Initiative for Climate Action Transparency - ICAT

MEASUREMENT, REPORTING, AND VERIFICATION SYSTEM FOR RENEWABLE ENERGY POLICY OF CAMBODIA

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DELIVERABLE 1: A REPORT DETAILING ENVISIONED APPLICATION OF THE ICAT PILLAR 1 METHODOLOGY FOR RENEWABLE ENERGY POLICY OF CAMBODIA (REVERSE AUCTIONING FOR GRID CONNECTED SOLAR POWER)

DISCLAIMER

This publication has been produced as part of a component of the Initiative for Climate Action Transparency project (ICAT) implemented by UNEP DTU Partnership (UDP). The views expressed in this publication are those of Consultants and do not necessarily reflect the views of the GSSD or UDP.

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The Royal Government of Cambodia (RGC) has joined hands with the rest of the world in combating the adverse effects of climate change and global warming through the development and implementation of several policies and strategies, including the Nationally Determined Contributions (NDCs) submitted to the UNFCCC in 2015.

Among other mitigation activities, the RGC is considering to increase the share of electricity generation using renewable energy, especially the introduction of grid-connected solar PV systems.

An internationally recognized and transparent system for the Measurement, Reporting, and Verification (MRV System) of the the greenhouse gas (GHG) effects of mitigation activities is an essential requirement to enhance transparency.

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General Secretarait of the National Council for Sustainable Development

List of Acronyms

AAGR	Average Annual Growth Rate
ADB	Asian Development Bank
AHP	Analytical Hierarchy Process
BAU	Business as Usual
BM	Build Margin
CCAP	Climate Change Action Plan
CCCSP	Cambodia Climate Change Strategic Plan
CDM	Clean Development Mechanism
CH_4	Methane
CM	Combined Margin
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalents
COP	Conference of the Parties
CFR	Complementary Function to REF
DTU	Technical University of Denmark
EAC	Electricity Authority of Cambodia
EDC	Electricité Du Cambodge
GHGs	Greenhouse Gases
GWh	Gigawatt-hour
HFO	Heavy Fuel Oil
ICAT	Initiative for Climate Action Transparency
IEA	International Energy Agency
IGES	Institute for Global Environmental Strategies
IIED	International Institute for Environment and Development
IPCC	Intergovernmental Panel on Climate Change
IPPs	Independent Power Producers
JICA	Japan International Cooperation Agency
KP	Kyoto Protocol
kWh	Kilowatt-hours

LUCF	Land Use Change and Forestry
MWh	Megawatt-hours
M & E	Monitoring & Evaluation
MME	Ministry of Mines and Energy
MoU	Memorandum of Understanding
MoP	Ministry of Planning
MP	Mid Term Policy Measures
MPWT	Ministry of Public Works and Transport
MRV	Measurement, Reporting and Verification
N_2O	Nitrous oxide
NAMA	Nationally Appropriate Mitigation Action
NCCC	National Climate Change Committee
NCGG	National Council for Green Growth
NCSD	National Council for Sustainable Development
NDCs	Nationally Determined Contributions
NFM&ECC	National Framework for M&E of Climate Change
NGGR	National Green Growth Roadmap
NSDP	National Strategic Development Plan
NSPGG	National Strategic Plan on Green Growth
OECD	Organisation for Economic Co-operation and Development
OM	Operation Margin
PDP	Power Development Plan
PV	Photovoltaic
RE	Renewable Energy
REAP	Renewable Electricity Action Plan
REEs	Rural Electricity Enterprises
REF	Rural Electrification Fund
REREP	Rural Electrification by Renewable Energy Policy
RGC	Royal Government of Cambodia
SNC	Second National Communication
SP	Short Term Policy Measure

TAMD	Tracking Adaptation and Measuring Development
T & D	Transmission & Distribution
TFES	Total Final Energy Supply
TOE	Tons of oil equivalent
TPEC	Total Primary Energy Consumption
UNDP	United Nations Development Programme
UN DESA	United Nations Department of Economic and Social Affairs
UNFCCC	United Nations Framework Convention on Climate Change
UNEP	United Nations Environment Programme
VERs	Voluntary Emission Reductions
VRE	Variable Renewable Energy
VERRA	Verified Carbon Standard
WWF	World Wildlife Fund
WRI	World Resources Institute

Glossary of Terms

Activities	The administrative activities involved in implementing the policy (undertaken by the authority or entity that implements the policy), such as permitting, licensing, procurement, or compliance and enforcement
Assessment period	The time period over which GHG impacts resulting from a policy is assessed
Assessment report	A report, completed by the user, that documents the assessment process and the GHG, sustainable development and/or transformational impacts of the policy
Barrier	Any obstacle to develop and deploy renewable energy (RE) potential that can be overcome or attenuated by a policy, programme or measure
Baseline scenario	A reference case that represents the events or conditions most likely to occur in the absence of a policy (or package of policies) being assessed
Causal chain	A conceptual diagram tracing the process by which the policy leads to impact through a series of interlinked logical and sequential stages of cause-and-effect relationships
Emission factor	A factor that converts activity data into GHG emissions data
Ex-ante assessment	The process of estimating expected future GHG impacts of a policy (i.e., a forward-looking assessment)
Ex-post assessment	The process of estimating historical GHG impacts of a policy (i.e., a backward-looking assessment)
Expert judgment	A carefully considered, well-documented qualitative or quantitative judgment made in the absence of unequivocal observational evidence by a person or persons who have a demonstrable expertise in the given field (IPCC 2006)
Feed-in tariff	The price per unit of electricity that an utility or a power supplier has to pay for distributed or renewable electricity fed into the grid by non- utility power producers

GHG assessment boundary	The scope of the assessment in terms of the range of GHG impacts that are included in the assessment
GHG impacts	Changes in GHG emissions by sources that result from a policy
Electricity grid (grid)	A network consisting of wires, switches and transformers to transmit electricity from power sources to power users. A large intermediate voltage (1-50 kV) to high-voltage (above 50 kV to MV) transport subsystems. Interconnected grids cover large areas up to continents. The grid is a power exchange platform enhancing supply reliability and economies of scale
Grid access	Refers to the acceptance of power producers to deliver to the electricity grid
Impact assessment	The estimation of changes in GHG emissions or removals resulting from a policy, either ex-ante or ex-post
In-jurisdiction impacts	Impacts that occur inside the geopolitical boundary over which the implementing entity has authority, such as a city boundary or national boundary
Independent policies	Policies that do not interact with each other, such that the combined effect of implementing the policies together is equal to the sum of the individual effects of implementing them separately
Inputs	Resources that go into implementing the policy, such as financing
Intended impacts	Impacts that are intentional based on the original objectives of the policy. In some contexts, these are referred to as primary impacts.
Interacting policies	Policies that produce total effects, when implemented together, that differ from the sum of the individual effects had they been implemented separately
Intermediate effects	Changes in behavior, technology, processes, or practices that result from the policy, which leads to GHG impacts
Jurisdiction	The geographic area within which an entity's (such as a government) authority is exercised
Key performance indicator	A metric that indicates the performance of a policy indicator

Levelized Cost of Electricity LCOE)	The unique cost price of the outputs (cUS/kWh or USD/GJ) of a project that makes the present value of the revenues (benefits) equal to the present value of the costs over the lifetime of the project
Long-term impacts	Impacts that are more distant in time, based on the amount of time between implementation of the policy and the impact
Monitoring period	The time over which the policy is monitored, which may include pre-policy monitoring and post-policy monitoring in addition to the policy implementation period
Negative impacts	Impacts that are perceived as unfavorable from the perspectives of decision makers and stakeholders
Net metering	The practice of using a single meter to measure consumption and generation of electricity by a small generation facility (such as a house with a wind or solar photovoltaic system). The net energy produced or consumed is purchased from or sold to the power producer, respectively.
Non-policy drivers	Conditions other than RE policies, such as socioeconomic factors and market forces, that are expected to affect the emission sources included in the GHG assessment boundary
Own use of electricity	Consumption of the electricity for the direct support of the power plants
Out-of-jurisdiction impacts	Impacts that occur outside the geopolitical boundary over which the implementing entity has authority, such as a city boundary or national boundary
Overlapping policies	Policies that interact with each other and that, when implemented together, have a combined effect less than the sum of their individual effects when implemented separately. This includes both policies that have the same or complementary goals (such as national and subnational energy efficiency standards for appliances), as well as counteracting or countervailing policies that have different or opposing goals (such as a fuel tax and a fuel subsidy).

Parameter	A variable such as activity data or emission factors that are needed to estimate GHG impacts
Policy or action	An intervention taken or mandated by a government, institution, or other entity, which may include laws, regulations, and standards; taxes, charges, subsidies, and incentives; information instruments; voluntary agreements; implementation of new technologies, processes, or practices; and public or private sector financing and investment, among others
Policy implementation period	The time period during which the policy is in effect
Policy scenario	A scenario that represents the events or conditions most likely to occur in the presence of the policy (or package of RE policies) being assessed. The policy scenario is similar to the baseline scenario except the fact that it includes the policy (or package of policies) being assessed.
Positive impacts	Impacts that are perceived as favorable from the perspectives of decision makers and stakeholders
Power purchase agreement (PPA)	A contract between an electricity (power) producer and an electricity utility/consumer/distributor. Historically, PPAs have been frequently signed between utilities and independent power producers as a way for the utility to procure additional generation. In recent years, PPAs have been used as a way for power consumers to purchase electricity, often from solar systems, from a third-party power producer
RE addition	The additional installation of renewable energy capacity or electricity generation from renewable sources realized via the policy, expressed in megawatts (MW) or megawatt-hours (MWh) respectively
Reinforcing policies	Policies that interact with each other and that, when implemented together, have a combined effect greater than the sum of their individual effects when implemented separately

Renewable energy	Any form of energy from solar, geophysical or biological sources that is replenished by natural processes at a rate that equals or exceeds its rate of use. Renewable energy is obtained from the continuing or repetitive flows of energy occurring in the natural environment and includes low-carbon technologies such as solar energy, hydropower, wind, tide and waves and ocean thermal energy, as well as renewable fuels such as biomass.
Renewable portfolio standard	A legal mandate that require utilities to procure a certain percentage or flat amount of renewable electricity or power based on their total generation. Utilities can procure the renewable energy via direct ownership or the purchase of renewable energy
Short-term impacts	Impacts that are nearer in time, based on the amount of time between implementation of the policy and the impact
Solar energy	Energy from the sun that is captured either as heat, as light that is converted into chemical energy by natural or artificial photosynthesis, or by photovoltaic panels and converted directly into electricity
Stakeholders	People, organizations, communities or individuals who are affected by and/or who have influence or power over the policy
Sustainable development impacts	Changes in environmental, social, or economic conditions that result from a policy, such as changes in economic activity, employment, public health, air quality, and energy security
Transmission and distribution	The network that transmits electricity through wires from where it is generated to where it is used. The distribution system refers to the lower-voltage system that delivers the electricity to the end consumer.
Uncertainty	1. Quantitative definition: Measurement that characterizes the dispersion of values that could reasonably be attributed to a parameter. 2. Qualitative definition: A general term that refers to the lack of certainty in data and methodological choices, such as the application of non-representative factors or methods, incomplete data, or lack of transparency.
Unintended impacts	Impacts that are unintentional based on the original objectives of the policy. In some contexts, these are referred to as secondary impacts.

Utility	An entity in the electric power industry that engages in electricity generation and distribution of electricity for sale, generally in a regulated market
Weighted average cost of capital (WACC)	The rate that a company is expected to pay on average to all its security holders to finance its assets, including the fraction of each financing source in the company's capital structure

Source: https://climateactiontransparency.org/wp-content/uploads/2019/06/ICAT-Renewable-Energy-Methdology-June-2019.pdf

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1. Introduction

1.1. Background

The Paris Agreement (UN, 2015) aims to strengthen the global response to the threat of climate change by keeping a global temperature rise well below 2 degrees Celsius above pre-industrial levels, and to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius. Within this context, 189 Parties to the United Nations Framework Convention on Climate Change (UNFCCC) have submitted their Nationally Determined Contributions (NDCs), which consist of mitigation and adaptation goals, policies, programmes, and projects. The mitigation actions will support the achievement of the temperature goal under the Paris Agreement. The adaptation actions aim to strengthen the ability of countries to deal with the impacts of climate change in line with the Agreement.

Article 4 of the Paris Agreement states that the Parties should prepare and communicate their NDCs, and pursue mitigation measures listed therein. In communicating their NDCs, the Parties need to provide all the information necessary for clarity, transparency, and understanding. In this context, Article 13 establishes an enhanced transparency framework to track progress in implementing NDCs in the countries with clarity, and report to the UNFCCC regularly. Thus, under this framework, the countries will have to monitor and report information on their mitigation actions in a way that provides clarity and allows the level of progress made in achieving the mitigation targets specified in their NDCs. Thus, this framework is one of the central pillars for enhancing information on NDC implementation and raising the ambition to meet the Paris Agreement's goal of limiting the temperature rise to well below 2ºC. Measurement, Reporting, and Verification (MRV) systems will, therefore, play a significant role in effectively tracking and improving the implementation of mitigation actions articulated under each country's Nationally Determined Contributions (NDCs) (CDKN, 2016).

Decision 1/CP.21 states that the modalities, procedures, and guidelines of this transparency framework are to build upon and eventually to supersede MRV system established under COP-16 in Cancun and COP-17 in Durban. Thus, the existing MRV arrangements agreed during these COPs would form the basis for the new enhanced transparency framework.

Previous assessment of national low emission policies and GHG MRV system under the ICAT support (MME and GSSD, 2019) identified key national development policies, renewable energy (RE) policies, and existing MRV system in Cambodia.

The main focus of this assessment is to investigate the applicability of the ICAT Pillar 1 methodologies for a selected RE policy in Cambodia. This study is facilitated by the General Secretariat of the National Council for Sustainable Development (GSSD) and the Ministry of Mines and Energy (MME) of the Royal Government of Cambodia (RGC), with financial support from the ICAT and technical assistance from UNEP DTU Partnership.

1.1.1. National GHG emissions

Cambodia shared her first (based on GHG emission data for year 1996) and second national communications (based on GHG emission data for year 2000) with the UNFCCC in the years 2002 and 2015, respectively. According to the second national communication, estimated GHG emissions of Cambodia for the year 2000 were 24,108.7 $GgCO_2e$, while the removal was 24,565.5 $GgCO_2e$. The net emission of Cambodia for the year 2000 was recorded as - 456.8 $GgCO_2e$. Therefore, Cambodia remained as a net carbon sink in the year 2000.

However, as the country develops further and expands its infrastructure and industries, GHG emissions are expected to increase while de-forestation for agriculture and other land uses may reduce the GHG removals.

Total and sectoral GHG emissions according to the SNC of Cambodia (GSSD, 2015) are shown in Table 1 below:

Table 1: Total GHG emissions ($GgCO_2e$)

GHG source and sink categories	GHG emissions, $GgCO_2e$	%
(a) GHG Emissions		
Energy	2,767.30	11.47%
Agriculture	21,112.16	87.57%
Waste	229.24	0.95%
Total Emissions	24,108.70	
(b) GHG Absorptions		
Land Use Change & Forestry	-24,565.50	N/A
Total Absorptions	-24,565.50	
Total net emissions	-456.80	N/A

Source: (GSSD, 2015)

Agriculture sector has the highest GHG emissions in the year 2000 (87.6% of the national GHG emissions), which is followed by Energy (11.5% of the national GHG emissions) sector. Sectoral distribution of GHG emissions is shown in figure 1 below:

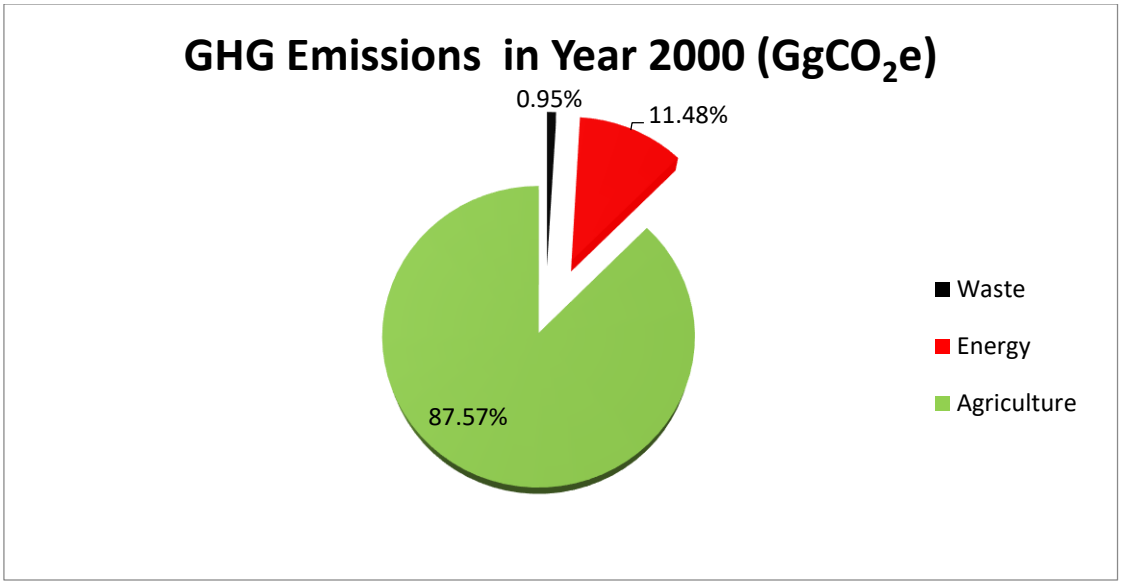

Figure 1: National GHG Emissions in year 2000, Source: (GSSD, 2015)

1.1.2. GHG emissions in the energy sector

GHG emissions of Cambodian energy sector in the year 2000 were estimated as 2,767.30 $GgCO_2e$, which was 11.5% of the national GHG emissions. This illustrates that the share of the energy sector's GHG emissions to the national GHG emissions is not as prominent as in most of the countries around the world.

Table 2: GHG emissions of energy sub sectors in 2000

Sectoral Report for National GHG Inventories (Gg)				
GHG Source and Sink Categories	**CO_2**	**CH_4**	**N_2O**	**CO_2e**
Total Energy	2,052.59	28.19	0.40	2,767.30
Fuel Combustion Activities (Sectoral Approach)	2,052.59	28.19	0.40	2,767.30
1. Energy Industries	383.59	0.02	0.00	384.85
2. Manufacturing Industries and Construction	313.66	0.10	0.01	320.01
3. Transport	704.76	0.11	0.01	708.82
a. Civil Aviation	0.00	0.00	0.00	
b. Road Transportation	695.92	0.11	0.01	699.95
c. Railways	8.84	0.00	0.00	8.87
4. Other Sector	462.38	27.95	0.37	1,164.41
a. Commercial/ Institutional	61.64	0.30	0.00	68.50
b. Residential	189.34	27.63	0.37	883.66
c. Agriculture/ Forestry/ Fishing	211.40	0.01	0.00	212.24
5. Other	188.19			
Memo Items (International Bunkers and CO_2 emission from biomass are excluded from the national emissions)				
International Bunkers	55.55	0.00	0.00	
Aviation	55.55	0.00	0.00	
Marine	0.00	0.00	0.00	0.00
CO_2 emissions from Biomass	9,193.33			

Source: (GSSD, 2015)

As illustrated by figure 2, Transport sector accounts for the highest GHG emissions in the energy sector in Cambodia (34% of the national GHG emissions), which is followed by other sectors (Commercial, Residential, Agriculture) and Energy Industry.

1.1.3. NDCs of Cambodia

Cambodia has communicated its goal for climate change mitigation (and adaptation) via NDCs to the UNFCCC in 2017. As per its NDCs, the focus will be on energy and forestry sectors, the two main sectors for GHG mitigations with the following targets (with the GHG mitigation contribution for the period 2020 –2030);

I. Cambodia expects to reduce 3,100 $GgCO_2e$ from the energy sector compared to baseline emissions of 11,600 CO_2e by 2030.

II. Cambodia intends to undertake voluntary and conditional action to achieve the target of increasing forest cover to 60% of the national land area by 2030.

1.1.4. Energy sector NDCs

According to the energy sector NDCs shown in Table 3, Cambodia has highest ambitions for GHG emission reductions (ERs) from the Energy Industries, having an emission reduction target of 16% by the year 2030. Manufacturing Industries and Transport have targets of 7% and 3%, respectively.

Table 3: Energy Sector NDCs

Sector	Priority actions	ERs[1] in 2030 $GgCO_2e$ (%)
Energy Industries	National grid connected renewable energy generation (Solar energy, hydropower, biomass and biogas) and connecting decentralized renewable generation to the grid. Off-grid electricity such as solar home systems, hydro (pico, mini and micro). Promoting energy efficiency by end users.	1,800 (16%)
Manufacturing Industries	Promoting use of renewable energy and adopting energy efficiency for garment factory, rice mills, and brick kiln.	727 (7%)
Transport	Promoting mass public transport. Improving operation and maintenance of vehicles through motor vehicle inspection and eco- driving, and the increased use of hybrid cars, electric vehicles and bicycles.	390 (3%)

[1] Expected Emission Reduction (ER) by 2030 compared to business as usual scenario.

Other	Promoting energy efficiency for buildings and introducing more efficient cook stoves. Reducing emissions from waste through the use of bio digesters and water filters. Use of renewable energy for irrigation and solar lamps	155 (1%)
Total Savings		3,100 (27%)

Source: (First Nationally Determined Contribution, 2017)[2]

Energy industry has to play a leading role in achieving the emission reduction targets of the energy sector under the NDCs given the fact that over 50% of emission reduction is expected from energy industry via the promotion of solar, hydro, biomass and biogas power plants.

1.2. Objectives and Outcomes

1.2.1. The objective of the ICAT project in Cambodia

The main objective of this assignment is to build capacity to design an MRV system for a selected policy / action in Cambodia, that helps meet the NDC commitments. It is coordinated by the General Secretariat of the National Council for Sustainable Development.

The specific objectives of this assignment are to:

- Task 1: Review of the Guidance Material and Methodologies Developed Under the ICAT Pillar 1 Relevant to a Selected Policy
- Task 2: Design of the MRV System, Establishment of Roles and Responsibilities
- Task 3: Conduct Workshops and design an Implementation Plan

[2] Summry of the NDCs are included in the Annex 1.

The assignment will focus on:

- Reviewing and applying the ICAT Renewable Energy (RE) Guidance to measure GHG impacts of prioritized RE policies;
- Designing MRV system, which follows the guidance material reviewed in Task 1 for calculating GHG emissions, and thus includes the followings;
    - Methodology finalized and related calculations
    - Establishing institutional arrangement (roles and responsibilities, reporting channel);
    - Designing data management system;
    - Data collection templates; and
- Identifying necessary legal arrangements.

This will facilitate the development of a robust national MRV system subsequently.

1.3. What is an MRV system?

According to the Bali Action Plan, which introduced the term MRV, climate change mitigation actions - mainly GHG emission reductions, shall be implemented in a measurable, reportable and verifiable manner. Measurement, Reporting, and Verification (MRV) are key elements for:

(a) Ensuring greater transparency, accuracy, and comparability of information with regard to climate change in order to identify good practice, foster a learning process, and allowing international benchmarking;

(b) Recognizing and enhancing the visibility of the achievement of mitigation actions in order to raise ambitions of other countries;

(c) Attributing the quantified GHG effects of policies;

(d) Accounting national and international progress;

(e) Identifying gaps and international support needs; and

(f) Creating access to international public and private finance.

According to the "handbook on Measurement, Reporting and Verification for developing country parties" published by the UNFCCC, an MRV is applied in three areas:

(a) MRV of emissions (estimation of emissions at national, regional and sectoral levels);

(b) MRV of NAMAs (MRV of the impacts of mitigation policies and actions); and

(c) MRV of support (MRV of financial flows / technology transfer / capacity building and their impacts).

1.3.1. **The National MRV System:**

Interaction between MRV of emissions, NAMAs, and Support

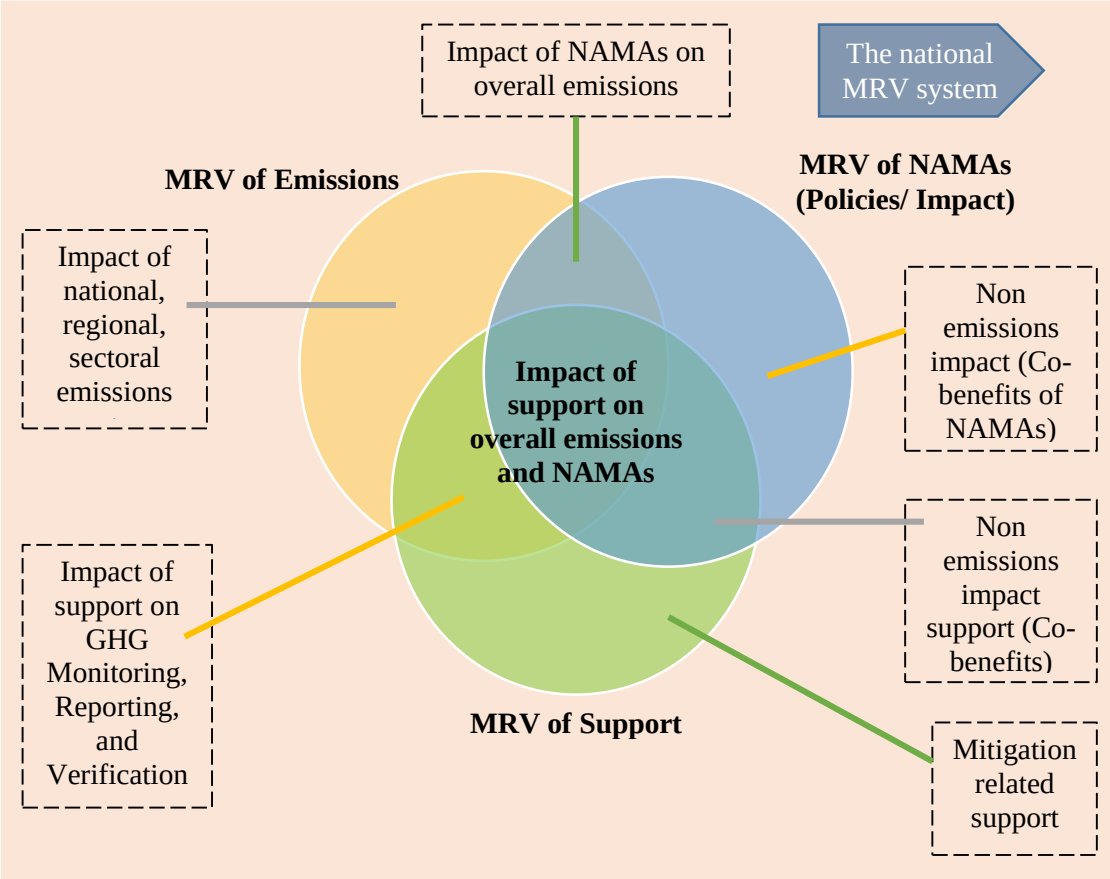

Figure 2: Interaction between MRV of emissions, NAMAs, and support - adapted from "Handbook on Measurement Reporting and Verification for developing country parties, 2014

- ✓ MRV of GHG emissions refers to estimating, reporting, and verifying actual emissions over a defined period of time. This type of MRV can be performed at national level, or by organizations and facilities. For example, national GHG inventories include an account of emissions from a country for a particular period, are reported to the UNFCCC, and undergo some form of review.

- ✓ MRV of mitigation actions involves assessing (ex-ante or ex-post) GHG emission reductions and/or sustainable development (non-GHG) effects of policies, projects, and actions, as well as monitoring their implementation progress. It also involves assessing progress towards mitigation goals. An example would be a national government estimating the GHG and job growth-related impacts of its home insulation subsidy programme. While MRV of GHG

emissions measures actual emissions, MRV of mitigation actions estimates the change in emissions and other non-GHG variables that results from those actions.

- ✓ MRV of support focuses on monitoring the provision and receipt of financial flows, technical knowledge, and capacity building, and evaluating the results and impact of support. An example of this kind of MRV would be developing countries tracking climate-specific finance received through bilateral or multi-lateral channels.

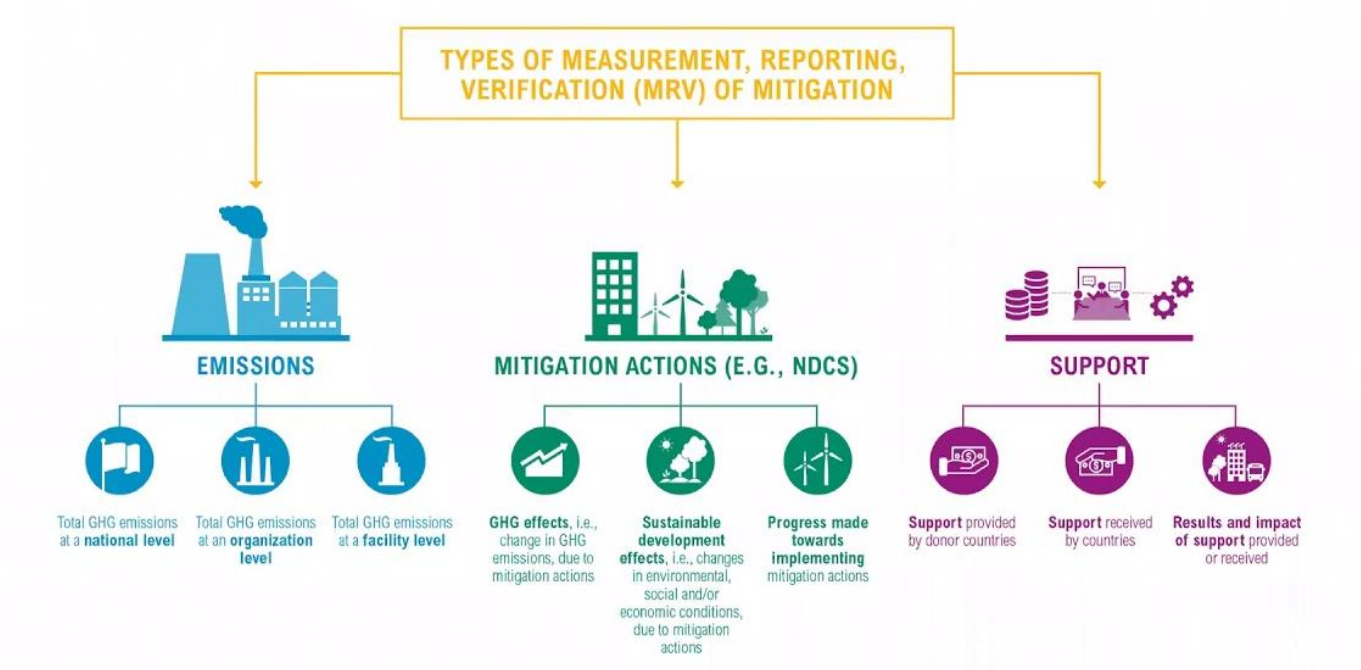

Figure 3: Various Types of Mitigation-related MRV. Source: MRV 101: Understanding measurement, reporting, and verification of climate change mitigation by WRI, 2016

1.4. Scope

The scope of this study is reviewing the guidance material and methodologies developed under the ICAT Pillar 1 relevant to the selected policy (Use of reverse auctioning for grid connected solar power generation) in the power sector of Cambodia.

1.5. Methodology

In order to support achieving its emission reduction targets, the RGC expects to establish an internationally recognized Measuring, Reporting, and Verification System (MRV System) in order to assess the effectiveness of their mitigation activities.

The proposed MRV system would focus on the effects of a selected policy for renewable energy development. As per the requirement of the country, the ICAT Renewable Energy Methodology (ICAT, 2019) will be used to measure the GHG effects of identified renewable energy policies.

The renewable energy policy to be assessed was identified based on the discussion with the national experts.

Subsequently, the applicability of the ICAT methodology to the selected policy has been discussed in order to demonstrate how the methodology can be applied to assess the impacts of the policy on GHG mitigation.

1.6. Limitations

1.6.1. Selection of a Policy

The ICAT guidance for Renewable Energy (RE) consists of several steps, though at policy level, the impact of a policy on the reduction of GHG emissions has been developed only for three kind of policies - namely, Feed-in tariff, Auction/Tender, and Tax incentives.

Cambodia has experienced a variety of RE policies, but currently Cambodia does not appear to have a specific policy exclusively intended for renewable energy development. Therefore, RE auction policy, which has been adopted for the upcoming ADB supported 100 MW solar park, has been selected after consulting the relevant stakeholders in order to estimate impact on renewable energy development and GHG emissions.

However, this policy is currently being used only for a single solar park (ADB financed 100MW solar park) on pilot basis. Therefore, data on the policy is limited.

1.6.2. Selection of Base Year

Selection of the base year is a vital factor in the design of a MRV system.

Cambodia has developed the first set of NDCs based on the Second National Communication though the base year for the NDCs was not specifically mentioned there. However, year 2016 appears to have been considered as base year in Cambodian first Biennial Update Report (BUR). The same base year has been opted by the relevant national stakeholders. Based on these circumstance, 2016 has been considered as base year for this assessment. As Cambodia is in the process of revising its NDCs, it is also recommended prudent that revised NDCs may refer the same base year.

1.6.3. Targets for different Renewable Energy Technologies

The energy industry has a target to reduce the GHG emissions by 1,800 tCO_2e (16%) by 2030 using Solar energy, hydropower, biomass and biogas compared to the baseline emissions in accordance with the NDCs. However, specific emission reduction targets are not set for different renewable energy technologies.

1.7. Status of the Energy Sector

The main primary energy source in Cambodia is biomass. However, the demand for electricity has been rising rapidly as indicated by figure 4.

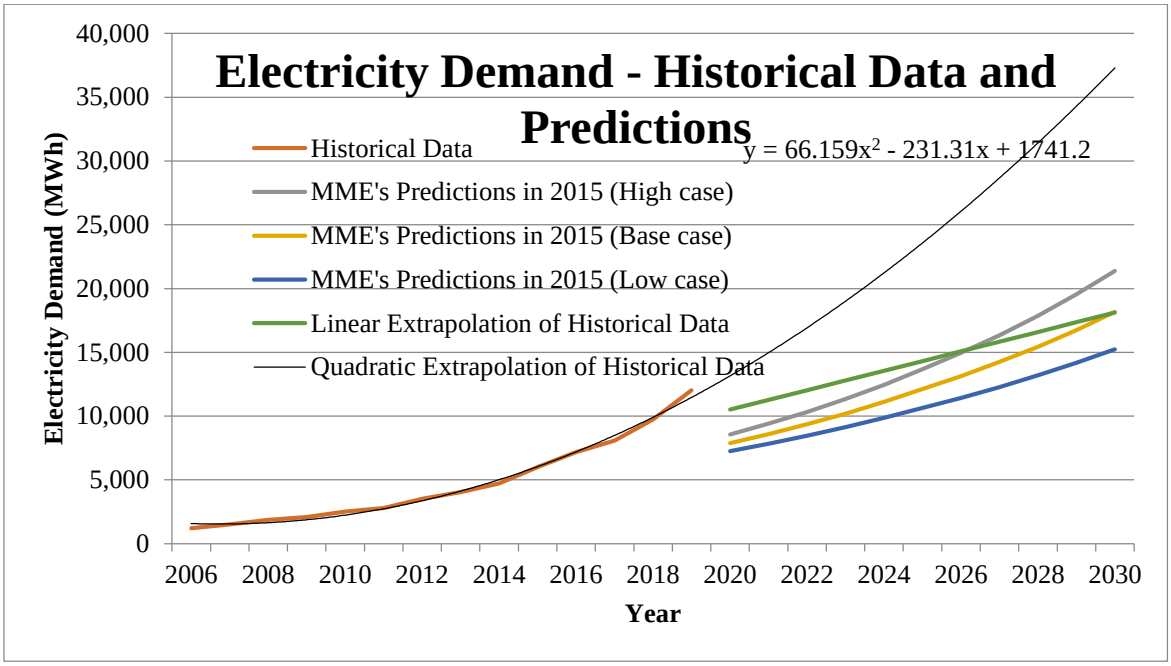

Figure 4: Historical Data and projections on Electricity Demand[3]

Source: Historical Data (2006 to 2019) – EIA; Predicted demand (2020 -2030) - MME (2015)

Some of the electricity demand is met through imports from neighboring countries but there is a decreasing trend in the imports. Further, it was observed that Cambodia has given preference to developing hydro power after an initial phase where thermal energy was the predominant source of electricity generation. However, to diversify energy sources and to overcome the issue of low hydro power generation during dry period, Cambodia is also promoting the grid connected solar power development.

Sources of electricity generation in Cambodia in the recent years are shown in table 4.

[3] Please refer Annex 2 for original data set

Table 4: Electricity Generation by Source

Power Sources	2017			2018			2019 (Estimated Plan)		
	MW	MWh	%	MW	MWh	%	MW	MWh	%
	Domestic Generation								
Coal	538	3,569	23%	538	3,211	20%	660	3,390	23%
Hydro Power	980	2,711	42%	1,330	4,511	50%	1,330	4,626	46%
Fuel Oil	272	259	12%	272	180	10%	272	425	9%
Renewable Energy	65	56	3%	65	42	2%	164	73	6%
by Industries & Licensees	25	38	1%	3	9	0%	3	8	0%
Total Domestic Generation	1,880	6,634	81%	2,208	7,954	83%	2,428	8,522	85%
	Import Power Sources								
Thailand	136	291	6%	136	263	5%	136	665	5%
Vietnam	277	1,095	12%	277	1,027	10%	277	1,549	10%
Laos	30	54	1%	30	64	1%	30	72	1%
Total Import	443	1,439	19%	443	1,354	17%	443	2,286	15%
Total Power Sources	**2,322**	**8,073**	**100%**	**2,650**	**9,307**	**100%**	**2,871**	**10,808**	**100%**
Annual Increase				328	1,235	14%	220	1,500	8%

Source: (The General Department of Energy of the MME, 2019), Note: The numbers were rounded off.

1.7.1. Energy Sector Development Policies and Strategies

Several national policies and strategies have encouraged the renewable energy deployment in the country. Energy Sector Development Policy in 1994, Rural Electrification by Renewable Energy Policy (REREP) in 2006, National Policies and Strategies on Green Growth in 2009, and National Energy efficiency Policy in 2018 are the most prominent policies (and strategies) that are promoting the renewable energy in the country while the Law on Electricity in 2001 & National Strategic Development Plan in 2019 also provide the necessary basis to develop MRV framework focusing on power sector.

The publication "Review of Cambodia's Key National Policies and Strategies & Current Status of National Climate MRV and M & E Activities and Initiatives" (MME &GSSD, 2019) under this ICAT project provides a detailed analysis of the national policies and strategies. A summary of the same is attached as Annex 3.

1.7.2. National Solar Programme

Under national solar programme, the EDC expects to increase the installed capacity of solar power to 340 MW during the period 2020-2022 (EDC, 2019), while the RGC plans to generate 130 MWh from utility-scale PV by 2020 (UNDP, 2019).

Cambodia commissioned first national solar park with installed capacity of 10 MW at Svay Rieng Province in 2017. Another solar park is being constructed in Kampong Chhnang (100 MW). Reverse auction policy has been applied only for the phase one (60 MW) of the above 100MW National Solar Power Park project, which is supported by the ADB.

List of grid connected solar power plants in Cambodia has been attached as Annex 4.

1.7.3. Existing Institutional Framework for Energy Development and Management

The Ministry of Mines and Energy (MME) is the key decision maker related to the energy sector activities. The MME is the authority for the formulation of policies and guidelines in the energy sector.

The Electricity Authority of Cambodia (EAC) functions as the regulator safeguarding the rights of the consumers in the energy industry. It is responsible for licensing and regulating the actors in the energy industry.

The Electricite Du Cambodge (EDC) is a state-owned utility carrying out the functions of generation, transmission, and distribution of electricity. It purchases electricity from the Independent Power Producers (IPPs) and sells electricity to the Rural Electricity Enterprises (REEs) as well.

The IPPs and REEs are privately owned, while all other organizations in the industry are government entities.

Further information on the existing institutional arrangements at national and sub-national levels in the energy sector has been attached as Annex 5.

2. Prioritizing Renewable Energy sub-sector and policy

2.1. Prioritizing a renewable energy sub-sector

Cambodia benefits from consistent sunshine year around as a country which is border lined to equator. This geographical position of the country provides high solar power potential with an average solar potential of 5 kWh/m^2/day and an average sunshine of 6-9 hours per day. The solar

power potential in Cambodia has been discussed in the other publication (MME & GSSD, 2019) under this ICAT project.

It is to be noted that the RGC encouraged solar power production through the programme of the Rural Area Electrification Fund created in 2004. Further the RGC is planning to increase its investments in solar energy by 12% by 2020, and by 20% over the next three years.

Recent studies by the WWF have also recommended development of grid connected solar power in order to achieve improved energy security through the diversification of energy sources. Main advantages of solar power for Cambodia are:

- Abundant solar irradiance as the country is located close to the equator; and
- Availability of solar power is improved during the dry seasons when hydro generation is reduced.

Further, the Cambodian national grid has the ability to absorb a reasonably high amount of solar power given the fact that: 1) 50% of the installed capacity in the year 2018 is from hydro power; and 2) Cambodian grid is connected with the electricity grids of three neighboring countries, which also have flexibility to absorb variable power due to hydropower in their grids.

From the above discussions, it can be summarized that solar power development appears to be a priority in the country. Moreover, Cambodia expects to reduce 1,800 $GgCO_2e$ (16%) of GHG emissions compared to baseline emissions from Energy Industry by 2030 as per the NDCs. Solar power can contribute effectively to this target.

Considering all the above points, desk review, a series of stakeholder consultations, and feedback from the government including the MME & GSSD (2010), grid connected solar PV has been selected as the prioritized sub-sector for development of the MRV framework in this assignment.

2.2. Mapping Renewable Energy Policies relevant to grid connected solar power plants

Following table summarizes the available policies in Cambodia which have a bearing on the development of renewable energy resources.

Table 5: Summary of RE policies in Cambodia[4]

Policy	Source	Year	Action
Feed-in tariff policy	Draft Environment and Natural Resources Code (Environmental Code)	2020	One-year pilot for a feed-in-tariff system, in which the government offers a fixed rate for solar energy fed into the grid.
Tax incentive	Draft Environment and Natural Resources Code (Environmental Code)	2020	Businesses, which use sustainable energy sources, shall be eligible for: a. 10% reduction to the income tax rate for 5 years since they started reporting profits; and b. 20% reduction to the income tax rate.
Reverse auction	News Release from ADB Country Office	2019[5]	Reverse auction was used by the EDC for first phase of 60 MW and received the lowest bid for solar power (First phase of 100 MW National Solar Park).
Tax incentive	Master Plan Study on Rural Electrification by Renewable Energy in Kingdom of Cambodia	2006 & 2009-2020	The tax exemption on the imports of RE equipment (15% of custom tax and 10% of VAT). Tax exemption on imports of RE equipment is estimated to be $13 million from 2009 to 2020.

[4] This consists of RE policies, which are valid and applicable in Cambodia after 2010 (base year for NDCs).

[5] PPA is valid for 25 years

2.3. Selecting a RE Policy

The aim of this subsection is to select a solar energy policy listed in subsection 2.2. to develop a MRV system. The authenticity of the source material of the policy, determinateness of the policy and progressiveness or recentness of the policy are the traits considered during the discussion with national experts when selecting a RE policy.

As already discussed in section 2.1, solar power is being developed using reverse auction policy in the ADB funded 100MW solar park. Cambodian national team considered "Reverse Auctioning Policy" for the solar power development as the most appropriate RE policy for development of MRV framework under this ICAT project. Therefore, auction policy for development of Renewable energy, for which the ICAT guidance is available, has been selected for development of MRV framework in this assignment.

2.4. Reverse Auction Policy in Cambodia

A reverse auction policy is a type of auction where sellers who meet minimum eligibility criteria submit non-negotiable price bids and the buyer then picks up the lowest bid as the starting price for the next round of bidding. Bidders then compete to provide their lowest bids. Bid decrement can be announced before start of reverse auction. The objective of the reverse auction is to obtain the maximum benefit in cost saving through competitive bidding.

At the moment in Cambodia, reverse auction policy has been enforced on pilot basis for phase one (60 MW) of the ADB funded 100 MW solar park. As the EDC has received the lowest tariff through this process, it can be reasonably expected to be continued. As the project is financed by the ADB, their guidelines on monitoring and reporting the progress of the project would be followed. Therefore, collection of data required for the MRV system will be convenient. The power purchase agreement has a validity period of 25 years. Therefore, generation and other relevant data would be collected and stored for calculating payments. That data and any additional information could be used for the MRV system as well.

The reverse auction policy has higher viability to be continued as it allows to get the lowest possible tariff through competitive process for solar power production with the guaranteed long term contract.

Solar power potential under reverse auction policy for the future (upto 2030) can be determined using one of the following options.

Assumption

'The proposed option is based on the assumption that the power producres of all future solar power projects (until 2030) will be selected based on the reverse auction policy.'

Proposed option: The total solar/wind capacity expected by 2030 (305 MW) under Power Generation Development Plan was considered when determining the solar potential for remaining 10 years. Since Cambodia has already installed 94.3 MW solar power as of 2019 (EAC, 2019) and 100 MW solar power has been committed under reverse auction policy to be implemented from 2019 to 2020, remaining solar power addition will be 110.7 MW from 2021 to 2030. As such, expected annual solar power capacity addition from 2021 is 110.7 MW.

Table 6:Solar power capacity allocation for future according to the option 2

2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Total over assessment period
100 MW project will be completed in 2020		11.07 MW	11.07 MW	11.07 MW	11.07 MW	11.07 MW	11.07 MW	11.07 MW	11.07 MW	11.07 MW	11.07 MW	210.07 MW

The proposed option has been agreed with the power generation plan in the country.

Based on above facts and the preference, reverse auction policy for grid connected solar power was selected as prioritized RE policy. As such, envisioned application of the ICAT RE guidance will be explained for reverse auction policy for grid connected solar power under chapter 2, while same policy will be used to develop national RE MRV system in Cambodia.

(Reverse auction policy has been enforced for phase one (60 MW) of the 100 MW. Hence, GHG effects of 60 MW can be measured using ex-post method provided that the relevant data are available. However, ex-ante assessment of GHG effects will be conducted for expected toal solar power capacity of 210.7 MW, which includes 60 MW as well).

3. Envisioned Application of ICAT RE Methodology

3.1. Scope of Applicability

The Scope of Applicability under the ICAT RE Methodology

The ICAT RE Guidance focuses on estimating the GHG impacts of three categories of policies. Feed-in tariff policies (including feed-in premiums), auction policies (including tender policies), and tax incentive policies. The methodology is applicable for policies at any level of government (national, subnational, municipal), at any stage (planned, adopted, and implemented) and that are new policies or actions, or extensions, modifications or eliminations of existing policies or actions. Furthermore, the methodology focuses on policies that target RE deployment, while the other types of instruments and actions are only discussed peripherally.

The Scope of Applicability for the ICAT RE methodology to reverse auction policy

Solar power generation is currently one of the most preferable RE technology in Cambodia in the context of GHG reduction as per the outcome of chapters 1 and 2 of this report. Taking into consideration that the reverse auction policy is implemented for the initial phase of 60 MW solar power plants, same was selected as the RE policy for investigating the GHG mitigation potential.

The selected policy is an auction policy which has been adopted by the EDC in 2019 for the phase one (60 MW grid connected solar power project) of the ADB assisted National Solar Park Project of 100 MW. This project is also listed under the Power Development Plan (2020 – 2030) of the Ministry of Mines and Energy, Cambodia.

3.2. Causal Chain for reverse auction Policy

The Causal Chain of the ICAT RE Methodology

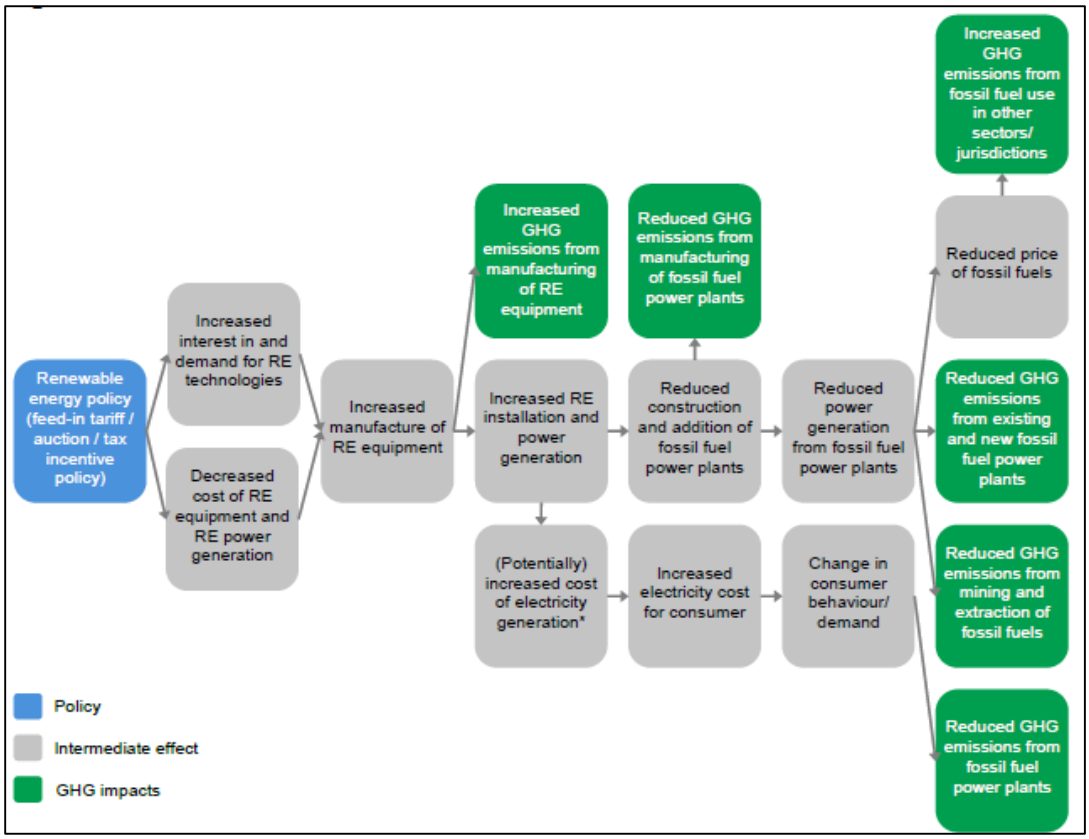

Figure 5: Causal Chain for Renewable Energy Policies, Source: ICAT RE Guidance, 2019

The Figure 5 demonstrates causal chain for a typical renewable energy policy. Then, Figure 6 demonstrates causal chain for reverse auctioning policy for solar PV.

Identifying the Causal Chain of reverse auction policy

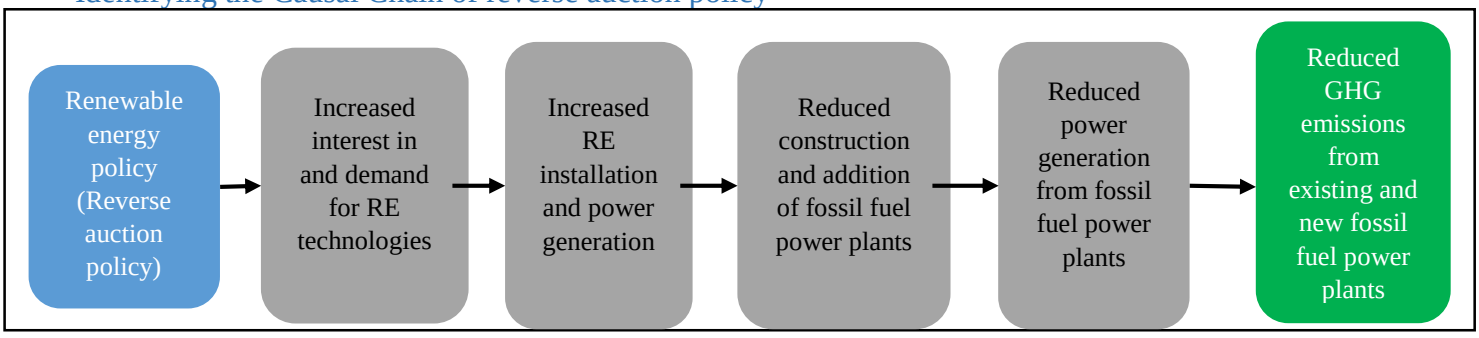

Figure 6: Causal Chain for Reverse Auction Policy for Solar Power, Source: ClimateSI, 2020[6]

[6] Developed based on ICAT RE guidance

The reverse auction policy would offer better transparency and competitiveness to bidders and attract more private sector investment into the RE industry. The healthy completion will keep the prices low and more responsive to the market trend of decreasing cost of solar PV equipment.

This would result in a lower tariff to the end consumers and increase the demand for electricity.

In this project, the EDC provides the land and access to the transmission network for the developers. Further, the long-term power purchase agreement with the EDC provides assurance to the developers on the long term stability of their projects.

All the above factors would increase the interest in the development or renewable energy sources. As more investors turn to green energy, the demand for fossil fuel generated electricity would decrease. That would result in a lower dispatch of existing fossil fuel based power plants and suppress the addition or new fossil fuel based power plants too.

Therefore, the reverse auction policy will encourage GHG emission reductions from existing and new fossil fuel power plants in Cambodia.

3.3. Defining the GHG Assessment Boundary

Assessment boundary described under the ICAT RE Methodology

The following list of impacts and source categories are referred by the ICAT methodology. Each of them should be included or excluded from assessment boundary according to the selected policy.

1. Reduced GHG emissions from existing and new fossil fuel power plants
2. Reduced emissions from mining for fossil fuels
3. Increased emissions from the manufacturing of RE equipment
4. Reduced emissions from construction of fossil fuel power plants
5. Possible leakage emissions to other jurisdictions
6. Reduced emissions from lower energy use due to increased cost of electricity
7. For geothermal power plants, fugitive emissions of CH_4 and CO_2
8. For hydro power plants, emissions of CH_4 and CO_2 from water reservoirs
9. For biomass power plants, emissions associated with agriculture and land-use change

Identifying the assessment boundary for the reverse auction policy

The Phase 1 of 100 MW ADB National Park Project (60 MW grid connected solar power project) is considered as the boundary for the ex-post GHG emissions calculation.

However, the GHG emission reduction for 2030 will be estimated including the expected future solar power capacity (110.7 MW between 2020 to 2030) along side with 100 MW solar power project. The 210.7MW will be estimated according to the ex-ante method. Hence, the total technical potential of the entire assessment boundary is 210.7 MW.

The amount of electricity that would have been generated using power plants in the business as usual scenario, which consists of fossil fuel fired power plants as well, will be replaced by the capacities of the new grid connected solar power projects . Therefore, only influential GHG impact for the assessment boundary is the reduction of GHG emissions from existing and new fossil fuel power plants as explained in the ICAT RE guidance. According to the ICAT guidance, CO_2 is the only GHG source that is directly affected by the influence of the process.

Even though the GHG impact will be estimated only for this expected 210.7 MW through the existing data from the current 60 MW assignment, the MRV system will be developed with the ability to be applied for any reverse auction policy that will be launched in the future. Hence, several other institutes will be involved when developing the MRV system for reverse auction policy in Cambodia.

3.4. Selecting an approach for reverse auction policy

The ICAT RE methodology provides two approaches to calculate the GHG impact of RE policies Ex-Ante.

1. Trajectory method
2. Grid emission factor method

Table 7: Parameters of Reverse Auction Policy

Reverse auction policy for solar power project

a). Impact on the energy system	The share of grid connected solar generation in Cambodian energy mix is less than 5% (In 2019, it was only 4% as per EAC Annual Reports 2006 - 2018). However, Cambodian grid can accommodate additional variable renewable energy generation without experiencing major challenges given the fact that over half of Cambodian energy generation (56%) is from firm renewable energy (hydro power).
b). Time of the intervention	Power purchase agreement of the project has a validity period of 25 years indicating this project can operate 25 years without any regulatory barrier.
c). Objective of the assessment	Objective of developing the MRV system is to identify the GHG reductions that can be attributed to the implementation of reverse auction policy in order to promote grid connected solar power generation in Cambodia. Finally, the RE MRV system will help monitor whether the reverse auction policy is on track to achieve solar PV targets and GHG reduction in the RE sector of Cambodia or not.

a). Impact on the energy system: Current solar power generation in Cambodia is less than 5%. In the absence of wind power in the energy mix, Cambodian variable renewable energy (VRE) share is solely based on solar power generation. The energy systems of a country have been classified into four phases by the International Energy Agency (IEA) based on the approximate share of VRE generation as follows:

- Less than 5% corresponds to phase 1;
- Between 5% and 10% corresponds to phase 2; and
- Between 10% and 20% corresponds to phase 3 and
- More than 20% corresponds to phase 4 .

With a VRE share less than 5%, Cambodia belongs to phase 1, same as in countries like Indonesia, South Africa and Mexico (Figure 10). Hence, grid emission factor method can be applied for Cambodia.

However, the ICAT RE guidance also indicates that the emission trajectory method can be used for a country with an energy system at any stage. Limitations of the emission trajectory method are its relative complexity and data intensity.

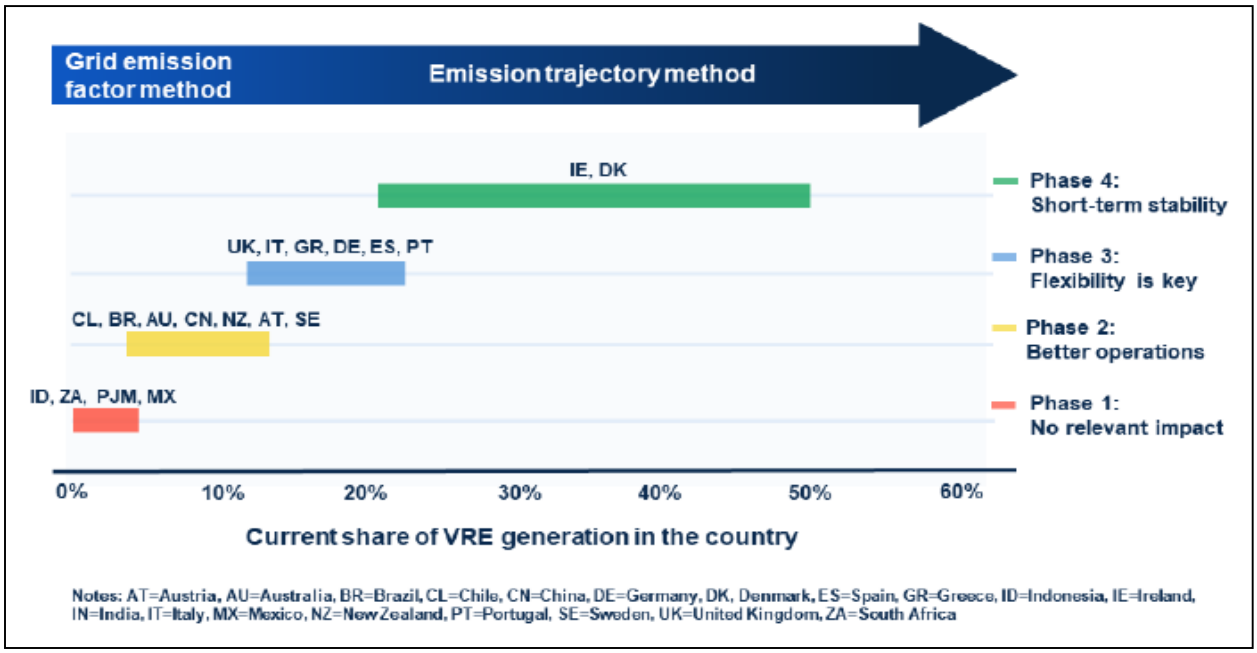

Figure 7*:Correlation between current energy share and phases of RE development*

b). Timeframe of the intervention: Interventions with longer timeframes are likely to have a larger impact. The power purchase agreement of the solar power project is 25 years. Since 100MW solar power project has a long-term contract (more than 15-20 years), it can contribute to a larger impact.

Furthermore, the assessment of GHG effects will be based on the capacity addition of grid connected solar power projects between 2020 to 2030. This will lead to reduction of GHG emissions of Cambodian power sector against the business as usual scenario.

Hence, the emission trajectory method can be used to estimate the GHG impact of reverse auction policy.

c). Objective of the assessment: There are two objectives given by the ICAT RE Guidance for selection of methodological approach. Both objectives need to be achieved in order to develop a

functional MRV system for the selected reverse auction policy in Cambodia. These objectives are:

1. GHG emission level: To determine whether the reverse auction policy is on track to meet NDC and RE targets of the country. The emission trajectory method should be used for meeting this objective.

2. GHG emission reductions: To assess the effectiveness of reverse auction policy and improve the design and implementation while reporting on the progress of implementation. Either the emission trajectory method or grid emission factor method can be used to meet this objective.

The emission trajectory method will be suitable to assess the GHG impacts of the reverse auction policy, as the emission trajectory method can meet both objectives of the ICAT Methodology,

3.5. Availability of data for the baseline parameters

Baseline data is necessary to estimate the emission as per the BAU scenario. As per the selected Emission Trajectory Method, following data is required to assess the GHG impacts of the reverse auction policy:

Table 8: Data availability for baseline parameters on reverse auction policy

Baseline parameters	Data Availability	Period of available data	Source [7]
Total electricity demand for the past years (GWh/year)	Available	Actual: 2006 - 2019	EAC, 2019
		Forecast: 2020 - 2030	MME Revised PDP, 2015
Total population for the past years (millions)	Available	Actual: 2006 - 2019	MoP, 2019, UN DESA, 2017 and MoP, 2013
		Forecast: 2020 - 2030	UN DESA, 2017
	Available	Actual: 2006 - 2019	EAC, 2019

[7] Data provided by local consultants

Growth rate of electricity demand(%)		Forecast: 2020 - 2030	MME Revised PDP, 2015
T & D loss in past years (%)	Available	Actual: 2006 - 2019	EAC Annual Reports 2006 – 2018
		Forecast: 2020 - 2030	MME Revised PDP, 2016
Own use of electricity[8] (%)	Available	Actual: 2006 - 2019	IEA Energy Balance 2016 – 2018, and MME Revised PDP, 2016
		Forecast: 2020 - 2030	MME Revised PDP, 2015
Electricity generation mix for past years (GWh/year) or share (%)	Available	Actual: 2006 - 2019	EAC Annual Reports 2006 – 2018; EAC 2019
		Forecast: 2020 - 2030	MME Revised PDP, 2015& MME, 2019

All the necessary data for baseline parameters of emission trajectory method for auction policy are available. Both actual data (from 2006 to 2019) and forecast data (from 2020 to 2030) necessary for ex-ant calculation of baseline emissions are available.

3.6. Availability of data for the projection of parameters

The following table indicates the availability of data for projection of parameters for emission trajectory method.

Table 9: Data availability for projection of parameters

Projected parameters	Data availability	Period of available data	Source[7]
Account for policy design characteristics			

[8] Own use of electricity is the electricity use by the power plant to maintain their own operations and maintenance

1/ Auction demand and auction design	**Available** (60 MW solar project 0.03877 US$ / kWh)	Reverse auction in 2019	ADB - 100MW National Solar Park Project (Phase 1)
2/ Longevity of the power purchase agreement (PPA)	**Available** (for 60 MW solar power projects = 25 years)		
3/ Qualification requirements	**Some data is available**		
4/ Winner selection process	**Available**		
5/ Sellers' contractual liability requirements	**Pending**		
Account for effect on financial feasibility	**Pending**		
Account for other barriers	**Pending**		
Annual average operation days	**Available** (360 days)		
Average annual capacity factor for the RE technology type (solar, hydro, wind, etc.)	**Available** (Solar: 18 - 20 % Hydro: 31 - 53% Biomass: 55 - 60% Wind: n/a)		

Most of the project data on the 60 MW solar power project are available at present. Some of the available data are needed only for the ex-post GHG impact assessment. Much of the available data are from the ADB 100 MW solar power park project. The balance data are required to be collected. Ex-ante GHG impact of the solar power (210.7 MW) can be estimated using credible assumptions.

3.7. Availability of emission factors

Cambodia has calculated its grid emission factor for the year 2012. Table 11 indicates the build margin, operating margin and combined margin for Cambodia for the year 2012.

Table 10: Emission Factors for Cambodia, 2012

		National Grid	Kampot-Sihnouk grid	Kampong Cham grid
Operating margin (2010 – 2012)		0.2339	0.5907	0.7239
Build margin (2012)		0.5338	0.6942	
Weighted average CM	W_{OM}:W_{BM}=0.75:0.25	0.3089	0.6116	
	W_{OM}:W_{BM}=0.5:0.5	0.3089	0.6425	
	W_{OM}:W_{BM}=0.25:0.75	0.4588	0.6683	
Simplified CM				0.7239

Source: Grid Emission Factors in Cambodia, 2016

Emission factors for coal, natural gas, oil, and other fuel and the annual generation of electricity by different sources can be used to estimate the GHG emissions of baseline scenario in case the grid emission factors are not available for some years. The country has been using the default emission factors of the IPCC (Table 2.2. – Chapter 2: Stationary combustion) for coal, natural gas, oil, and other fuel when estimating GHG impact of the energy sector on the GHG inventory of the Kingdom of Cambodia. Furthermore, the ICAT RE guidance also provides average emission factors for fuel (Table 8.5 in the ICAT Guidance). Table 12 indicates the average emission factors applicable to different regions.

Table 11: Average emission factors (2012 -2016) for the region

	Average emission factor (2012 – 2016) per fuel and region in $MtCO_2/GWh$							
Specific power plant technology	World	Africa	Americas	Asia	Europe	Oceania	OECD Total	Non-OECD Total

Anthracite- fired power plant	0.97	NA	0.93	0.96	1.00	NA	0.84	1.03
Other bituminous coal fired power plant	0.91	1.04	0.91	0.91	0.89	0.88	0.88	0.93
Sub-bituminous coal-fired power plant	0.96	NA	0.95	0.99	1.09	0.94	0.94	1.00
Lignite-fired power plant	1.05	1.35	1.04	1.12	0.98	1.28	1.03	1.11
Natural gas – fired power plant	0.45	0.46	0.42	0.47	0.39	0.50	0.41	0.50
Crude oil-fired power plant	0.88	0.85	1.06	0.87	NA	NA	0.62	0.97

Source: ICAT RE Guidance, 2019

Based on above values, the ICAT methodology has estimated following average values for coal, oil and gas for any region.

Table 12: Average emission factors assumed based on Table 8.5 in the ICAT RE Guidance, 2019

Technology	Coal	Oil	Gas
EF (tCO_2/MWh)	0.97	0.88	0.45

3.8. Monitoring, Reporting, and Verification Frameworks Described in the Methodology

3.8.1. Monitoring

The ICAT methodology describes the monitoring procedure using three steps.

1. Identifying key performance indicators;
2. Creating a monitoring plan; and
3. Monitoring the indicators and parameters over time.

Identifying key performance indicators

Key performance indicators are necessary to track the performance of reverse auction policy over time. Parameters are necessary to estimate ex-post GHG emissions too. In section 3.4 the methodological approach "emission trajectory" was selected to assess the GHG impact of reverse auction policy. According to the selected approach, parameters listed under sections 3.5 and 3.6 are necessary to estimate GHG emissions under ex-ante and ex-post scenarios. Availability of data for the reverse auction policy was also discussed under the sections 3.5 and 3.6. However, some of the indicators necessary to estimate GHG emissions under the project scenario are yet to be collected.

Most of the actual data for the BAU scenario are available at the EAC and the MoP, while most of the forecast data for BAU are available in the revised the PDP of the MME. Project scenario data are collected mainly from the National Solar Park project.

However, the final selection of indicators will depend primarily on the needs of stakeholders and the availability of data.

Creating a monitoring plan and Monitoring the indicators and parameters over time

According to the ICAT methodology, a monitoring plan is a system for obtaining, recording, compiling and analyzing data and information important for tracking performance and estimating GHG impacts.

Monitoring plan for the reverse auction policy will be developed during the assessment period of remaining deliverables (Deliverable 2 and Deliverable 3). Roles and responsibilities of organizations in the process of collecting data, competencies required for collecting data, method of collecting data, frequency of reporting different data, managing the data, quality assurance, and quality control of the data will be presented under the remaining deliverables.

3.8.2. Reporting

The assessment process and the GHG impacts resulting from the reverse auction policy should be reported. Following outline indicated in the ICAT methodology would be followed during the preparation of the final report.

Table 13: Application of reporting outline for the reverse auction policy

Chapter	**Information**	***Description***
Chapter 1: General Information	Title of the policy or action	Reverse auction policy for solar power projects (between 2020 – 2030) based on 100 MW National Solar Power Park
	Type of policy or action	Reverse auction
	Implementing entity or entities	Electricite du Cambodge (EdC)
	Date of implementation	13 Feb – 17 May, 2019 (1st phase of solar power park project)
	Status of the action	Under construction
	Date of completion of auction period (if relevant)	29 Aug 2019 (for first pilot solar farm) However, future potential capacity from 2020 to 2030 also consider alongside the 1st phase of solar park project
	Status of policy	Pilot (New policy)
	Level of the policy	This project is piloted for utility solar scale for a capacity of 100MW.
Chapter 2: Objectives of	Objective	The pilot project is intended to support the construction of solar photovoltaic (PV) power plants in Cambodia, and address the country's need to:

Assessing the GHG Impacts of RE Policies		(i) expand low-cost power generation, (ii) diversify the power generation mix and increase the percentage of clean energy in its generation mix in line with its stated greenhouse gas emissions reductions targets, and (iii) expand the use of competitive tendering and other global best practices in the sector.
Chapter 3: Steps and Assessment Principles	Key stakeholders:	MME, EAC, ADB, private developers
	Opportunities for stakeholders	Competitive bidding process provides a convincing argument to the EDC in promoting transparent auction exercises which will attract private investors to invest more in the renewable energy development in the country.
Chapter 4: Description of Selected RE Policy	Description of specific interventions	This is a reverse auction piloted at Phase 1 (60MW) of the ADB assisted National Solar Park Project of 100MW capacity. Phase 1 has been awarded to an IPP, with support of the ADB's Office of Public–Private Partnership working as a transaction advisor to assist the EDC to design and conduct an open and competitive bidding process. In the project arrangement, the EDC provides the land and transmission access, while the IPP provides power generation capacity based on a long-term power purchase agreement with EDC.
Chapter 5: Identifying Impacts: How RE Policies Reduce GHG Emissions	Outline of sustainable development impacts of the policy or action	It is expected to enhance transparency through reverse auction, and attract more investors to invest in the country. The competition allowed the EDC to select the cheapest tariff while increasing the share of renewable energy in the current generation mix. This is very much in line with the country's SDGs and the national strategic development plan (NSDP)

Chapter 6: Estimating RE Addition of the Policy Ex-Ante	RE addition	The solar energy addition due to the reverse auction policy will be estimated for the assessment period from 2020 to 2030, taking into account the design characteristics of reverse auction policy, factors affecting the economic viability of solar energy technology and barriers.
Chapter 7: Estimating the GHG Impacts of the RE Policy Ex-Ante - methodological approach	Methodological approach for estimating GHG impact	Emission trajectory method using the method for limited data availability
	Ex-ante GHG impact will be estimated for the 210.7 MW as explained in the section 3.4 under assessment boundary.	
Chapter 8: Estimating GHG Impacts Ex-Post – technical potential and methodological approach	Technical potential	60 MW
	Methodological approach for estimating GHG impact	Emission trajectory using the method for limited data availability
Chapter 9: Estimating GHG	All sources of data used to estimate GHG emission	Activity data: Baseline and project activity data are listed under sections 3.5 and 3.6 in this document

Impacts Ex-Post – data availability	reduction due to reverse auction policy	Emission factors: Emission factors that can be used to assess GHG impact of reverse auction policy are discussed under section 3.7 in this document
	Ex-post estimation will also be carried out using same parameters as for ex-ante. However real data of the project will be used to assess the ex-post GHG impact of revers auction policy. 1st phase of the 100MW solar power project had been commissioned in 2019. Hence, GHG impact of 1st phase (60MW) of 100MW solar power project will be estimated in Deliverable 2	
Chapter 10: Monitoring Performance over Time	Key performance indicators and monitoring frequency	According to the ICAT RE guidance, Electricity mix of the country need to be recorded monthly or at least annually Technology specific emissions factors need to be calculated annually. Procedure and frequency of collecting the remaining parameters will be decided after stakeholder consultations.
	Monitoring, reporting and verification procedures	Performance of solar electricity plant will be monitored by the plant owner and data will be sent to EDC for their records. Currently, the plant is under construction.
Additional information to report	Title of establishing legislation, regulations, or other founding documents	ADB's Office of Public-Private Partnership (OPPP) has supported EDC to design and conduct a competitive tender for procurement of 60MW of utility solar power on a pilot basis. No legislation or regulations are established so far as the policy is still at the pilot phase.

4. Next Steps

This assessment concludes that Cambodia has a high potential to develop a MRV system for the reverse auction policy that has been introduced by the EDC with the assistance of the ADB in order to select power purchase tariff for 60 MW grid connected solar power park, which is phase1 of the 100 MW ADB National Solar Park.

Application of the methodology to estimate the GHG impact and the development of a MRV system for reverse auction policy will be completed and finalized after completing the following steps:

- Conduct first stakeholder consultation meeting;
- Prepare and present the MRV framework;
- Prepare and present MRV system (Procedure, Protocol & Institutional Arrangement);
- Conduct the validation workshop; and
- Present the implementation plan.

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ANNEX – 1: Summary of Cambodian NDCs

Information Contained in Cambodian NDC	Mitigation	Target	Unconditional	Reduce GHG emissions by 27% from BAU levels in 2030 in energy, manufacturing, and transportation sectors.
			Conditional	Additional LULUCF contribution of 4.7tCO_2e/ha/year (equivalent to 10.6 MtCO_2eq of additional sequestration compared to BAU).
		Basis of Target	Analytical Basis	• Mitigation potential evaluated based on sectoral reductions and "previous needs analyses, experience from successful projects, pilot projects, feasibility studies, literature reviews, and expert opinion." • BAU projections developed using the LEAP model for the energy sector and COMAP for LULUCF sector.
			Existing Policies	• Rectangular Strategy • National Strategic Development Plan • Cambodia Climate Change Strategic Plan 2014-2023 • Green Growth Policy, Strategic Programme, and Roadmap • National Forest Program (2010-2029) • REDD+ Strategy
			Mitigation Actions	• Mitigation actions include: ✓ 16% reduction in energy emissions (1.8 MtCO_2eq). Includes renewable generation and promoting energy efficiency. ✓ 7% reduction in manufacturing emissions (0.727 MtCO_2eq). Includes renewable energy

				and energy efficiency for factories and brick kilns. ✓ 1% reduction from other sources (0.155 $MtCO_2eq$). Includes energy efficient buildings, cook stoves, and biodigesters. ✓ Increase forest cover to 60% of total land cover through the implementation of the *National Forest Program (2010-2029)* and the Forest Law Enforcement, Governance and Trade program. ✓ 3% reduction in transport emissions (0.39 $MtCO_2eq$.). Includes mass transit and motor vehicle inspections.
	Adaptation	Included in NDC		Yes
		Implementation Strategies		Yes; climate change adaptation mainstreamed in national and subnational planning, including through the National Adaption Plan.
		Priority Sectors		Agriculture; Infrastructure; Forestry; Health; and Coastal Zones.
		Data Quality & Transparency		The NDC includes qualitative actions to incorporate adaptation into Cambodia's priority sectors.
	Participation			The NDC developed under the National Council for Sustainable Development, which has representatives from relevant ministries.
	Financial Assistance			US$1.27 billion for implementation of the NDC activities is required (to 2018).
	Technical Needs Identified in the INDC			• Technical support to develop the MRV and M&E systems. • Technical support for a detailed technology needs assessment.

Information from other sources	GHG Inventories and Reports	• Submitted First National Communication in 2002.
		  • Submitted Second National Communication in 2015
		  • Preparing Third National Communication
		  • Preparing NDC update
		• Latest inventory submitted to the UNFCCC was for 1994, prepared using Tier 1 methodology following IPCC 1996 Guidelines.
		• No BUR submitted to date.

ANNEX – 2: Electricity Demand in Cambodia

Historical Data on Electricity Demand

Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Historical Data (MWh)	1,203	1,517	1,858	2,077	2,515	2,788	3,527	4,051	4,713	5,990	7,175	8,073	9,739	12,015

Source: EAC

Predicted Electricity Demand

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
High Case	8,566	9,406	10,328	11,340	12,452	13,673	14,951	16,349	17,878	19,550	21,378
Base Case	7,881	8,589	9,360	10,200	11,115	12,113	13,135	14,244	15,446	16,749	18,162
Low Case	7,261	7,837	8,458	9,129	9,853	10,634	11,428	12,281	13,197	14,182	15,240

Source: Predictions made by MME in 2015

ANNEX – 3: Energy Sector policies and strategies

Following table summarizes various policies, strategies and other relevant activities in the energy sector.

Law/ Policy/ Plan	Title	Year	Current status	Purpose
Policy	Energy Sector Development Policy	1994	Some targets have been achieved.	• To provide an adequate supply of energy at a reasonable and affordable price throughout Cambodia; • To ensure a reliable, secure electricity supply at prices which facilitate investment in Cambodia and development of the national economy; • To encourage environmentally and socially acceptable development and exploration of energy resources for all sectors of Cambodian economy; • To encourage the efficient use of energy; and • To minimize detrimental environmental effects resulting from energy supply and use.
Law	The Law on Electricity - 2001	2001	Amended in 2015	• To govern and prepare a framework for the electric power supply and services throughout Kingdom of Cambodia
Plan	Renewable Electricity Action Plan (REAP) 2002-2012	2002	Expired	• Introduce and encourage the implementation of the rural electrification policy targeting the rural areas by emphasizing the adoption of the new and existing RE technologies.

	Rural Electrification Fund	2004	Achieved the installation of 929.47 MW hydro power capacity through the fund. (Enforcesd)	• To facilitate the poor households in rural areas to have access to electricity for their houses from grid supply by providing interest free loan to be repaid in instalments, • To facilitate the remote rural household, which is not likely to have access to the electricity network for a long period, to have access to electricity through Solar Home System, • To facilitate the private electricity supplier in rural areas to access fund for investment on expansion of electricity supply network in order to allow all rural households in its license areas to have access to electricity for use, • To facilitate the poor households in rural areas to have access to electricity with low price under the Framework of Strategic Planning for Reduction the Rate and Gap of the tariff for Sale of the Electricity in the Kingdom of Cambodia for the year 2015 to 2020 in Provinces and Cities, and To provide electricity for pumping for agricultural irrigation uses.
Plan	National Strategic Development Plan (NSDP)	2019	Recently updated to NSDP (2019-2023) & Enfoeced	• Operational and guiding tools to achieve the objectives, goals and targets. • Practical document to achieve realistic, specific high priority national targets. (Chapter 6 of this plan has M&E section that cover the energy sector too)

Policy	Rural Electrification by Renewable Energy Policy (REREP) 2006-2020	2006	A Master Plan Study on Rural Electrification by Renewable Energy (RE) in the Kingdom of Cambodia was prepared in 2006 with the support from JICA support. RE targets have also been set up until 2020.	• To increase opportunity for renewable energy technologies through adopting actionable framework. • To increase access to electricity in rural areas nationwide.
Road Map	National Policies and Strategies on Green Growth	2009	The National Green Growth Roadmap (NGGR) was adopted in 2009 (MoE, 2009)	• To green the development sector through creating enabling environment for green investment to grow in Cambodia
Policy & Strategies	National Policies and Strategies on Green Growth	2013	The National Policy of Green Growth and the National Strategic Plan on Green Growth 2013 – 2030 adopted in 2013 (NCGG, 2013)	• To promote national economy with - growth stability, - reduction and prevention of environmental pollution, - safe ecosystem, - poverty reduction, and • To promote: - public health service, - educational quality, - natural resource management,

				- sustainable land use, and water resource management Furthermore, policy encourage energy efficiency improvements, ensure the food safety and promote or glorify the national culture in Cambodia
Policy	National Energy Efficiency Policy (2018 – 2035)	2018	Done	• Reduce energy demand by 20% in 2035 relative to the business as usual scenario (BAUs) • Reduce CO2 emissions of 3 million tons in 2035, or 28.5 cumulative million tons between 2017 and 2035, relative to the BAU scenario • To save energy consumption of 1 million tons of oil equivalent (toe) by 2035 relative to the BAU scenario • To reduce energy intensity of 65% in 2035, relative to 2014

Source: *Review of Cambodia's Key National Policies and Strategies & Current Status of National Climate MRV and M & E Activities and Initiatives, 2019*

ANNEX – 4: List of Grid Connected Solar Power Plants in Cambodia

No	Project	Capacity (MW)	Developer	Status
1	Bavet Solar Farm	10	Joint Venture between Sunseap (Singapore) and SchneiTec (Cambodia) (ADB funded Pilot project)	Operational
2	Kampong Speu Solar power plant	60	joint venture among SchneiTec Group and Chinese investors	Under Construction
3	Kampong Chhnang National Solar Park (BOO Project)	100	Not yet Selected.	Bids called for 60MW
4	225 MW of solar projects in Kampong Speu, Takeo, and Kampong Chhnang provinces.	15	Global Purify Power (GPP)	Approved (December, 2015)

Source: (MME and GSSD, 2019)

ANNEX – 5: Existing National & Sub-national Level Institutional Arrangement in Cambodia

Following tables show the existing institutional arrangements at national and sub-national levels in the energy sector.

National Level Institutional Framework

Institution	Roles and Responsibilities
Ministry of Mines and Energy (MME)	Setting and administering government policies and strategies. Carrying out planning activities in the power sector.
Electricity Authority of Cambodia (EAC)	Regulating and monitoring the electric power sector throughout the country. Issuing licenses and enforcing performance standards to ensure a quality supply and better services to consumers Determining tariffs and charges fair to both consumers and licensees. Dispute resolution related to electric power services.
Electricite Du Cambodge (EDC)	• State owned • Carrying out Generation, transmission and distribution of electricity • Raising capital investments in response to market needs • Bound by license conditions • Implementing its business plan in accordance with national energy policy and national development plan.

Source: *Review of Cambodia's Key National Policies and Strategies & Current Status of National Climate MRV and M & E Activities and Initiatives, 2019*

Sub-national Level Institutional Framework

Institution	Roles and Responsibilities
Independent Power Producers (IPPs)	Privately owned Generation and selling of electricity to EDC Bound by license conditions

Rural Electricity Enterprises (REEs)	Privately-owned Distribution of electricity in rural areas Generation of electricity, mainly using diesel or biomass. Purchasing electricity from EDC in bulk

Source: *Review of Cambodia's Key National Policies and Strategies & Current Status of National Climate MRV and M & E Activities and Initiatives, 2019*