Initiative for Climate Action Transparency - ICAT

PROTOCOL

MRV FOR RENEWABLE ENERGY POLICY

CAMBODIA

Initiative for Climate Action Transparency - ICAT –

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

DELIVERABLE 3.2: PROTOCOL OF THE MRV SYSTEM FOR REVERSE AUCTION POLICY IN CAMBODIA

DISCLAIMER

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General Secretariat of the National Council for Sustainable Development

List of Acronyms

EAC	Electricity Authority of Cambodia
EDC	Electricite du Cambodge
GSSD	General Secretariat of the National Council for Sustainable Development
GHGs	Greenhouse Gases
IPPs	Independent Power Producers
LCOE	Levelized Cost of Electricity
MEF	Ministry of Economy and Finance
MoE	Ministry of Environment
MME	Ministry of Mines and Energy
MoP	Ministry of Planning
MRV	Measurement, Reporting and Verification
NCSD	National Council for Sustainable Development
UNFCCC	United Nations Framework Convention on Climate Change
WACC	Weighted Average Coast of Capital

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1 Monitoring Reporting and Verification Protocol
Promoting Solar Energy through reverse auction policy

Overview

This protocol serves as an overview of the monitoring process, a qualitative assessment of the monitored parameters, the organizational structure and primary responsibilities of the personnel involved in monitoring and QA/QC process.

1.1 Introduction

Reverse auction policy, which is a type of competitive bidding, has been introduced in Cambodia to select project developers of grid connected solar power projects. Introduction of the reverse auction policy can lead to increase the solar power generation and to reduce the construction and addition of fossil fuel power plants. This will cause a reduction of GHG emissions from existing and new fossil fuel power plants.

1.2 Overall monitoring plan

Figure 1 Overall monitoring plan

Source: Author

1.3 Monitoring methodology

ICAT RE guidance, 2019. Guidance can be applied for

- ➢ i) Auction policy ii) Feed-in tariff policy iii) Tax incentive policy
- ➢ At National, subnational and municipal levels
- ➢ During planned, adopted and implementation stage of the policy

Main steps of the methodology
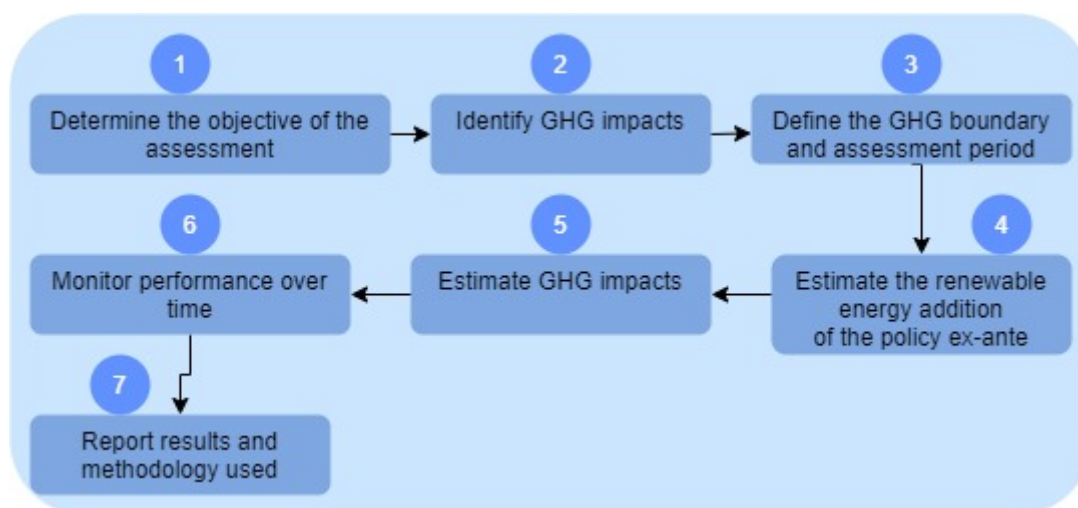
Figure 2 Main steps of methodology,   Source: ICAT, 2020

Step 1 - Determine the objective of the assessment

- • Determine the objectives of the assessment at the beginning of the impact assessment process

Step 2 - Identify GHG impacts

- • Identify all potential GHG impacts of the policy and associated GHG source categories
- • Develop a causal chain
- • Include all significant GHG impacts in the GHG assessment boundary
- • Define the assessment period

Step 3- Define the GHG boundary and assessment period

- The GHG assessment boundary defines the scope of the assessment in terms of the range of GHG impacts.

Step 4- Estimate the renewable energy addition of the policy ex-ante

- Estimate the technical potential for the assessment period of the policy
    - Policy with cap set for entire assessment period
    - Policy without cap set for entire assessment period
    - Policy with cap set for a portion of the assessment period
- Identify policy design characteristics and account for their effect on the technical potential for the assessment period of the policy
    - Identify design characteristics that are likely to influence the RE technical potential in their country context
    - Describe how the identified policy design characteristics are expected to influence RE deployment
    - Estimate the overall influence of these characteristics on the RE technical potential for the assessment period of the policy.
- Identify factors that affect the financial feasibility of RE technologies and account for their effect on the technical potential for the assessment period of the policy
    - Calculate the levelized cost of electricity for different renewable energy technologies
    - Compare the LCOE with financial incentives provided by renewable energy policies
    - Account for other cost considerations in a national context (if relevant)
    - Consider the effect of other policies in the sector (if relevant)
    - Consider the effect of sectoral trends (if relevant)
- Identify other barriers not addressed by the policy and account for their effect on the technical potential for the assessment period of the policy
    - Identify barriers
    - Evaluate severity of barriers
    - Identify policies that may help overcome barriers
    - Determine effect of barriers on technical potential for the assessment period

Step 5- Estimate GHG impacts

- Choose the method for estimating GHG impacts based on the objectives of the assessment, and the policy's expected impact and time frame – Trajectory method is selected

Step 6 - Monitor performance overtime

Step 7 – Report results and methodology used

Table 1 List of equations

Equation 1: Electricity demand per capita	$$EDpCt\left[\frac{kWh}{capita}\right] = \frac{TED_t\left[\frac{kWh}{year}\right]}{Pop_t\left[\frac{capita}{year}\right]}$$
Equation 2: Average growth rate of electricity demand	$$GR_{t2}[\%] = \left[\left(\frac{EDpC_{t2}}{EDpC_{t1}}\right)^{\frac{1}{t2-t1}} - 1\right] * 100$$
Equation 3: Total electricity demand (Min)	$$TED_{2030(min)} = EDpC_{2016}\left[\frac{kWh}{capita}\right] * Pop_{2030}\left[\frac{capita}{year}\right] * \left(\frac{1\ GWh}{10^6 kWh}\right)$$
Equation 4: Electricity demand per capita (Max)	$$EDpC_{2030} = EDpC_{2016} * (1 + GR_{2006-2016})^{(2030-2016)} + 1$$
Equation 5: Total electricity demand (Max)	$$TED_{2030max} = EDpC_{2030} * Pop_{2030}\left[\frac{capita}{year}\right]$$
Equation 6: Total electricity generation	$$TEG_{min2030\ or\ max2030} = \frac{TED_{min2030\ or\ max2030}}{1 - T\&D_{loss}[\%] - OwnUse[\%]}$$
Equation 8: Electricity generation due to the policy	$$EG_{2030} = Assessed\ technical\ potential * Specific\ yield$$
Equation 9: Levelized Cost of Electricity	$$LCOE = \frac{\sum_{t=1}^{n}\frac{I_t + M_t + F_t}{(1+d)^t}}{\sum_{t=1}^{n}\frac{E_t}{(1+d)^t}}$$
Equation 10: Weighted average cost of capital (WACC)	$$WACC = Y_e * W_e + Y_d * (1-T_c)$$
Equation 11: Electricity Generation	$$E_t = Pt*8760+CFt$$

1.3.1 Ex-ante parameters

Table 2 List of parameters required for ex-ante analysis

Parameter	Parameter description
Policy cap	Maximum quantity of installed capacity supported by the policy
N/A	National renewable energy potential[1]
N/A	Renewable Energy resource availability[1]
N/A	Auction demand and auction design
N/A	Longevity of the power purchase agreement (PPA)
N/A	Qualification requirements
N/A	Winner selection process
N/A	Sellers' contractual liability requirements
N/A	Electricity tariff for solar power
N/A	Consumer tariff
LCOE	Levelized Cost of Electricity
I_t	Investment expenditures[2]
M_t	Operational and maintenance costs in year t[2]
F_t	Fuel costs in year t[2]
E_t	Electricity generation in year t[2]
d	Discount rate (or weighted average cost of capital: WACC)[2]
n	Economic lifetime of the system[2]
P_t	Power generation capacity of the system in year t[2]
CF_t	Capacity factor in year t[2]
N/A	Effect of other policies
N/A	Effect of sectoral trends
N/A	Account for barriers
TED_t	Total electricity demand (current)

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[1] Only required if policy cap is not available

[2] Only required if LCOE is not available

N/A – Not applicable

TED$_t$	Total electricity demand (projected)
Pop$_t$	Total population in year t[3]
Pop$_t$	Projected population in year t[3]
T & D $_{loss\ (current)}$	Transmission & distribution loss - current[4]
T & D $_{loss\ (projected)}$	Transmission & distribution loss -projected
N/A	Own electricity use of the plant
N/A	Electricity generation mix
TE_EG	The total emissions from electricity generation by a technology
EG	Electricity generation
N/A	Annual capacity factor
N/A	Annual average operation days
N/A	Number of working hours of the power plant
N/A	Investment in electricity generation technologies
N/A	Status of abundance of natural resources in the country
N/A	Fuel price (historical/projected)
N/A	Subsidy schemes for certain technologies
N/A	Type of System and system changes to accommodate higher shares of VRE

1.3.2 Ex-post parameters

Table 3: List of parameters required for ex-post analysis

Parameter	Parameter description
N/A	Electricity generation mix
N/A	Net electricity supplied to the electricity grid from solar power plant
TE_EG	The total emissions from electricity generation by a technology
N/A	Grid emission factor[5]
EG	Electricity generation
N/A	Installed solar capacity or solar capacity addition

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[3] Only required if projected electricity demand of the country is not available

[4] Only required if projected T&D loss is not available

[5] Only required if TE_EG is not available

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N/A	Investment in electricity generation technologies		
N/A	Status of abundance of natural resources in the country		
N/A	Fuel price (historical/projected)		
N/A	Subsidy schemes for certain technologies		
N/A	Type of system and system changes to accommodate higher shares of VRE		

1.4 Parameter and procedure

Table 4 Parameter and procedure table

Parameter	Parameter description	Applied for	Procedure
Policy cap	Maximum quantity of installed capacity supported by the policy	Estimate technical potential	P3_PRS_MME
N/A	National renewable energy potential[1]		P3_PRS_MME
N/A	Renewable Energy resource availability[1]		P3_PRS_MME
N/A	Auction demand and auction design	Design characteristics	P1_PRS_EDC
N/A	Longevity of the power purchase agreement (PPA)		P1_PRS_EDC
N/A	Qualification requirements		P1_PRS_EDC
N/A	Winner selection process		P1_PRS_EDC
N/A	Sellers' contractual liability requirements		P1_PRS_EDC
N/A	Electricity tariff for solar power	Financial feasibility	P1_PRS_EDC
N/A	Consumer tariff		P2_PRS_EAC
$LCOE$	Levelized Cost of Electricity		P4_PRS_PD_RE
I_t	Investment expenditures[2]		P4_PRS_PD_RE
F_t	Fuel costs in year t[2]		P4_PRS_PD_RE
M_t	Operational and maintenance costs in year[2]		P4_PRS_PD_RE
E_t	Electricity generation[2]		P4_PRS_PD_RE
d	Discount rate (or weighted average cost of capital: WACC)[2]		P4_PRS_PD_RE
n	Economic lifetime of the system[2]		P4_PRS_PD_RE
Pt	Power generation capacity of the system[2]		P4_PRS_PD_RE

CFt	Capacity factor in year t[2]		P4_PRS_PD_RE
N/A	Effects of other policies		P3_PRS_MME
N/A	Effects of sectoral trends		P3_PRS_MME
N/A	Effects of other barriers	Account for barriers	P3_PRS_MME
TED_t	Total electricity demand (projected)		P3_PRS_MME
TED_t	Total electricity demand (current)		P2_PRS_EAC
Pop_t	Total population[3]	Baseline (Ex-ante)	-
Pop_t	Projected population[3]		-
$T \& D_{loss}$	Transmission & distribution loss - current[4]		P2_PRS_EAC
$T \& D_{loss}$	Transmission & distribution loss - projected		P3_PRS_MME
N/A	Own electricity use of the plant		P2_PRS_EAC
N/A	Electricity generation mix	Baseline (Ex-ante), Baseline (Ex-post) & Project (Ex-post)	P2_PRS_EAC
TE_EG	Total emissions from electricity generation of a technology	Baseline (Ex-ante) & Baseline (Ex-post)	P2_PRS_EAC
N/A	Grid emission factor[5]		P2_PRS_EAC
EG	Electricity generation		P2_PRS_EAC
N/A	Annual capacity factor		P2_PRS_EAC
N/A	Annual average operation days	Project (Ex-ante)	P4_PRS_PD_RE
N/A	Number of working hours of the power plant		P4_PRS_PD_RE
N/A	Investment in electricity generation technologies		P3_PRS_MME
N/A	Status of abundance of natural resources in the country	Project (Ex-ante) & Project (Ex-post)	P3_PRS_MME
N/A	Fuel price (historical/projected)		P3_PRS_MME
N/A	Subsidy schemes for certain technologies		P3_PRS_MME
N/A	Type of System and system changes to accommodate higher shares of VRE		P3_PRS_MME

N/A	Net electricity supplied to the electricity grid from solar power plant	Project (Ex-post)	P1_PRS_EDC
N/A	Installed solar capacity (MW) or solar capacity addition		P1_PRS_EDC

1.5 Organization structure and MRV specific responsibilities

Table 5 MRV specific responsibilities of the stakeholders

Parameter	Parameter description	Task	Responsible staff	Procedure
Policy cap	Maximum quantity of installed capacity supported by the policy	Calculate the value and report to the Existing working group at MME	Responsible officer at EDC	P3_PRS_MME
na	National renewable energy potential[1]	Calculate the RE potential of the country and report to existing working group at MME	Responsible officer at MME	P3_PRS_MME
na	Renewable Energy resource availability[1]	Analyze the resource availability and report to the existing working group at MME	Responsible officer at MME	P3_PRS_MME
na	Auction demand and auction design	Collect volume of competitive bidding, design conditions, and details of pre-analysis of the conditions regarding proposed projects and keep records. Report to the existing working group at MME	Responsible officer at EDC	P1_PRS_EDC
na	Longevity of the power purchase agreement (PPA)	Collect , record and report the data to data collection team of the existing working group at MME	Responsible officer at EDC	P1_PRS_EDC
na	Qualification requirements	Gather data regarding eligibility requirement to participate in the auctions	Responsible officer at EDC	P1_PRS_EDC

		such as business experience, financial ability, technical expertise, resources required and report to the existing working group at MME at MME		
na	Winner selection process	Gather data on bidding procedures, minimal requirements for competition, winner selection criteria, clearing mechanism, and payment to the winner. Keep records and report to the existing working group at MME	Responsible officer at EDC	P1_PRS_EDC
na	Sellers' contractual liability requirements	Collect data regarding the liabilities of the seller according to the contract. May collect data such as commitments to contract signing, contract schedule, remuneration profiles & financial risks, nature of liability, and settlement rules, delays, and institutional & regulatory framework. Submit the documented data to the existing working group at MME	Responsible officer at EDC	P1_PRS_EDC
na	Electricity tariff for solar power	Collect data and report to the existing working group at MME	Responsible officer at EDC	P1_PRS_EDC
na	Consumer tariff	Collect data and report to the existing working group at MME	Responsible officer at EAC	P2_PRS_EAC
LCOE	Levelized Cost of Electricity	Calculate the Levelized Cost of Electricity and report to the existing working group at MME	Responsible officers at power plants	P4_PRS_PD_RE

I_t	Investment expenditures[2]	Collect data and submit to the existing working group at MME	Responsible officers at power plants	P4_PRS_PD_RE
F_t	Fuel costs in year t[2]	Collect data and submit to the existing working group at MME	Responsible officers at power plants	P4_PRS_PD_RE
M_t	Operation and maintenance costs in year [2]	Collect data and submit to the existing working group at MME	Responsible officers at power plants	P4_PRS_PD_RE
E_t	Electricity generation[2]	Measure, record and submit to the existing working group at MME	Responsible officers at power plants	P4_PRS_PD_RE
d	Discount rate (or weighted average cost of capital: WACC) [2]	Collect data and submit to the existing working group at MME If discount rate is not available, following data need to be collected capital using Cost of equity (Υ_e), Percentage of financing that is equity (W_e), Cost of debt (Υ_d), Percentage of financing that is debt (W_d), Corporate tax rate (T_c) and submit to the existing working group at MME to calculate the WACC	Responsible officers at power plants	P4_PRS_PD_RE
n	Economic lifetime of the system[2]	Collect data and submit to the existing working group at MME	Responsible officers at power plants	P4_PRS_PD_RE
Pt	Power generation capacity of the system[2]	Collect data and submit to the existing working group at MME	Responsible officers at power plants	P4_PRS_PD_RE
CFt	Capacity factor in year t[2]	Collect data and submit to the existing working group at MME	Responsible officers at power plants	P4_PRS_PD_RE

na	Effect of other policies	Gather data on the policies that can positively or negatively affect on the 'reverse auction policy' (selected policy) to promote the solar energy. May collect data on the available emission tracking programmes, Energy or carbon tax, policies that mandate the closing of inefficient power plants, subsidies given for certain technologies or fuel, other direct or indirect subsidies that affect the power generation technologies, modifications or changes done to the electricity generation system which improve the absorption of variable renewable energy into the system	Responsible officer at MME	P3_PRS_MME
na	Sectoral trends	Collect data related to the electricity generation sector (International/National) to understand the current trends. Submit the reported data to existing working group at MME.	Responsible officer at MME	P3_PRS_MME
na	Other barriers	Collect data on barriers to promote the selected RE technology. Data may be collected on technical barriers, Infrastructure barriers, regulatory and policy uncertainties, institutional and administrative barriers, market barriers, financial	Responsible officer at MME	P3_PRS_MME

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		barriers, public acceptance, awareness, environmental concerns, etc. Identified barriers may be recorded and reported to existing working group at MME at the MME		
$TEDt$	Total electricity demand (Current)	Calculate the value for the respective year and submit to the existing working group at MME	Responsible officer at MME	P3_PRS_MME
$TEDt$	Total electricity demand (projected)	Calculate the value for the respective year and submit to the existing working group at MME	Responsible officer at EAC	P2_PRS_EAC
$Popt$	Total population[3]	Collect the data from NIS and submit to the existing working group at MME at the MME	Responsible officer at the MoP	-
na	Projected population[3]	Extract from published data from a reliable source (UN, DESA etc.)	Data collection team of the existing working group at MME	-
$T \& D_{loss}$	Transmission & distribution loss (current)[4]	Calculate the value for current year and submit to the existing working group at MME	responsible officer at EAC	P2_PRS_EAC
$T \& D_{loss}$	Transmission & distribution loss (projected)	Collect the forecasted T&D loss and submit to the existing working group at MME	responsible officer at MME	P3_PRS_MME
na	Own electricity use of power plants	Collect data and report to the existing working group at MME	Responsible officer at EAC	P2_PRS_EAC
na	Electricity generation mix	Collect/or analyze electricity generation mix and submit to the existing working group at MME	Responsible officer at EAC	P2_PRS_EAC

TE_EG	Total emissions from electricity generation of a technology	Calculate GHG emissions based on electricity generation, fuel type and fuel consumption and submit to existing working group at MME	Responsible officer at EAC	P2_PRS_EAC
N/A	Grid emission factor[5]	Calculate grid emission factor and submit to existing working group at MME	Responsible officer at EAC	P2_PRS_EAC
EG	Electricity generation	Collect data and report to the existing working group at MME	Responsible officer at EAC	P2_PRS_EAC
na	Annual capacity factor	Calculate and submit to the existing working group at MME	Responsible officer at EAC	Responsible officer at EAC
na	Annual average operation days	Collect data and submit to the existing working group at MME	Responsible officers at the power plants	P4_PRS_PD_RE
na	Number of working hours of the power plant	Collect data and submit to the existing working group at MME	Responsible officers at the power plants	P4_PRS_PD_RE
na	Investment in electricity generation technologies	Collect data and submit to the existing working group at MME	Responsible officer at MME	P3_PRS_MME
na	Status of abundance of natural resources in the country	Collect data/analyze and submit to the existing working group at MME	Responsible officer at the MME	P3_PRS_MME
na	Fuel price (historical/projected)	Collect/calculate data and submit to the existing working group at MME	Responsible officer at the MME	P3_PRS_MME
na	Subsidy schemes for certain technologies	Collect data and submit to the existing working group at MME	Responsible officer at the MME	P3_PRS_MME
na	Type of system and system changes to accommodate higher shares of VRE	Collect data and submit to the existing working group at MME	Responsible officer at the MME	P3_PRS_MME
na	Net electricity supplied to the electricity grid from solar power plant	Calculate data and submit to the existing working group at MME	Responsible officers at power plants	P1_PRS_EDC

na	Installed solar capacity (MW) or solar capacity addition	Measure data and submit to the existing working group at MME	Responsible officer at EDC	P1_PRS_EDC

1.6 Proposed data management system
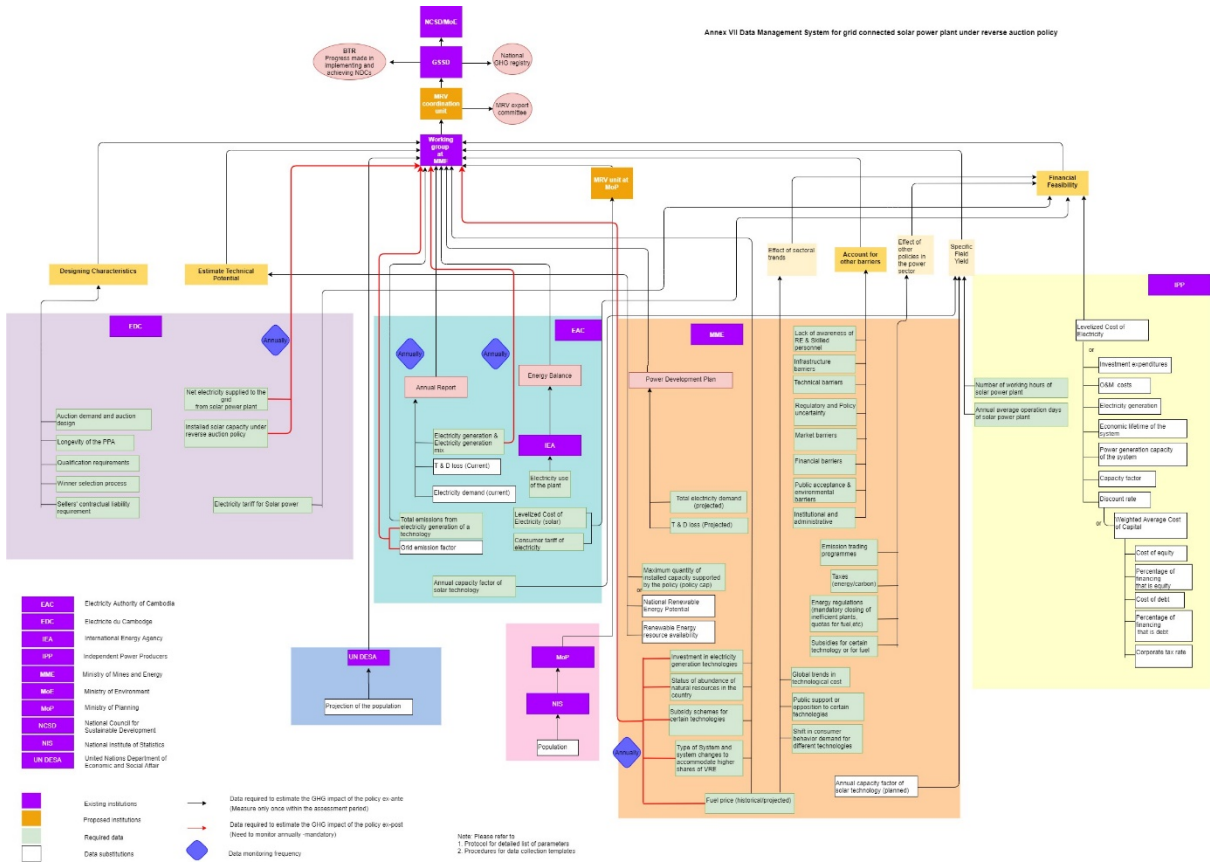
Figure 3: Proposed data management system

Source: Author

1.7 Data requirement

Data/Parameter	Policy cap
Data unit	MW
Description	Maximum quantity of installed capacity supported by the policy
Source of data	Ministry of Mines and Energy
Monitoring frequency	Once in the assessment period
QA/QC procedure	-
Measurement procedure (if any)	-
Any comment	-

Data/Parameter	National renewable energy potential
Data unit	MW
Description	-
Source of data	Ministry of Mines and Energy
Monitoring frequency	Once in the assessment period
QA/QC procedure	Compare with country data available in international databases
Measurement procedure (if any)	-
Any comment	-

Data/Parameter	Renewable Energy resource availability
Data unit	-
Description	Availability hydro, solar, wind, biomass generation potential etc.
Source of data	Ministry of Mines and Energy
Monitoring frequency	Once in the assessment period
QA/QC procedure	Compare with the data available in international databases
Measurement procedure (if any)	-
Any comment	-

Data/Parameter	Auction demand and auction design
Data unit	-
Description	Choice of the volume auctioned, and differentiation between different technologies and project sizes (technology-neutral auctions or technology-specific auctions, and stand-alone or systematic auctioning policies)
Source of data	EDC
Monitoring frequency	Once in the assessment period
QA/QC procedure	-
Measurement procedure (if any)	-
Any comment	-

Data/Parameter	Longevity of the PPA
Data unit	-
Description	PPA signed with the preferred bidder provides power producers with a fixed price for a certain number of years and guaranteed purchase of all the generated energy
Source of data	EDC
Monitoring frequency	Once in the assessment period
QA/QC procedure	-
Measurement procedure (if any)	-
Any comment	-

Data/Parameter	Qualification requirements
Data unit	-
Description	Power producers eligible to participate in the auction and requirements related to reputation, Equipment and production site selection, Securing grid access, Instruments to promote local socioeconomic development
Source of data	EDC
Monitoring frequency	Once in the assessment period
QA/QC procedure	-
Measurement procedure (if any)	-
Any comment	-

Data/Parameter	Winner selection process
Data unit	-
Description	Bidding procedure Minimal requirements for competition Winner selection criteria Clearing mechanism and marginal bids Payment to the auction winner
Source of data	EDC
Monitoring frequency	Once in the assessment period
QA/QC procedure	-
Measurement procedure (if any)	-
Any comment	-

Data/Parameter	Sellers' contractual liability requirements
Data unit	-
Description	Commitments to contract signing Contract schedule Remuneration profile and financial risks Nature of the quantity liabilities Settlement rules and under-performance penalties Delay and under-building penalties
Source of data	EDC
Monitoring frequency	Once in the assessment period
QA/QC procedure	-
Measurement procedure (if any)	-
Any comment	-

Data/Parameter	Consumer tariff
Data unit	USD/kWh
Description	-
Source of data	EAC
Monitoring frequency	Once in the assessment period
QA/QC procedure	Trend check with the past data
Measurement procedure (if any)	-
Any comment	-

Data/Parameter	Electricity tariff for solar power
Data unit	USD/kWh
Description	-
Source of data	EDC
Monitoring frequency	Once in the assessment period
QA/QC procedure	Trend check with the past data
Measurement procedure (if any)	-
Any comment	-

Data/Parameter	Levelized Cost of Electricity
Data unit	USD/kWh
Description	-
Source of data	Project developers
Monitoring frequency	Once in the assessment period
QA/QC procedure	Trend check with the past data
Measurement procedure (if any)	-
Any comment	-

Data/Parameter	It
Data unit	USD[6]
Description	Investment expenditures in year t
Source of data	Financial records of the power plant
Monitoring frequency	Once in the assessment period
QA/QC procedure	Check with the values attributed to similar sized power plants
Measurement procedure (if any)	-
Any comment	-

Data/Parameter	Mt
Data unit	USD
Description	Operational and maintenance costs in year t
Source of data	Financial records of the power plant
Monitoring frequency	Once in the assessment period

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[6] This parameter will be used to calculate the LCOE of an energy project, which is representing the present value of the costs over the lifetime of the project.

QA/QC procedure	Check with the values attributed to similar sized power plants
Measurement procedure (if any)	-
Any comment	

Data/Parameter	Ft
Data unit	USD
Description	Fuel costs in year t
Source of data	Financial records of the power plant
Monitoring frequency	Once in the assessment period
QA/QC procedure	Check with the values attributed to similar sized power plants
Measurement procedure (if any)	-
Any comment	

Data/Parameter	Et
Data unit	kWh
Description	Electricity generation in year t
Source of data	Operation records of the power plant
Monitoring frequency	Once in the assessment period
QA/QC procedure	Check with the values attributed to similar sized power plants
Measurement procedure (if any)	-
Any comment	-

Data/Parameter	d
Data unit	%
Description	Discount rate (or weighted average cost of capital)
Source of data	Financial records of power plants
Monitoring frequency	Once in the assessment period
QA/QC procedure	Check with the values attributed to similar sized power plants
Measurement procedure (if any)	Alternative - Calculate Weighted average cost of capital $$WACC = Y_e * W_e + Y_d * (1-T_c)$$ r_e Cost of equity (expected return on equity) W_e Percentage of financing that is equity r_d Cost of debt W_d Percentage of financing that is debt T_c Corporate tax rate (all are dimensionless parameters are needed to be collected from the power plants)
Any comment	-

Data/Parameter	n
Data unit	Years
Description	Economic lifetime of the system
Source of data	Records of the power plants
Monitoring frequency	Once in the assessment period
QA/QC procedure	Compare with the national/international data sources
Measurement procedure (if any)	-
Any comment	

Data/Parameter	Pt
Data unit	kW
Description	Power generation capacity of the system
Source of data	Records of the power plant
Monitoring frequency	Once in the assessment period
QA/QC procedure	-
Measurement procedure (if any)	-
Any comment	

Data/Parameter	CFt
Data unit	-
Description	Capacity factor in year t
Source of data	Records of the power plants
Monitoring frequency	Once in the assessment period
QA/QC procedure	Compare with national/international values
Measurement procedure (if any)	-
Any comment	-

Data/Parameter	Effect of other policies
Data unit	-
Description	Emissions trading programs -which through GHG emission pricing may provide an additional incentive for RE technologies by increasing the cost of high emission technologies Taxes, such as energy or carbon taxes Energy regulations, such as mandatory closing of inefficient plants and reduction of fuel quotas Subsidies such as fossil fuel subsidies, or direct and indirect electricity subsidies
Source of data	Ministry of Mines and Energy
Monitoring frequency	Once in the assessment period
QA/QC procedure	-
Measurement procedure (if any)	Conduct surveys and interviews, review literature to collect relevant data.
Any comment	Other policies in the sector may affect the financial feasibility of RE technologies. They may also enable or impede the implementation of the policy, and may continue into the future or be discontinued. Therefore, analyze the effects of policies that may interact with the financial feasibility of RE technologies

Data/Parameter	Effect of sectoral trends
Data unit	-
Description	Changes in fossil fuel prices that can cause shifts between fossil fuels (e.g., shift from coal to natural gas due to lower costs of natural gas), or alter the financial feasibility of RE power plants Public support or opposition to certain technologies, such as mini hydro instalment Global trends in technology and costs, whether these relate to RE technologies (e.g. falling costs of solar PV panels) or to fossil fuel-based plants including carbon capture and storage Shifts in consumer behavior, such as increasing demand for renewable electricity
Source of data	Ministry of Mines and Energy
Monitoring frequency	Once in the assessment period

QA/QC procedure	-
Measurement procedure (if any)	
Any comment	Sectoral trends can reinforce or counteract RE policies and the financial feasibility of RE technologies; they may affect electricity tariffs or wholesale market prices. Therefore, relevant sectoral trends need to be considered

Data/Parameter	Account for barriers
Data unit	-
Description	Describe barriers to RE deployment in the geographic area of the policy
	Technical Lack of technical standards (e.g. uniform engineering or technical criteria, methods, processes and practices) for some RE technologies Lack of sufficient technology providers Insufficient transmission and distribution infrastructure to connect new RE capacity to the grid, especially where RE resource potential is highest
	Regulatory and policy uncertainty Insufficient clarity and transparency in existing regulations or in the development of new policies
	Institutional and administrative Lack of strong and dedicated institutions to carry out policies Permits for new RE plants are difficult to obtain, approval procedures are lengthy and cumbersome, or there is a lack of spatial planning for RE Unclear procedures and responsibilities, and/or complex interactions and lack of coordination between the various authorities involved Other barriers in the energy system, such as existing industry, infrastructure and energy market regulation; intellectual property rights; tariffs on international trade; and allocation of government financial support
	Market Inconsistent pricing structures that put renewables at a disadvantage

	Asymmetrical information among market actors
	Market power and subsidies for fossil fuels
	Blockage of incumbent actors and limited access for new actors into the market
	Import tariffs and technical barriers that impede trading in renewables
	Access to market
	Financial or budgetary Absence of adequate funding opportunities and financing products for RE
	Financing unreasonably costly for RE technologies
	Concerns about possible devaluation of asset value
	Disproportionately high transaction costs in relative terms
	Total budget available for policy measures (e.g. for tax incentives, feed-in tariffs)
	Infrastructure Lack of flexibility of the energy system (i.e. of the electricity grid to integrate or absorb RE)
	Energy markets are not prepared for RE (e.g. integration of intermittent energy sources, grid connection and access are not fairly provided)
	Higher grid connection costs for RE

	Lack of awareness of RE and skilled personnel Insufficient knowledge about availability, benefits and performance of RE Insufficient numbers of skilled workers, and lack of training and education Lack of general information and access to data relevant to RE deployment (e.g. deficient data about natural resources) Lack of experience and expertise among the relevant stakeholders, including project sponsors and power producers, investors and financiers, and regulators and authorities
	Public acceptance and environmental concerns Linked to experiences with planning regulations and public acceptance of RE Lack of research into the more complex interactions between RE technologies and the environment Competition with other interests in the geographic area (e.g. fishing, shipping and aviation, recreational use of land, archaeological and historical heritage interests, civil and military airport interests)
Source of data	Ministry of Mines and Energy
Monitoring frequency	Once in the assessment period
QA/QC procedure	-
Measurement procedure (if any)	Consult with national experts and relevant stakeholders from universities, ministries, the private sector, or the public
Any comment	The barrier analysis focuses only on those barriers not directly addressed by the policy being assessed

Data/Parameter	TEDt
Data unit	kWh/year
Description	Total electricity demand (projected)
Source of data	Ministry of Mines and Energy
Monitoring frequency	Once in the assessment period
QA/QC procedure	Compare the value with similar economy countries
Measurement procedure (if any)	-
Any comment	-

Data/Parameter	TEDt
Data unit	kWh/year
Description	Total electricity demand (current)
Source of data	EAC
Monitoring frequency	Once in the assessment period
QA/QC procedure	Trend check with the past data
Measurement procedure (if any)	-
Any comment	-

Data/Parameter	Popt
Data unit	-
Description	Total population (current)
Source of data	Ministry of Planning/ National Institutes of statistics
Monitoring frequency	Once in the assessment period
QA/QC procedure	Trend check with the past data
Measurement procedure (if any)	-
Any comment	-

Data/Parameter	Popt
Data unit	-
Description	Total population (projected)
Source of data	UN DESA or any other reliable data source
Monitoring frequency	Once in the assessment period
QA/QC procedure	Trend check with the available actual data
Measurement procedure (if any)	-
Any comment	-

Data/Parameter	T & D $_{loss\ (Current)}$
Data unit	%
Description	Transmission & distribution loss
Source of data	EAC
Monitoring frequency	Once in the assessment period
QA/QC procedure	Trend check with the past data Compare with the value of similar economy countries
Measurement procedure (if any)	-
Any comment	-

Data/Parameter	T & D $_{loss\ (Forecasted)}$
Data unit	%
Description	Transmission & distribution loss
Source of data	Ministry of Mines and Energy
Monitoring frequency	Once in the assessment period
QA/QC procedure	Trend check with the past data Compare with the value of similar economy countries
Measurement procedure (if any)	-
Any comment	-

Data/Parameter	Own electricity use of the plant
Data unit	%
Description	
Source of data	EAC
Monitoring frequency	Once in the assessment period
QA/QC procedure	Comparison with the sample data of power plants Compare with the internationally available data sources
Measurement procedure (if any)	-
Any comment	-

Data/Parameter	Annual capacity factor
Data unit	%
Description	Annual capacity factor for solar technology
Source of data	EAC
Monitoring frequency	Once in the assessment period
QA/QC procedure	Trend check with the past data
Measurement procedure (if any)	-
Any comment	-

Data/Parameter	**Annual average operational days**
Data unit	days
Description	-
Source of data	Records of the power plants
Monitoring frequency	Once in the assessment period
QA/QC procedure	Trend check with the past data
Measurement procedure (if any)	-
Any comment	-

Data/Parameter	**Number of working hours of the power plant**
Data unit	hours
Description	-
Source of data	Records of the power plants
Monitoring frequency	Once in the assessment period
QA/QC procedure	-
Measurement procedure (if any)	-
Any comment	-

Data requirement (Ex-post)

Data/Parameter	Net electricity supplied to the electricity grid from solar power plant
Data unit	GWh
Description	-
Source of data	EDC
Monitoring frequency	Annually
QA/QC procedure	Trend check with the past data
Measurement procedure (if any)	Calculated as the difference between quantity of electricity exported to the grid and quantity of electricity imported from the grid, as measured by electronic energy meters at the grid delivery point
Any comment	-

Data/Parameter	Installed solar capacity or solar capacity addition
Data unit	MW
Description	-
Source of data	EDC
Monitoring frequency	Annually
QA/QC procedure	-
Measurement procedure (if any)	-
Any comment	-

Data/Parameter	Electricity generation mix
Data unit	%
Description	
Source of data	EAC
Monitoring frequency	Annually
QA/QC procedure	Trend check with the past data
Measurement procedure (if any)	-
Any comment	-

Data/Parameter	TE_EG
Data unit	tCO$_2$
Description	The total emissions from electricity generation of a technology
Source of data	EAC
Monitoring frequency	Annually
QA/QC procedure	Trend check with the past data Compare with the value of similar economy countries
Measurement procedure (if any)	-
Any comment	-

Data/Parameter	N/A
Data unit	tCO$_2$e/MWh
Description	Grid emission factor
Source of data	EAC
Monitoring frequency	Annually
QA/QC procedure	Trend check with the past data Compare with the value of similar economy countries
Measurement procedure (if any)	-
Any comment	-

Data/Parameter	EG
Data unit	MWh/y
Description	Electricity generation
Source of data	EAC
Monitoring frequency	Annually
QA/QC procedure	-
Measurement procedure (if any)	-
Any comment	-

Data/Parameter	Investment in electricity generation technologies
Data unit	USD
Description	Trends in investment costs for different electricity generation technologies
Source of data	Ministry of Mines and Energy
Monitoring frequency	Annually
QA/QC procedure	Trend check with the past data
Measurement procedure (if any)	-
Any comment	-

Data/Parameter	Status of abundance of natural resources in the country
Data unit	-
Description	**Renewable resources** Compare resource map and existing power plant types **Conventional resources** Abundance of fossil fuel resources
Source of data	Ministry of Mines and Energy
Monitoring frequency	Annually
QA/QC procedure	-
Measurement procedure (if any)	-
Any comment	-

Data/Parameter	Fuel price (historical/projected)
Data unit	USD/ton
Description	-
Source of data	Ministry of Mines and Energy
Monitoring frequency	Annually
QA/QC procedure	-
Measurement procedure (if any)	-
Any comment	-

Data/Parameter	Subsidy schemes for certain technologies
Data unit	-
Description	Policies that artificially decrease energy prices or production costs of power generation technologies
Source of data	Ministry of Mines and Energy
Monitoring frequency	Annually
QA/QC procedure	-
Measurement procedure (if any)	-
Any comment	-

Data/Parameter	Type of System and system changes to accommodate higher shares of VRE
Data unit	-
Description	Demand-side management Energy efficiency and demand reduction policies Energy storage T&D infrastructure (Including interconnection) grid codes for VRE Electricity markets **(**Capacity market mechanisms, and market-based measures for energy storage and demand-side management)
Source of data	Ministry of Mines and Energy
Monitoring frequency	Annually
QA/QC procedure	-
Measurement procedure (if any)	-
Any comment	-