	Could be significant in long term; however, the impact is insignificant till end of the scheme in 2022

5.3 GHG assessment period

The assessment period is the time period over which GHG impacts resulting from the policies/actions are assessed. In this case, GHG impacts from two solar schemes, which have a defined time horizon, are being assessed. GHG impacts will however continue until the lifetime of the assets (solar plants) created by the schemes. The assessment timeframe will however depend on scheme timeframe, NDC commitments, and related reporting requirements decided by the parties to the UNFCCC. Currently, reporting is due in 2020 and 2030.

Assessment can be ex-ante as well as ex-post. Ex-ante assessments are used to estimate the potential GHG emissions reductions as a result of mitigation policies or actions *prior* to their implementation. The assessment thus provides a trajectory of *estimated impacts* (GHG emissions reduction) over the assessment period. The ex-post assessments on the other hand are used to calculate the actual impacts (GHG emissions reduction) that have occurred in a year during or after the implementation of the policy/action. It can thus only be for a year in the past.

In the report, we consider two utility scale solar schemes which are at different stages of their implementation. VGF 750 MW scheme has been implemented and hence has been considered for ex-post assessment for the period 2013–2018. Solar parks scheme is at various stages of implementation and therefore is considered both for ex-post and ex-ante assessment. The capacity installed until 2018 is considered for ex-post assessment for the period 2014–2018. Ex-ante assessment is considered for the period 2019–2022.

6. Assessing GHG Mitigation Impacts

In this chapter, we estimate GHG impacts of the policy / action; in this case, changes in GHG emissions resulting from the addition of RE plants under the two schemes. Since the RE power plants replace the fossil fuel plants that are expected to have been built in the baseline scenario, the major impact is avoided emissions from the plants that are replaced. The RE capacity addition yields two key impacts: (i) positive impact – reduced GHG emissions from new power plants that are replaced; (ii) negative impact – increased emissions from the manufacturing of RE-based systems/equipment. Only the first impact has been considered here. Furthermore, these policies result in generating multiple sustainable development impacts in addition to their GHG impacts. The sustainable development impacts are shift to sustainable energy, reduced air pollution, employment, public health, new business opportunities, and access to clean, reliable, and affordable energy. These impacts have also not been estimated and accounted here in the calculations.

6.1 Determine Method to Estimate GHG Impacts from RE Addition

As per ICAT RE guidance, for ex-ante analysis, there are two methods for translating estimated RE addition into GHG impacts:

- **Emission trajectory method:** This method develops a trajectory for future emissions from the electricity grid based upon the expected future mix of generating technologies. The method involves making assumptions about the future electricity mix, and can be done using limited data or more complex models that model the energy sector development in detail. The resulting emission trajectory can either be used as a stand-alone assessment to determine whether the trajectory is on track to meet a target, or in combination with a baseline scenario to determine the emission reductions.
- **Grid emission factor method:** This method uses simple assumptions about the development of the electricity sector and can be useful for policies with a limited impact on the grid. It is assumed that the generated electricity resulting from the policy will displace carbon-intensive electricity generation and, to a certain extent, replace future carbon-intensive capacity additions. The grid emission factor reflects the emission intensity of the carbon-intensive electricity generation being displaced by the RE addition (expressed in tCO_2e/MWh). The GHG impact of the policy is then calculated by multiplying the grid emission factor with the estimated RE addition.

The grid emission factor method can be used for both ex-ante and ex-post analysis. The only difference is that in case of ex-ante various parameter values (expected addition of RE electricity and grid emission factor each year) are estimated using required assumptions while in cases of ex-post, actual values are used.

For example, for ex-post analysis, using the grid emission factor method, GHG impact of a policy after its implementation can be calculated using the Equation1.

$$ER_y = EG_y * EF_{grid,CM,y} \quad \text{Equation 1}$$

Where,

ER_y: Emission Reduction in year 'y' (tCO_2e)

EG_y = Quantity of net electricity that is produced by solar plants and fed into the grid as a result of the implementation of a policy/action in the year 'y'

(Note: The electricity produced here is from the plants installed as a result of policy/action / scheme).

$EF_{grid.CM,y}$ = Combined margin emission factor in year 'y', calculated using CEA Baseline CO_2

emission factor database[1] for the year 'y' and CDM methodology ACM 0002[2].

Since solar is an intermittent energy source, the combined margin emission factor is calculated using simple operating margin (OM) and build margin (BM) and typical weightages used under the CDM ACM0002 for solar (W_{OM}:W_{BM} = 0.75:0.25). Therefore,

$$EF_{grid.CM,y} = EF_{grid.OM,y} * W_{(OM,y)} + EF_{grid.BM,y} * W_{(BM,y)}$$

Equation 2

6.2 Ex-ante Analysis: GHG Reduction Potential of Solar Parks Scheme

This method is envisaged to develop a trajectory for future emissions from the electricity grid based upon expected future energy mix of generating technologies. For this, we create a baseline scenario, a policy scenario, and a current trajectory scenario. It is assumed that the existing cohort of thermal power plants would remain operational in 2022.

Baseline Scenario: a narrative description of the baseline situation in the absence of planned solar park scheme

In order to measure the impact of GHG mitigations policies, it is important to create a baseline scenario which is considered as a point of reference for the evaluation of achieved policy targets. The first step towards setting a baseline scenario is to select a base year which is representative of the state before policy implementation. Once the base year is determined, the next step is to identify the data parameters required for undertaking the assessment and data sources for the same. For the purpose of analysing the mitigation impact from solar parks scheme, the year 2022 has been considered as an assessment year for illustration purposes, which is in line with the implementation period of the scheme. This scenario is built on the premises considering the possible development of the Indian power system in the absence of the solar parks scheme. Looking at the current demand-supply scenario of the Indian power system, it is assumed that the demand in 2022 will be met majorly from the coal capacity including the installed and coal capacities in pipeline, including additional capacity of 40 GW, that would come up if solar parks are taken out from this baseline scenario. As per NEP 2018, the Indian power system would require 479 GW installed capacity in 2021–22 with a generation of 1,738,411 million units. The emissions from the estimated generation mix (as per NEP 2018) are calculated using emission factor of conventional plants. The resulting baseline scenario emissions in 2022 are expected to be 1,219 $MtCO_2e$ (refer Table9).

Table 9: India's installed capacity in the year 2021–22

Source	Installed Capacity (MW)	Generation (Million units)	PLF	Calculated combined margin CO_2 for the year 2018-2019 using CDM (75%OM+25%BM) (t CO_2/MWh)	Baseline scenario emissions ($MtCO_2$/y)
Thermal	257,302	1,287,467	0.57	0.947	1,219
Gas	25,735	51,897	0.23	—	—
Nuclear	10,080	57,010	0.65	—	—
Hydro	51,301	142,852	0.32	—	—
ORES	135,000	199,186	0.17	—	—
Total	**479,418**	**1,738,411**	—	—	**1,219**

[1] CO_2 Baseline Database for the Indian Power Sector, User Guide, Version 15.0, December 2019. Published by Central Electricity Authority, Ministry of Power, Government of India. Available online at: http://cea.nic.in/reports/others/thermal/tpece/cdm_co2/user_guide_ver15.pdf ; last accessed on March 18, 2020.

[2] UNFCCC CDM ACM0002 Large-scale consolidated methodology: Grid-connected electricity generation from renewable energy, Version 19.0. Available online at: https://cdm.unfccc.int/methodologies/DB/VJI9AX539D9MLOPXN2AY9UR1N4IYGD; last accessed on March 18, 2020.

Solar Park Policy scenario: narrative description of situation with full implementation of solar park scheme

This scenario considers the major policy drivers and India's thrust towards deployment of solar energy. The project capacity addition under the policy scenario follows capacity targets unhindered till end of the assessment period, with all factors performing in tandem for positive movement towards the set target. This implies that 40 GW solar parks will be deployed by 2022 resulting in 10,800,000 MWh power generation and about 10.23 $MtCO_2e/y$ emission reduction/ avoided emissions (Assuming 1500 sunshine hours per year and operating with a capacity factor of 18%) (refer Table 10).

Current trajectory scenario:a narrative description of the situation with the implementation of the solar park scheme under current implementation barriers

This scenario has been prepared in order to examine a possible current trajectory for the power system, given the current commercial and ground realities within the solar sector. It should be noted that it remains a scenario not a forecast, and is based on the TERI analysts' assessment and stakeholder judgements. It is assumed that the solar parks scheme target is missed by a moderate margin, given the current challenges being faced by the solar park segment (as explored in the barrier analysis section). In this scenario, the latest commissioned capacity from 2016 to March 2019 is used for extrapolation for the years 2020 to 2022. The net installed commissioned capacity for solar parks in 2022 is 11,941 MW which is based on extrapolation of the past solar capacity installation using compound annual growth rate (CAGR), barrier analysis, and stakeholder judgement. The installed capacity would supply 3.22 billion kWh electricity to the grid, resulting in 3.04 tCo_2 avoided GHG emissions. (Assuming 1500 sunshine hours per year and operating with a capacity factor of 18%) (refer Table11).

The GHG emissions reductions achieved by the policy are calculated by subtracting the baseline scenario emissions from the policy scenario and the current trajectory scenario. This produces a result of 10.23 $MtCO_2e/y$ (policy scenario) to 3.04 $MtCO_2e/y$ (current trajectory scenario). The emissions are presented in Table 12.

Table 10: GHG impact in the policy scenario (i.e. full implementation of the solar park scheme)

Year	Net installed operating capacity from solar parks scheme (MW)	Electricity supplied by solar parks to the grid (billion kWh/y)	Calculated combined margin CO_2 for the year 2018-2019 using CDM (75% OM +25%BM) (tCO_2/MWh)	Policy scenario avoided emissions ($MtCO_2$/y)
2022	40,000	10.8	0.947	10.23

Table 11: GHG impact in the current trajectory scenario (i.e. implementation of the solar park scheme under current implementation barriers)

Year*	Net installed operating capacity from solar parks scheme (MW)#	Electricity supplied by solar parks to the grid, (Billion kWh/y)	Calculated combined margin CO_2 for the year 2018-2019 using CDM+ (75%OM+25%BM) (tCO_2/MWh)	Current trajectory scenario avoided emissions ($MtCO_2$/y)
2016	250	0.07	0.955	0.06
2017	2230	0.60	0.937	0.56
2018	3780	1.02	0.927	0.94
2019	5160	1.39	0.947	1.21
2020	6825	1.84	0.947	1.74
2021	9028	2.43	0.947	2.3
2022	11,941	3.22	0.947	3.04

Operational capacity is referred to as the commissioned capacity uptil the month of March for each respective years.

+ CO_2 Baseline Database for the Indian Power Sector, User Guide, Version 15.0, December 2019. Published by Central Electricity Authority, Ministry of Power, Government of India. Available online at: http://cea.nic.in/reports/others/thermal/tpece/cdm_co2/user_guide_ver15.pdf ; last accessed on March 18, 2020.

Table 12: GHG impact of the solar park scheme in three different scenarios

Scenario Name	Scenario Logic	Avoided Emission, year 2022 ($MtCO_2$)
Baseline Scenario (BS)	Situation in absence of planned solar park scheme	—
Policy Scenario (PS)	Situation with full implementation of solar park scheme	10.23
Current Trajectory Scenario (CTS)	Situation with implementation of solar park scheme under the current implementation barriers	3.04

6.3 Ex-post Assessment: Actual GHG Reduction from Solar Parks Scheme

An ex-post impact assessment is a backward looking assessment of the GHG impacts achieved by a policy/action to date. Box 1 depicts the Ex-post assessment done for emission reduction from Solar Parks Scheme.

6.4 Ex-post Analysis: Actual GHG Reduction from VGF 750 MW Scheme

Ex-post assessments are used to calculate the GHG emissions due to the effects of policies after their implementation. The 750 MW VGF scheme was launched in the year 2013 and has resulted into a capacity addition of 680 MW till 2018.[3] The emission reduction from the year 2013 and 2018 can be calculated using the following equation:

$ER_{2018}=EG_{2018} * EF_{grid,CM,2018}$

ER_{2018}: Emission Reduction in the year 2018 ($tCO_2 e$)

EG_{2018} = Quantity of net electricity that is produced and fed into the grid as a result of the implementation of 750 MW VGF solar scheme in year 2018

$EF_{grid.CM,2018}$ = Combined margin emission factor in year 'y', calculated using CEA Baseline CO_2 emission factor database for the year 2018-2019 and CDM methodology ACM 0002 (Box1)

Assuming 1500 sunshine hours per year (depending upon location) and operating with a capacity factor ranging from 18–20%.[4]

This estimate translates to a net electricity generation ranging between 183,600 and 272,000 MWh.

Therefore, the net emission reduction in case of high generation scenario (~272,000 MWh) for the year 2018 will be:

$ER_{2018}= 272,000 * 0.947$

$ER_{2018}= 257,584\ tCO_2e$

[3] As per the information provided by Ministry of New & Renewable Energy, available online at: http://pibarchive.nic.in/ndagov/ReferenceMaterials/minr30.htm; last accessed on March 9, 2020.

[4] As per the report on Performance analysis of Grid Connected Solar Power projects commissioned under Phase – I of JNNSM for the period of January 2014 to December 2014, released by Ministry of New & Renewable Energy, available online at: https://mnre.gov.in/file-manager/UserFiles/Performance-analysis-of-Grid-Connected-Solar-Power-Projects-Commissioned-under-Phase%20%E2%80%93I.pdf; last accessed on March 9, 2020.

Box 1: Example of estimating GHG impacts of solar parks scheme using grid emission factor method

In order to facilitate the adoption of authentic baseline emissions data and also to ensure uniformity in the calculations of CO_2 emission reductions by CDM project developers, the Central Electricity Authority (CEA) has been publishing CO_2 baseline database since the year 2013 containing the necessary data on CO_2 emissions for all grid-connected power stations in India. As per the same, the weighted average emission factor, simple operating margin (OM), build margin (BM), and combined margin (CM) for the Indian Grid are as follows:

Year	Operating margin (tCO_2/MWh)	Build margin (tCO_2/MWh)	Combined margin (50:50)	Calculated combined margin for solar using CDM (75%OM+25%BM)
2013–14	1.00	0.95	0.98	0.987
2014–15	0.99	0.93	0.96	0.975
2015–16	0.97	0.91	0.94	0.955
2016–17	0.96	0.87	0.92	0.937
2017–18	0.95	0.86	0.91	0.927
2018-19	0.97	0.88	0.92	0.947

The emission reduction from the year 2014 to 2019 due to implementation of Solar Parks scheme can be calculated using the Equation 1 given above:

$ER2_{2019} = EG_{2019} * EF_{grid,CM,2019}$

ER_{2019}: Emission Reduction in the year 2019 (tCO_2e) (Reductions for 2019 and January 2020 considered here as per data).

EG_{2019}= Quantity of net electricity that is produced and fed into the grid as a result of the implementation of solar parks scheme in the year 2019

$EF_{grid.CM,2019}$ = Combined margin emission factor for the year 2019, calculated using latest CEA Baseline CO_2 emission factor database for the year 2018-2019 and CDM methodology ACM 0002

Considering that the Solar Parks scheme was launched in the year 2014 and has resulted into commissioned capacity addition of 5680 MW till January 2020 (Infraline RE database 2020) with the remaining capacity is yet to be commissioned. Assuming 1500–2000 sunshine hours per year (depending upon location) and operating with a capacity factor ranging from 18–20%[4]. This estimate translates to a net electricity generation ranging between 1,533,600 MWh and 2,272,000 MWh.

Therefore, the net emission reduction in case of high generation scenario (~2,272,000 MWh) for the year 2019 will be:

ER_{2019}= 2,272,000* 0.947

ER_{2019} = 2,151,584 tCO_2e or 2.1 $MtCO_2e$

Further considering its full implementation potential, i.e., 40 GW by 2022, the total emission reduction can be calculated by summing up emissions reduction over individual years.

7. Monitoring Plan for MRV System

The information required for GHG estimation in RE sector is often widely dispersed and collected from various sources. Collating all relevant data for evaluating individual RE policy/scheme measures in a consistent way is a big challenge. However, the data is present but is widely spread across different channels and is insufficient for creating effective MRV framework. In order to make the framework robust, roles of nodal agencies needs to be clearly defined and time frame for data collection and monitoring specified. Considering the scope of MRV is mainly from the perspective of climate change mitigation actions, it is important that the institution responsible for this should have the necessary expertise and experience to enhance data collection. Based on stakeholder consultations, the data reporting mechanism for the Utility scale solar projects (under solar parks and VGF schemes) is proposed in the following section.

7.1 Data Collection Mechanism and Reporting Bodies for Measuring the GHG Impacts of Policies/Schemes for Utility-scale Solar Projects

Table 13 enlists some of the key data parameters that are required in order to assess the impact of mitigation policies and roles and responsibilities of the key agencies. The proposed structure is intended to streamline the monitoring and reporting of data among the stakeholders involved.

Table 13: Key parameter for GHG emissions assessment for RE policies

Data parameter and unit	Reported by	Reported to	Responsibility of the Reporter (for the purpose of assessing GHG impacts only)
Project level installed capacity (MW)	SPPD/SPD	State Transmission Utility (STU)	The third party Auditors (to be appointed by SPPD) will verify the data on installed capacity of each solar project
Net electricity supplied to the electricity grid at the project level (MWh)	SPPD	State Transmission Utility (STU)	The third party Auditors (to be appointed by SPPD) will verify the data on the net electricity generated and supplied to the electricity grid from each solar project (MWh)
State level installed solar project capacity (MW)	State Transmission Utility (STU)	SECI/IREDA and CEA	STU will provide solar-project specific data on total installed capacity in the state to CEA for calculating combined margin grid emission factor. In addition, STU will also provide this information to the nodal agency for implementing the solar project scheme i.e. SECI/IREDA
Net electricity supplied to the electricity grid at the state level (MWh)	State transmission utility	SECI/IREDA and CEA	STU will provide solar-project specific data on the net electricity generated and supplied to the electricity grid from all solar projects in the state (MWh) to CEA for calculating combined margin grid emission factor, In addition, STU will also provide this information to the nodal agency for implementing the solar project i.e. SECI/IREDA
Combined margin emission factor of the Indian electricity system (tCO_2e/MWh)	CEA	MRV Coordination Committee	CEA will calculate combined margin emission factor of the electricity system (calculated on annual basis) and provide updated emission factor to the MRV Coordination Committee

7.2 Proposed Data collection mechanism for MRV of Policies/ Schemes for Utility-scale Solar Projects

Successful implementation of an MRV framework requires an effective multi-stakeholder effort involving existing institutions and organizations. Currently, the data required for GHG estimation in RE sector is widely dispersed and collected at multiple sources. The implementation and data monitoring for the solar parks scheme is currently being undertaken by the MNRE and the Solar Energy Corporation of India Ltd. (SECI). Recently, the MNRE has appointed Indian Renewable Energy Development Agency Limited (IREDA) as the implementing agency for (for VGF Scheme and entrusted with the tasks of conducting bidding for the allocation of solar power projects in the Scheme with VGF amount as a bid parameter to select project proponents.[1] Based on the suggestions from stakeholders, an integrated institutional structure is proposed for data collection and MRV (Figure 5). A retrofit of the existing MRV structure for a streamlined data collection under solar utility scale projcest, it is suggested to form a MRV Coordination Committee comprising of the Ministry of Power (MoP) and the Ministry of New and Renewable Energy (MNRE), and supported by entities at different levels-

- At the Park level: Solar Power Park Developer (SPPD) or the Solar Project Developer to provide data on installed solar project capacity and the net electricity supplied to the electricity grid from the solar project. SPPD/SPD to also appoint third party Auditors to verify the data on installed capacity and generation of each solar project. The verified data to be reported to STU at the state level.
- At the state level: State Transmission Utility (STU) to collate information from all solar projects in the state and provide data on total installed solar project capacity and the net electricity supplied to the electricity grid in the state.
- At the national level:
  - SECI/ IREDA should be the main source of data collection for installed capacity and net electricity generation supplied to the grid from utility-scale solar projects at the national level.
  - CEA would be responsible to calculate combined margin emission factor of the electricity system (calculated on annual basis).
  - SECI/IREDA and CEA would then provide the total installed capacity of utility-scale solar projects, total generation and emission factor to the MRV Coordination committee comprising of MoP and MNRE which would report the data to MoEFCC for GHG emission analysis and international reporting.

The organizational chart of the solar park data collection could be depicted as follows:

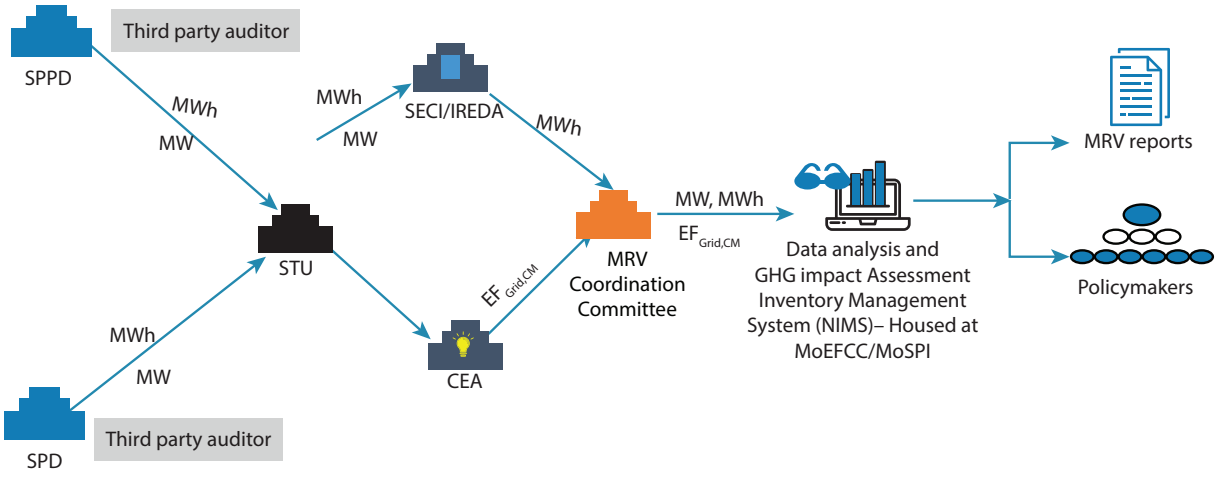


Figure 8: Proposed data collection mechanism for MRV

[1] https://energy.economictimes.indiatimes.com/news/renewable/ireda-to-handle-cpsu-scheme-on-behalf-of-mnre/75123515

Annexure

Annexure 1: Listing of key schemes and their scope

The following table highlights the solar utility policies/guidelines selected for the assessment:

S.No.	Scheme	Description	Achievement	Capacity Addition – Top 3 states
1	Scheme for setting up over 300 MW of Grid-Connected Solar PV Power Projects by Defence Establishments under Ministry of Defence and Para Military Forces with Viability Gap Funding under Phase-II/III of National Solar Mission	The Defence establishments, which are located in the border area and remote locations use diesel as the primary source of energy. In some areas they pay very high tariff. Solar power is clean source of energy and can replace diesel power generation to a large extent. Potential of Solar Energy in cantonment and Military Stations are approximately 5000 MW and in Ordnance Factory Boards (OFB) are 950 MW. Ordnance Factory Board (OFB) and other Defence Establishments agreed to set up solar power projects on the large tracts of land and vacant rooftops which they own. The Union oCabinet has approved the Scheme in its meeting held on 10th December, 2014. The Ministry has issued Administrative Approval on 07th January, 2015.	In-principle approval of 357.5 MW has been given to different Defence Organisations. Out of this, 22 MW has been commissioned so far	Telangana – 15 MW
2	Scheme for Development of Solar Parks and Ultra Mega Solar Power Projects	This scheme envisages supporting the States in setting up solar parks at various locations in the country with a view to create required infrastructure for setting up of Solar Power Projects. The solar parks will provide suitable developed land with all clearances, transmission system, water access, road connectivity, communication network, etc. This scheme will facilitate and speed up installation of grid connected solar power projects for electricity generation on a large scale. All the States and Union Territories are eligible for benefitting under the scheme	As on 31.12.2017, a total of 35 Solar Parks in 21 States have been approved with a solar power capacity of 20514 MW	Rajasthan – 4350 MW Andhra Pradesh – 4000 MW Madhya Pradesh – 2750 MW
3	Viability Gap Funding (VGF) Scheme	Solar Energy Corporation of India (SECI) has allocated 4,835 MW of project capacity under the VGF route, whereby a capital subsidy is provided to project developers bidding for projects at a predetermined tariff. As of March 31, 2017, another 785 MW of tenders under SECI VGF scheme are under process.		
3.1	750 MW VGF Scheme under JNNSM Phase-II, Batch-I	Solar Energy Corporation of India (SECI) has implemented the first VGF scheme of 750 MW, under JNNSM Phase-II, Batch-I for setting up large scale ground-mounted solar PV projects on pan-India basis. After a transparent selection and award process, project capacity of 680 MW could successfully achieve financial closure. This entire capacity has been commissioned and projects are under commercial operation.	As of 31.12.2017, a total of 680 MW has been commissioned in 7 states across India.	Rajasthan – 355 MW Madhya Pradesh – 220 MW Gujarat – 40 MW

S.No.	Scheme	Description	Achievement	Capacity Addition – Top 3 states
3.2	2000 MW VGF Scheme under JNNSM Phase-II, Batch-III	◆ Guidelines issued on dated 04th August 2015. Power purchased by SECI @ Rs. 4.43/kWh (PPA) and sold to buying utilities @ Rs. 4.50/kWh (PSA). ◆ Bidding have been carried out amounting to Rs. 1515 Crore out of the total approved scheme allocation of Rs. 2100 Crore. ◆ 2 categories: DCR (250 MW) & Open (1750 MW). Project Size is Minimum 10 MW up-to 50 MW (in multiples of 10 MW). ◆ State-specific tenders based on the demand from State. Projects could be set up either in the Solar Parks and or outside the solar park. ◆ VGF up-to Rs. 1.31 Crore per MW (DCR) and Rs. 1 Crore per MW (Open) is being provided. ◆ Average bided VGF under the open category is 63.27 lakh/MW and DCR category is 1.11 Crore/MW. ◆ RfS have been issued for 2410 MW capacity in 7 States/UTs (Maharashtra, Uttar Pradesh, Andhra Pradesh, Chhattisgarh, Karnataka, Puducherry and Himachal Pradesh), LoI placed: 2295 MW, PPA signed: 2295 MW & PSA signed: 2425 MW (As on 31.12.2017).	Total 300 MW Capacity reported as commissioned in Maharashtra, at non-solar park locations	Maharashtra – 300 MW
3.3	5000 MW VGF Scheme under JNNSM Phase-II, Batch-IV	The scheme is proposed to be implemented by SECI in four tranches of 1250 MW each, spread over four years, up to FY 2018-19. This scheme also provides for purchase of solar power by SECI from selected developers at a fixed tariff of Rs. 4.43 per kWh for 25 years and supply to DISCOMs at Rs. 4.50 per kWh (including trading margin of 7 paise per unit). The projects are being set up either in the solar parks being developed by states or outside the solar parks	In the FY 2017-18 (up to 31.12.2017), NIT has been issued for 3975 MW capacity. LoI have been issued for 750 MW and PPAs have been signed for the same capacity. Financial Closures have been achieved for 445 MW. 250 MW has been commissioned.	Gujarat – 250 MW
4	Installation of 15000 MW Grid-Connected Solar PV power plants through NTPC Ltd.	The Government of India (through Cabinet approval on 25.02.2015) has approved the Implementation of Scheme for setting up 15,000 MW of Grid connected Solar PV Power projects under National Solar Mission through NTPC/NVVN in three tranches as follows: Tranche-I: 3,000 MW: 2014-15 to 2016-17 Tranche-II: 5,000 MW: 2015-16 to 2017-18 Tranche-III: 7,000 MW: 2016-17 to 2018-19	Currently Tranche-I, is under implementation. In Tranche-I, which is Batch-II of Phase-II of National Solar Mission, 3000 MW capacity of solar PV power plants will be based on bundling of solar power (3000 MW) with unallocated thermal power (1500 MW) in the ratio of 2:1 (in MW terms), for which the required 1500 MW unallocated thermal power has been made available by the Ministry of Power.	

S.No.	Scheme	Description	Achievement	Capacity Addition – Top 3 states
4.1	3000 MW Grid connected solar PV power projects under NSM phase-ii, batch-II, Tranche-i – 'state specific bundling scheme'	Under this Scheme, this is part of Tranche-I of Batch-II of Phase-II of National Solar Mission, 3 GW capacity of solar PV power plants are being set up based on the mechanism of bundling of solar power (3 GW) with unallocated thermal power (1500 MW) in the ratio of 2:1 (in MW terms), for which the required 1500 MW unallocated thermal power has been made available by the Ministry of Power	Implementation (as on 30.11.2017): Notice Inviting Tender Published for full Tranche-I of 3,000 MW. ◆ Reverse auction completed: 3000 MW. ◆ Power Sale Agreement (PSA) Signed with State Discoms: 2750 MW ◆ Letter of Intent issued to successful bidders: 2750 MW ◆ Power Purchase Agreements (PPAs) signed: 2750 MW	Andhra Pradesh – 1250 MW Rajasthan – 650 MW Karnataka – 600 MW
6.	Scheme for setting up of 1000 MW of Grid connected Solar PV power projects by CPSUs and Govt. organizations under various Central/State Schemes/Self use/3rd Party sale/Merchant sale with Viability Gap Funding (VGF) under Phase-II of NSM	The Ministry launched the above scheme in January 2015 to set up 1000 MW of Grid Connected Solar PV Power Project by CPSUs and Govt. Organizations with VGF. Under the Scheme, MNRE, as on 15.12.2017, has allocated about 963 MW capacity to 12 different CPSUs/ Govt. Organisations within the sanctioned funds of Rs.1000 Crore for this scheme.	As of 15.12.2017, a total of 963 MW has been sanctioned, out of which 765 MW has been commissioned and VGF released by MNRE amounts to Rs. 583 Cr.	Andhra Pradesh – 255 MW Madhya Pradesh – 229 MW Rajasthan – 180 MW
7.	Solar RPO	The Electricity Act (EA), 2003 mandates that State Electricity Regulatory Commissions (SERC) promote renewable energy within their respective state. Under EA 2003, the SERCs set targets for obligated entities to purchase a certain percentage of their total power requirement from RE sources. This target is termed as the Renewable Purchase Obligation (RPO). Entities with an RPO target, which are required to purchase RE, are called 'Obligated Entities'. The following entities are generally obligated in the State, namely: (i) Distribution Licensees, (ii) Captive Consumers, and (iii) Open Access users.	Recently, India's power ministry has increased the RPO target from 17% now to 21% by 2022. As per the new norms, all entities that fall under the RPO should procure 10.5% of their total electricity from solar sources, up from 6.75% now and another 10.5% of their power from non-solar renewable sources by 2022, up from 10.25% now.	
8.	Competitive bidding (solar) Solar Guidelines for Tariff Based Competitive Bidding Process for Procurement of Power from Grid Connected Solar PV Power Projects*. (2017)			

* http://mnre.gov.in/file-manager/grid-solar/Guidelines_for_Tariff_Based_Competitive_Bidding_Process.pdf

Annexure 2: Stakeholder Questionnaire

A. During FY 2018–19, installed capacity for solar energy reached 28 GW and contributed to about 8% of the total installed power capacity in India. Going forward, what trend do you envisage for share of solar capacity to total installed power capacity, given the national solar installation target is 100 GW by 2022?- Select the value by highlighting from the below range				
By 2022	Less than 10%	10% to 15%	15% to 20%	more than 20%
By 2030	Less than 10%	10% to 15%	15% to 20%	more than 20%
KEY for Assigning Levels				
Level	Low	Medium	High	Very high
Rating	25	50	75	100

B. Barriers for Solar Park Implementation: From the list below, what are the major barriers for deployment of solar energy, particularly for solar parks scheme?				
No	**Categories**	**Weightage**	**Barriers**	**Level**
1	Financial		High upfront fees as development charges along with sizable recurring cost	
			Changes in financial parameters post competitive bidding such as GST and safeguard duties	
			Insufficient payment security to cover long payment delays by procurers	
			Penalties due to delay in infrastructure development such as land possession and evacuation facilities	
			High upfront cost of the plants	
			Others if any:	
2	Technical		Compliance to quality control standards	
			Poor quality of land surface	
			Availability of reliable solar radiation data	
			Availability of water for cleaning of solar panels	
			Lack of transmission/evacuation facilities across states	
			A lack of grid ability to absorb renewable energy	
			A lack of land availability	
			High transmission costs as solar power may be generated far from the load	
			Others if any:	

3	Capacity		Limited institutional capacity and coordination	
			Lack of skilled technicians at all levels for project designing and installation	
			Lack of awareness on new and more efficient technologies	
			Lack of indigenous production capacity	
			Others if any:	
4	Policy		Policy uncertainty & frequent changes	
			Issues around Land Procurement	
			Others if any:	
Total		100%		

C. Scheme on Solar Parks and Ultra Mega Solar Parks is targeted to deploy 40 GW of utility scale solar capacity by 2022. Till now, 45 solar parks in 20 states have been approved with a total of 26.45 GW capacity. Out of this, around 5 GW is operational to date. Going ahead, what trend do you envisage for operational solar parks installation capacity for the following years? - Select the value by highlighting from the below range

By 2022	less than 10 GW	10–20 GW	20–30 GW	30–40 GW
By 2030	30–40 GW	40–50 GW	50–60 GW	more than 60 GW

D. Measuring, Reporting and Verification related Questions

1. How is status (including approval, commission, installation, generation, etc.) of solar parks monitored? Which institutions are involved in this process?

2. How is solar electricity generation data collected from each solar park? At what frequency is this data collected?

3. Are there any capacity building programmes for improving electricity data collection process from solar parks?

4. Is there any mechanism in place to verify electricity generation data from solar parks? How can this be strengthened further?

5. What are the existing support programmes (financial, technical, capacity building, etc.) to strengthen MRV mechanism in developing countries?

6. Is the nodal agency for solar parks scheme working towards establishment of a data management system (software) to capture various information related to solar parks?

7. It may be difficult to absorb solar power in the grid on a large scale due to its intermittent nature. How is the issue of absorption of renewable power in the grid planned to be addressed?

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