Initiative for Climate Action Transparency - ICAT

TRACKING PROGRESS OF NDC IMPLEMENTATION IN VIETNAM:

APPLYING ICAT METHODOLOGIES FOR IMPACT ASSESSMENT OF AN INCENTIVE MECHANISM FOR SOLAR AND WIND POWER DEVELOPMENT

Hanoi, April 2021

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Tracking progress of NDC implementation in Vietnam: Applying ICAT methodologies for impact assessment of an incentive mechanism for Solar and Wind power development.

Deliverable: D2.2E

Date of the deliverable: April 2021

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PUBLISHED BY

- Energy Efficiency and Sustainable Development Department, Ministry of Industry and Trade, Vietnam;
- Center for Ozone Protection and Low-carbon Economy Development/ Department for Climate Change/ Ministry of Natural Resources and Environment, Vietnam;

PREPARED UNDER

Initiative for Climate Action Transparency (ICAT) project supported by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, the Children's Investment Fund Foundation (CIFF), the Italian Ministry of Ecological Transition (IMET) and ClimateWorks.

The ICAT project is managed by the United Nations Office for Project Services (UNOPS)

ACKNOWLEDGEMENT

This report was prepared with technical support from the Climate Change Response Team, and was managed and coordinated by Department of Energy Efficiency and Sustainable Development (EESD) under Ministry of Industry and Trade of the Socialist Republic of Vietnam (MOIT), and the experts of Centre for Ozone Layer Protection and Low-carbon Economy Development, Department of Climate Change under Ministry of Natural Resources and Environment of the Socialist Republic of Vietnam (MONRE), while UNEP DTU Partnership (UDP) and ISPRA provided technical, financial and logistical guidance. We believe that the exercise of using the ICAT methodology for tracking progress of NDC implementation in Vietnam, besides meeting commitments under the invention, has provided us with experience that can be used to undertake similar work in the future.

We would like to take this opportunity to express our gratitude to the UNEP DTU Partnership (UDP) and ISPRA for their financial and technical support. We acknowledge the role of the staff of the Centre for Ozone layer protection and Low-carbon economy Development of Department of Climate Change within MONRE, UNEP DTU Partnership (UDP) and ISPRA in organizing workshops and meetings online, and providing and distributing technical materials, information, and analytical tools to the stakeholders involved in the preparation of the report.

CONTENTS

LIST OF ACRONYMS

GHG	Greenhouse Gas
BAU	Business-as-usual
TPES	Total primary energy supply
EE	Energy Efficiency
EFFECT	Energy Forecasting Framework and Emissions Consensus Tool
GoV	Government of Vietnam
MOIT	Ministry of Industry and Trade
RE	Renewable Energy
SD	Sustainable Development
Solar PV	Solar Photovoltaics
EVN	Vietnam Electricity
WB	World Bank
MONRE	Ministry of Natural Resources and Environment
MOT	Ministry of Transport
NDC	National Determined Contribution
PDPr	Power Development Plan (including r - Revised)
VNEEP	Vietnam National Energy Efficiency Program
MRV	Monitoring, Reporting, and Verification
GoV	Government of Vietnam
RE GENCO	Renewable energy Generation Corporation
ETF	Enhanced Transparency Framework
GSO	General Statistics Office
MPI	Ministry of Planning and Investment
MARD	Ministry of Agriculture and Rural Development
PPA	Power Purchase Agreements

CHAPTER 1. INTRODUCTION

The scope of the assessment is to track progress of Vietnamese NDC implementation in the energy sector using ICAT methodologies (including renewable energy methodology) and tools (including GACMO) applied to renewable energy policies (Solar PV and wind energy policies), following the Enhanced Transparency Framework (ETF) modalities, procedures and guidelines (MPGs) including use of indicators.

The main purpose of the policies to support renewable energy, especially wind and solar power is to promote the investment and development of renewable energy resources in Vietnam to ensure energy security and provide stable energy for national socio-economic development. At the same time, realizing importance of renewable energy, the Prime Minister issued decision to address Vietnam's strategic renewable energy development goals to 2030 and a vision to 2050 (Prime Minister, 2015 and 2016)[1]

Through the project, ICAT seeks to support Vietnam's efforts to establish a domestic Monitoring, Reporting and Verification (MRV) system for tracking progress of NDC implementation in the energy and agriculture sectors in line with the requirements of the ETF of the Paris Agreement.

The present report has six chapters. Chapters 1, 2 and 3 provide information about objectives and activities of the ICAT project, the present status of MRV systems in Vietnam, the NDC update in 2020, and policies as well as targets for RE development in Vietnam. In Chapter 4, assessment will be done for GHG and SD impacts of the solar PV and wind policies by using the ICAT methodologies. Estimating impact ex-ante and ex-post of the policies in Vietnam as well as the results achieved through those activities. It explains the coverage and objectives of the ICAT Series of Guidance which have been applied to deliver some the project outputs. Chapter 5 also proposes MRV's key indicators for tracking implementation progress of RE policies and actions in the NDC. In Chapter 6, references and appendices are provided for more relevant details.

[1] Decision 428 / QD-TTG of the Prime Minister approving the Adjustment of National Electricity Development Planning for the period 2011 - 2020 with a vision to 2030, referred to as Revised Power Planning VII.

CHAPTER 2. VIETNAM'S NDC AND MRV SYSTEM IN VIETNAM

2.1 Vietnam NDCs

2.1.1 GHG inventory

Viet Nam committed to working with the international community to respond to climate change, which is reflected in the range of national policies and specific actions that have been or are being taken to combat climate change. On September 30th, 2015, Viet Nam sent the UNFCCC Secretariat "Viet Nam's Intended Nationally Determined Contribution (INDC)". Viet Nam signed the PA on Climate Change on April 22nd, 2016 and approved the PA on November 3rd, 2016. From that time, Viet Nam's INDC has officially become its NDC. According to Viet Nam's NDC, with domestic resources, by 2030, Viet Nam will reduce GHG emissions by 8% compared to the Business as Usual (BAU) scenario (estimated at 62.65 MtCO_2eq) and this above-mentioned 8% contribution could be increased to 25% (approximately 197.94 MtCO_2eq) if international support is received.

The institutional arrangement for implementing the 2013 National GHG inventory in accordance with the National GHG Inventory System is provided in Decision No. 2359/QD-TTg dated December 22nd, 2015 by the Prime Minister as follows:

- The Department of Climate Change of MONRE is assigned to establish a plan of GHG inventory, to chair and cooperate with related agencies in the National GHG Inventory System and to develop technical reports.

- The Institute of Strategy and Policy on Natural Resources and Environment (ISPONRE) of MONRE is in charge of Quality Control (QC)/Quality Assurance (QA).

- The General Statistics Office (GSO), Ministry of Planning and Investment (MPI), is responsible for compiling data from focal point units at MOT, MOIT, MARD, MOC and Provincies and Cities' People's Committees to provide data for the Department of Climate Change to implement the GHG inventory. Besides, some specific data are collected from other organizations and agencies outside the system.

The National Inventory Report 2013 has been compiled using methods which conform to the international guidelines, namely, the Revised 1996 Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories (hereinafter referred to as the Revised 1996 IPCC Guidelines), the IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (hereinafter referred to as the GPG (2000)) and the IPCC Good Practice Guidance for Land Use, Land-Use Change and Forestry (hereinafter referred to as the GPG-LULUCF).

Results of the 2013 National GHG inventory:

The total 2013 GHG emission in Viet Nam is 259.0 MtCO_2eq with LULUCF sector and 293.3 MtCO_2eq without LULUCF sector.

The results of the 2013 National GHG inventory by gases and shares of emissions by sectors are summed up in **Table 1**, **Figure 1** and **Figure 2**.

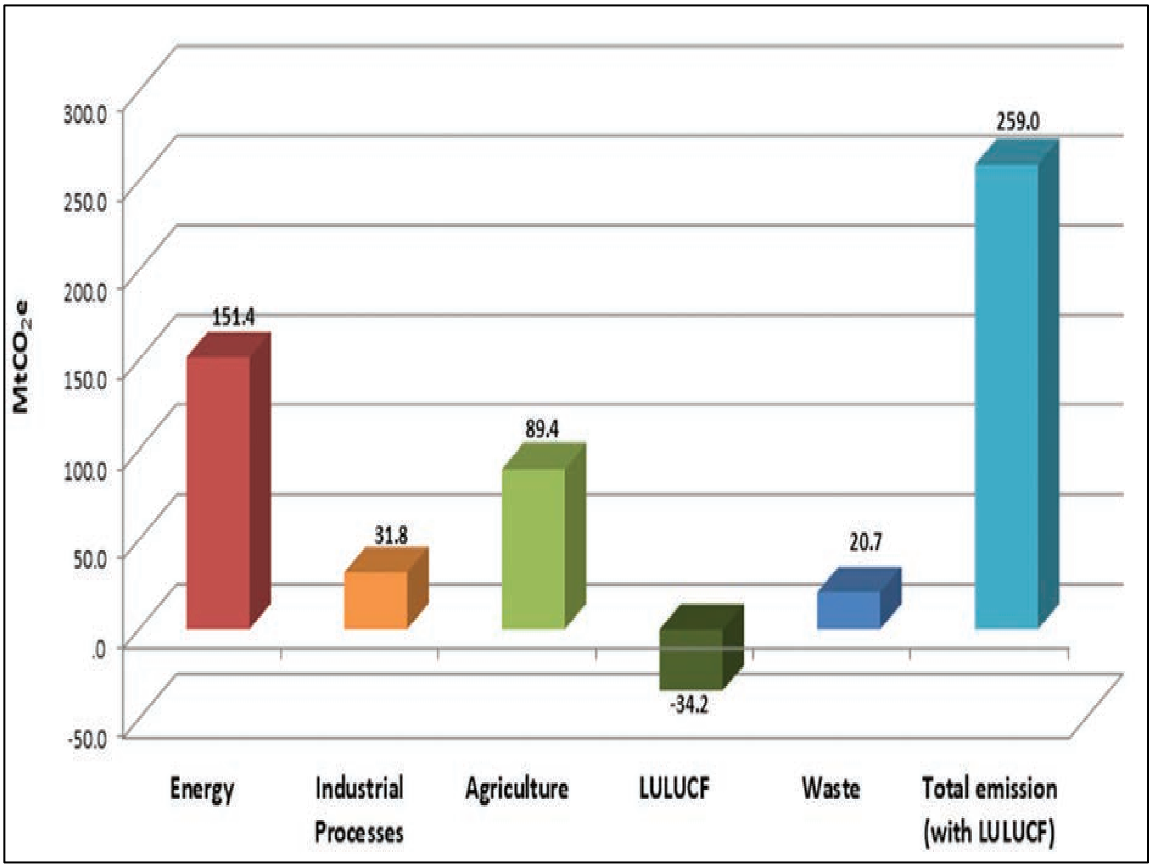
Table 1. The 2013 GHG emissions and removals by gases

Unit: ktCO_{2e}

Sectors	CO_2	CH_4	N_2O	HFCs	Total
Energy	126,914.6	23,397.8	1,090.1		151,402.5
Industrial Processes	29,799.8			1,967.6	31,767.4
Agriculture		59,131.2	30,276.7		89,407.9
LULUCF	- 34,359.5	101.1	18.6		- 34,239.8
Waste	254.9	18,494.4	1,936.9		20,686.2
Total emission (without LULUCF)	156,969.3	101,023.4	33,303.7	1,967.6	293,264.0
Total emission (with LULUCF)	122,609.8	101124.5	33322.3	1967.6	259,024.2

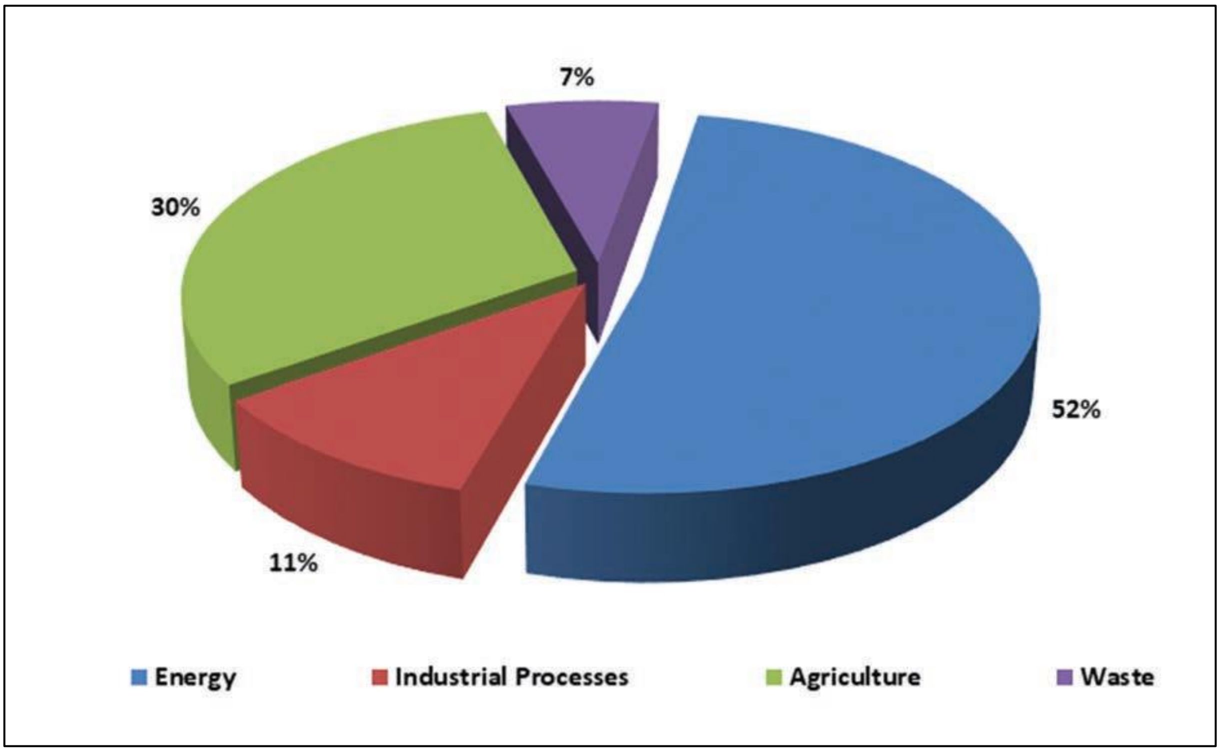
Source: The second biennial update report of Vietnam to the UNFCCC

Figure 1. The 2013 GHG emissions and removals by sectors



Source: The second biennial update report of Vietnam to the UNFCCC

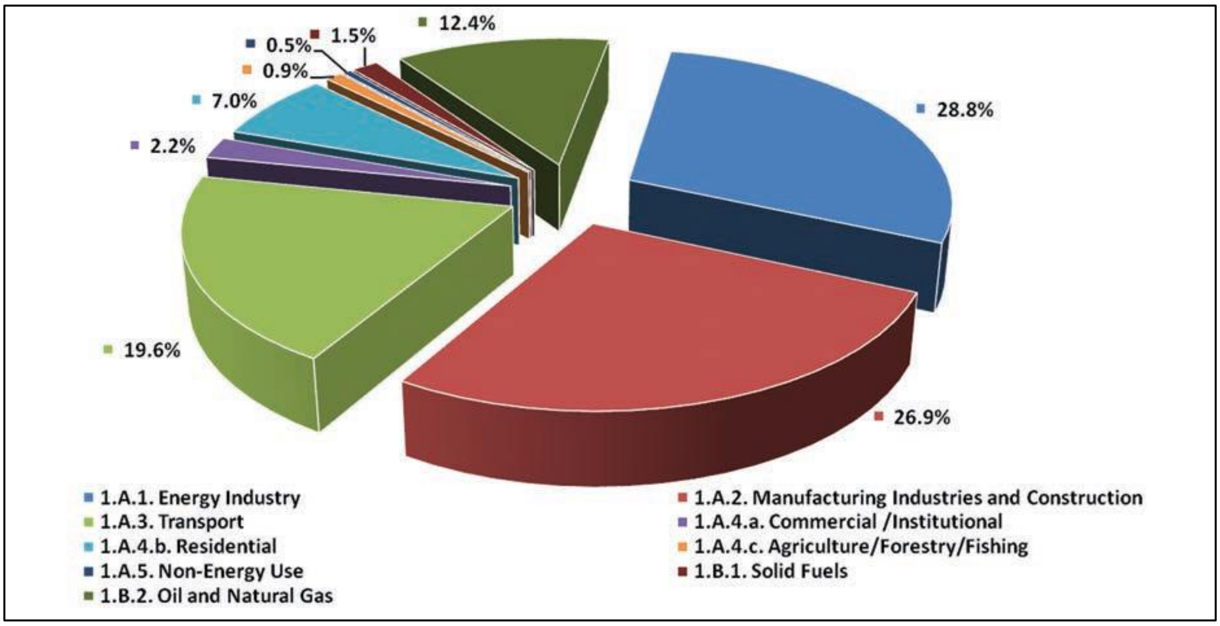
Figure 2. The 2013 GHG shares of emissions by sectors



Source: The second biennial update report of Vietnam to the UNFCCC

The total 2013 GHG emission in Energy sector is151.4 $MtCO_2e$. The shares of emissions among energy sub-sectors in 2013 are presented in **Figure 3**. Emissions from Fuel Combustion and Fugitive emissions are 86.1% and 13.9% respectively.

Figure 3. The 2013 GHG emissions shares of sub-sectors in Energy sector



Source: The second biennial update report of Vietnam to the UNFCCC

2.1.2 Vietnam's NDC update[2]

Vietnam's NDCs update in 2020 has set a target of reducing 9% of total GHG emissions by 2030 compared to BAU by country efforts, equivalent to 83.9 million tons CO_2eq, and the reduction can increase to 27% compared to BAU, equivalent to 250.8 million tons CO_2eq in 2030, when receiving international assistance through bilateral and multilateral cooperation as well as implementation of mechanisms in the new Global Climate Agreement.

To achieve these goals in the Vietnam's NDC update, Vietnam has proposed 79 options to reduce GHG emissions in the five major sectors: Energy, Agriculture, LULUCF, Waste and Industrial processes. In which, there are 39 GHG mitigation measures considered and evaluated in the energy sector, including 29 measures on the energy sector and 10 measures on the power supply, with total potential of GHG emission reduction of 943.1 million tons of CO_2eq in the period 2015-2030.

- For energy demand: there are 06 measures on energy efficiency and renewable energy for the household sector; 10 measures to efficiently use energy in industrial production; 12 energy efficiency measures, alternative transportation mode and switching fuel use to cleaner energy; 01 energy efficiency measure for commercial services.

- For energy supply: there are 02 measures of wind power; 02 measures of solar power; 01 measure of biomass electricity; 02 measures of electricity waste; 01 measure of biogas electricity; 01 small hydroelectric measure; and 01 supercritical coal thermal power measure.

Vietnam has a high potential for renewable energy (RE), including hydro, solar, wind, biomass, and waste. Therefore, the report will analyse in depth policies and the emission mitigation options related to renewable energy in the Vietnam's NDCs report in 2020.

Table 2:Assumptions for mitigation options in the energy sector, RE

Option	Assumption
E22. Small hydropower plants	The capacity of small hydroelectric plants could reach 3,800 MW by 2020; 4,700 MW in 2025 and 5,000 MW in 2030 to replace coal-fired power plants.

[2]https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Viet%20Nam%20First/Viet%20Nam_NDC_2020_Eng.pdf

Option	Assumption
E23. Solar PV power plants	Increase capacity from 4,464 MW in 2019 to 5,000 MW by 2020 (and maintain until 2030) to replace coal-fired power plants.
E24. Wind power plants by national funding	Increase capacity from 304.6 MW in 2019 to 1,010 MW by 2020 (and maintain until 2030) to replace coal-fired power plants.
E31. Biomass power plants	110 MW of biomass thermal power will be installed in 2020, 550 MW and 1,200 MW will be installed in 2025 and 2030 to replace coal-fired power plants.

Source: The Technical report Vietnam's NDC in 2020

2.2 MRV development

The existing and developing policies and regulations have been driving the efforts to provide the institutional framework including roles and responsibilities for the GHG inventory and for the measurement, reporting, and verification (MRV) framework for GHG emissions and emission reductions.

The MRV framework and system will enable tracking and management of GHG emissions from large emission sources and sectors; and tracking the impacts of domestic mitigation actions. The system will also support international reporting of emissions in the national emissions inventory and the national communication to the UNFCCC, tracking progress against NDC targets.

The MRV framework and system for which options are to be identified and analysed under this workstream should enable stakeholders to:

- Estimate GHG emission reductions at sectoral and facility level;
- Making a report on the progress of mitigation action/measure for NDCs implementation in the energy sector;
- Track climate finance flows and co-benefits of mitigation policies and actions;
- Strengthen transparency, accuracy and comparability of the national inventory system;
- Help to fulfil domestic and international reporting requirements in terms of emissions and emissions reductions data from the energy sector.

Vietnam has not yet developed a national MRV and sectoral MRV systems. However, some technical support from development partners have been implemented to support Vietnam in monitoring NDC implementation efforts and reporting required under the UNFCCC and the Paris Agreement. These projects primarily focus on the capacity building and recommendation for setting-up of MRV frameworks for mitigation action.

A key underlying aspect of planning and delivering mitigation activities is to strengthen stakeholder capacity and resources to carry out these activities. Recent projects have therefore focused on these specific elements:

- In the project to Support the Planning and Implementation of NAMAs in a MRV Manner (SPI-NAMA project) funded by JICA, an MRV framework has been proposed at city and sector level. In addition, a city level inventory has been conducted for Ho Chi Minh city and a manual for city-level MRV has been prepared, focusing on the energy, waste and transport sectors.

- Vietnam Partnership for Market Readiness (VN PMR), a World Bank funded-project, is currently implementing a number of projects that also address M&R-related issues in Vietnam. The VN PMR project aims to support the development of market-based - or carbon pricing - instruments and a roadmap for participating in domestic and international carbon markets.

CHAPTER 3. RENEWABLE ENERGY POLICIES FOR NDC IMPLEMENTATION

3.1. Background

3.1.1. Overall

For decades Vietnam has been one of the fastest growing economies in the region and in the world. Since 1990 the average annual growth in GDP has been at more than 6%, with economic growth expected to continue in the future. Economic development has been the key to improvements in the quality of life, and has resulted in a dramatic drop in poverty rate. While economic growth is high priority for the Vietnamese government, the governmental strategies emphasize that the fast development needs to uphold sustainability at the same time.

With its rapid economic growth, Vietnam is becoming an important actor in the global agenda – both from an economic and an environmental perspective. The rapid economic growth results in quick growth of energy demand and greenhouse gas emissions.

However, achieving the reduction of greenhouse gas emissions as agreed under the Paris Agreement depends heavily on the development path of Vietnam and other emerging economies. At the same time, the global energy market has witnessed a remarkable decline in the cost of renewable energy technologies, as well as of battery storage. This gives Vietnam the opportunity to embark on a sustainable development pathway, considering the opportunities for more efficient use of energy and the domestic resource potential for both solar PV and onshore and offshore wind.

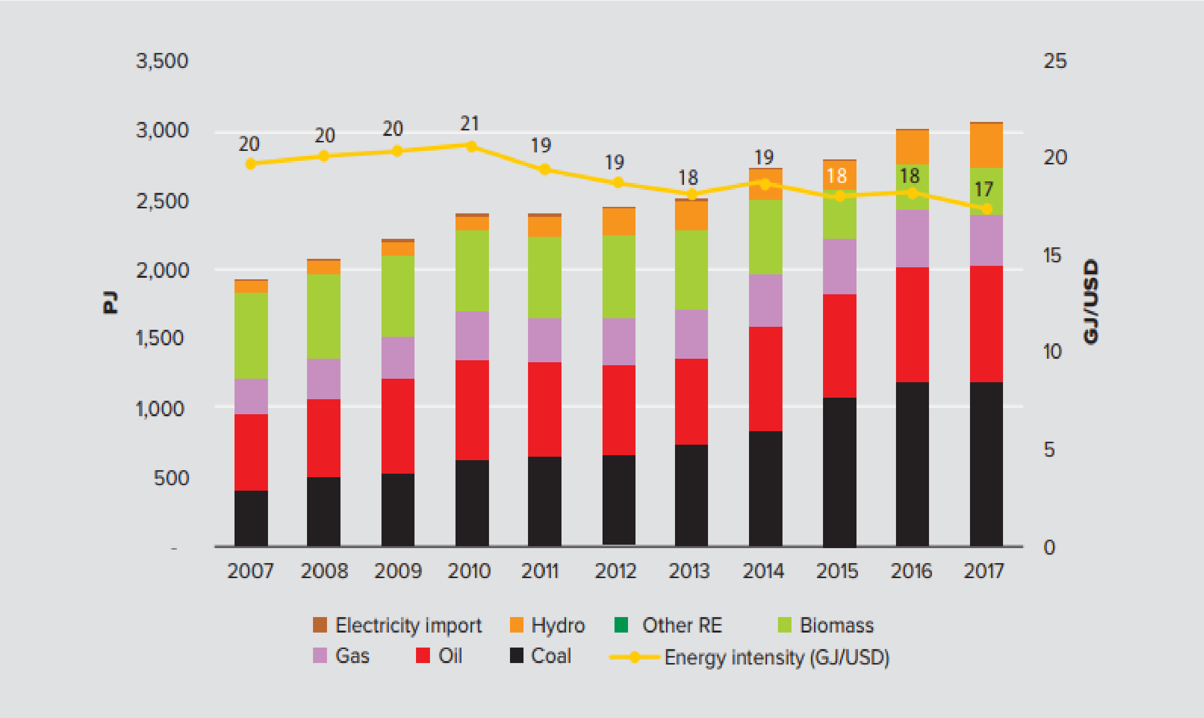
Energy sector development plays a key role in supporting the country's economic growth that requires secure and affordable supply of energy to all of the society and economic sectors. At the same time, to ensure a sustainable growth, the energy sector must be able to attract the capital required to expand the infrastructure and secure the efficient distribution and consumption of energy sources in the long term.

3.1.2. Status of RE in Vietnam

Vietnam has a high potential for RE, including hydro, solar, wind, biomass, and waste. The RE share in the total primary energy supply (TPES) was 37% in 2007. However, this share has been gradually reduced to 22% in 2017.

During the period 2007-2017, Vietnamese TPES grew at 4.7% p.a., thereby increasing from 1,900 PJ in 2007 to 3,000 PJ in 2017. Hydropower experienced the highest growth at 14.5% p.a., followed by coal at 11.3% p.a. The share of coal increased from the third largest fuel source in 2007 to the largest in 2017. Meanwhile, the share of biomass fell from being the largest contributor in 2007 to the third largest in 2017. Oil, growing at the rate of 4.3% per annum, is the second largest fuel source. Solar and wind have historically only contributed to a very small share in TPES. An overview of the historical Vietnamese TPES is presented in **Figure 4**.

Figure 4. Historical Vietnamese TPES from 2007-2017 by fuel type. The relatively stable energy intensity implies a coupling between TPES and GDP. TPES (2007-2014) is based on (IE, 2017). TPES (2015-2017) is based on (GSO, 2019)

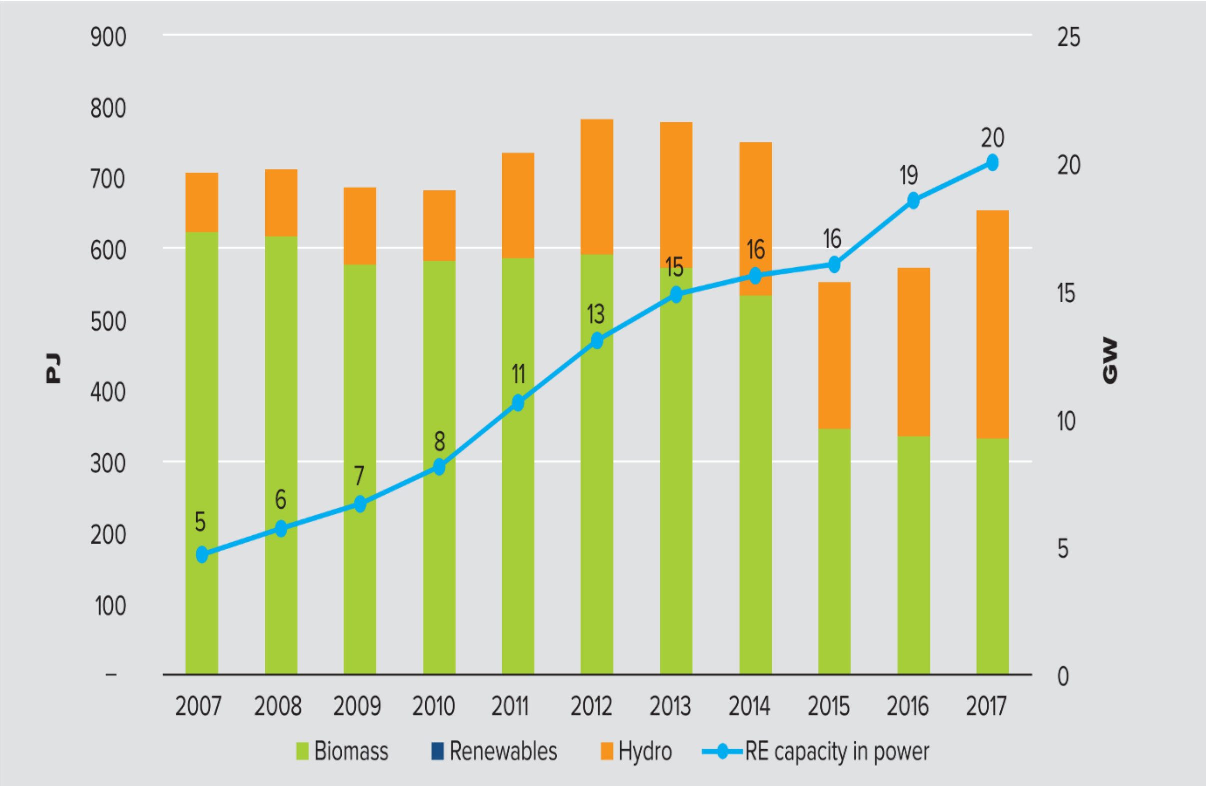


Source: Vietnam energy outlook report 2019

In 2017, biomass and hydro power have been the main types of RE in Vietnam, accounted for app. 51% and 49% of the RE energy mix, respectively, while solar and wind accounted for very small amounts in TPES.

Up until 2019, the medium and large hydropower sources (about 20GW capacity potential) have been almost fully utilized. The small hydropower resource has a total potential of about 6.7GW, with more than 3GW already in operation. The total technical potential of biomass resources is about 7GW for power production, while solid waste power is 1.5GW, of which currently only 0.3 GW is utilized. It should be noted that theoretically, energy from the waste is not considered as a pure RE source. It is only partially renewable due to the presence of fossil-based carbon in the waste, as a result, only the energy contribution from the biogenic portion is counted towards renewable energy targets. Nevertheless, according to the energy classification of Vietnam, energy from the solid watse is considered a source of RE.

Figure 5. RE (TPES) development in Vietnam in the period 2007-2017 (left axis) and RE power capacity (right axis)



Source: Vietnam energy outlook report 2019

RE sources with high future potential for development are **wind and solar power**. There was only a small amount of solar and wind capacity in operation before 2018, but it has been increased strongly in 2019 (with 4.5GW of solar and 0.45GW of wind at the end of June 2019) (Vietnam energy outlook report 2019).

In Vietnam, solar PV has the greatest potential, although limited by the demand for land use (the average land use rate is about 1.1-1.2 ha/MW depending on efficiency[3]). The solar potential used in the models is up to 380 GW (economic potential[4] in Vietnam energy outlook report 2019), but the distribution is not uniform across regions but concentrated in the South, South Central, and Highlands regions. Due to the solar promotion mechanism ended in June 2019, solar power projects have been booming in Vietnam. By August 2019, the total size of registered investment projects reached about 32 GW of which 10.3 GW was approved for additional planning up until 2025.

[3] Decision 11/2017/QD-TTg, dated 11/4/2017

[4] For the least-cost modelling, the technical potential is the preferred input from which the model determines economic feasibility. For solar PV, the lack of input data means that using the technical potential would result in an overestimation of competitive potential for PV. To avoid this, the economic potential has been chosen as input for solar PV.

The total potential of onshore wind power used in the models is around 217 GW (considering wind speed over 4.5 m/s, height of 80 m, technical potential in Vietnam energy outlook report 2019), mainly concentrated in the South, Highlands, and South-Central regions. With Vietnam's new mechanism, many investors have submitted wind power projects with the total capacity reaching 10 GW of which about 5 GW is approved for additional planning, mostly in the South- and South-Central regions. As mentioned for solar PV, the transmission grid may not be developed in time to connect all wind projects in the period up to end of 2021, when the support mechanism ends. Although wind power has a large potential and only takes a limited amount of land (limit of direct land-use is 0.35 ha/MW), only the best wind locations can compete with the rapidly decreasing costs for solar power.

In addition, Vietnam has a long coastline and a great potential for offshore wind, especially in the South- and South-Central regions, which have a relatively shallow seabed, convenient for offshore wind construction. For example, according to an assessment[5] for offshore wind in NinhThuan sea area, the average wind speed is about 10 m/s; for the area extending to the Southern coastline, the average wind speed is 7 m/s. This area has the technical potential for offshore wind up to 76 GW. However, offshore wind potential needs to be studied more in the coming period.

A number of challenges are being raised when developing large amounts of wind and solar power sources, including the ability to integrate and balance wind and solar power into the energy system, the ability to reinforce and expand the transmission grid and land use requirements, especially for large solar parks.

=> With the high potential in future of Solar PV and wind energy, we decided to choose the Solar PV and Wind power development incentive mechanism for tracking implementation progress by using ICAT methodology.

3.2. The role of Renewable energy for NDC

3.2.1. Renewable energy policies and targets

Existing mechanisms to encourage and support Solar PV power development in Vietnam are as follows:

- Solar power development incentive mechanism - Decision No. 11/2017/QD-TTg dated April 11, 2017: implementation of Feed-in-tariff mechanism, where the solar electricity purchase price is 9.35 US cents/kWh for projects put into operation before July 2019. After that the solar power apply according to Decision No. 13/2020/QD-TTg dated April 06, 2020.

[5] Going Global - Expanding offshore wind to emerging markets by ESMAP & World Bank, Otorber 2019

- Wind power development encouragement mechanism - Decision No. 39/2018/QD-TTg dated September 10, 2018: the purchase price is 8.5 US cents/kWh for onshore wind projects and 9.8 US cents/kWh for offshore projects in operation before November 2021.

- The mechanism of supporting the development of grid-connected biomass power projects in Vietnam - Decision 24/2014/QD-TTg dated March 24, 2014: the feed-in tariff for biomass power is 5.8 US cents/kWh.

- The mechanism to support the development of solid waste electricity projects - Decision No. 31/2014/QD-TTg dated May 5, 2014: the purchase price for direct solid waste-fired power plant is 10.05 US cents/kWh, the purchase price for landfill solid waste-fired power plant is 7.28 US cents/kWh.

Renewable energy policy targets in Vietnam include:

- In 2015, the Prime Minister approved Vietnam's Renewable Energy Development Strategy to 2030 vision to 2050 (Prime Minister, 2015), some main targets are as follows:

+ Develop and utilize RE sources in such a way that contributes to fulfilling the objectives of sustainable environment and development of green economy:

* Reduce greenhouse gas emissions in various energy activities as compared with BAU scenario: by approx. 5% in 2020; approx. 25% in 2030 and around 45% in 2050.

* Contribute to reduced fuel imports for energy purposes: Reduce by approx. 40 million tons of coal and 3.7 million tons of oil products in 2030; approx. 150 million tons of coal and 10.5 million tons of oil products in 2050.

+ Increase the total production and use of RE sources from approx. 25 million TOE (tons of oil equivalent) in 2015 to 37 million TOE in 2020; approx. 62 million TOE in 2030 and 138 million TOE in 2050; the RE share in total primary energy consumption in 2015 shall be approx. 31.8%; 31% in 2020; 32.3% in 2030 and 44% in 2050.

+ Increase the total electricity production from RE sources from approx. 58 billion kWh in 2015 to 101 billion kWh in 2020, approx. 186 billion kWh in 2030 and 452 billion kWh in 2050. The share of RE-based electricity in the total national production shall rise from 35% in 2015 to 38% in 2020; 32% in 2030 and 43% in 2050.

- Revised PDP7: it is expected that RE sources (including small hydropower, wind, solar and biomass) will account for 21% of the national power generation capacity by 2030.

- Resolution No.55-NQ/TW of the Politburo on the Orientation of Vietnam's National Energy Development Strategy to 2030, with a vision to 2045.

- PDP8 (is being drafted and has not yet been approved).

3.2.3. Solar PV and wind policies description using RE methodology

a. Description of Solar PV energy polices

The Government of Vietnam has issued two mechanisms to encourage and support the Solar PV energy development in Vietnam:

- Solar power development incentive mechanism – Decision No.11/2017/QD-Tg dated April 11, 2017;

- Solar power development incentive mechanism – Decision No.13/2020/QD-Tg dated April 06, 2020.

When Decision No.11/2017/QD-TTg came to expiry on June 30, 2019, the GoV issued Decision No.13/2020/QD-TTg to replace the former and to enhance the development of Solar PV energy in Vietnam.

Table 3. Brief Description of the Decision No.11

Information	Description
Title of policy	Decision No.11/2017/QD-TTg
Type of policy	Feed-in-tariff mechanism
Description	Policy characteristics: the Solar electricity purchase price is 9.35 US cents/kWh for projects put into operation before July 2019
Status of policy	Expiry
Date of implementation	11-April-17
Date of completion	01-July-19
Implementing entity	Ministry of Industry and Trade
Objectives	To increase deployment of solar PV and increase energy security
Level of the policy	National
Geographic coverage	All of provinces in Vietnam
Sector targeted	Energy supply
Greenhouse gases targeted	Carbon dioxide
Other related policies of actions	No

Table 4. Brief Description of the Decision No.13

Information	Description
Title of policy	Decision No.13/2020/QD-TTg
Type of policy	Feed-in-tariff mechanism
Description	➢ The grid-connected solar power project has been decided by the competent authorities before November 23, 2019 and has commercial operation date of the project or a part of the project from July 1. in 2019 to the end of December 31, 2020, that project or part of it shall apply the electricity purchase price list of grid-connected solar power projects at the electricity delivery point specified in the Appendix of this Decision. ➢ For NinhThuan province, the purchase price of electricity from grid-connected solar power projects is included in the electricity development planning at all levels and has the date of commercial operation before January 1, 2021 with the total accumulated capacity not exceeding 2,000 MW is **9.35 US cents / kWh.** ➢ The purchase price of electricity from grid-connected solar power projects which does not meet the conditions in two above conditions is determined through the competition mechanism.
Status of policy	Implemented
Date of implementation	06-Apr-20
Date of completion	Not yet set
Implementing entity	Ministry of Industry and Trade
Objectives	To increase deployment of solar PV and increase energy security
Level of the policy	National
Geographic coverage	All of provinces in Vietnam
Sector targeted	Energy supply
Greenhouse gases targeted	Carbon dioxide
Other related policies of actions	No

Table 5. Appendix of Decision No.13

The price of electricity from grid-connected solar power projects

No.	Solar power technology	Price of electricity (US cent/kWh)
1	Floating solar power project	7.69
2	Solar power project ground	7.09
3	Rooftop solar power system	8.38

b. Describe the Wind energy polices

The Government of Vietnam has issued two mechanisms to encourage and support the wind energy development in Vietnam:

- Wind power development incentive mechanism – Decision No.37/2011/QD-Tg dated June 29, 2011;

- Wind power development incentive mechanism – Decision No.39/2018/QD-Tg dated September 10, 2020.

Decision No.39/2018/QD-TTg revises and supplements Decision No.37/2011/QD-TTg on a mechanism to support the development of wind power projects in Vietnam.

Table 6. Brief Description of the Decision No.37

Information	Description
Title of policy	Decision No.37/2011/QD-TTg
Type of policy	Feed-in-tariff mechanism
Description	Policy characteristics: the Wind electricity purchase price is 7.8 US cents/kWh
Status of policy	Implemented
Date of implementation	20-Aug-11
Date of completion	Expiry
Implementing entity	Ministry of Industry and Trade
Objectives	To increase deployment of Wind energy and increase energy security
Level of the policy	National
Geographic coverage	All of provinces in Vietnam
Sector targeted	Energy supply
Greenhouse gases targeted	Carbon dioxide
Other related policies of actions	No

Table 7. Brief Description of the Decision No.39

Information	Description
Title of the policy	Decision No.39/2018/QD-TTg
Type of policy	Feed-in-tariff mechanism
Description	The purchase price is 8.5 US cents/kWh for onshore wind projects and 9.8 US cents/kWh for offshore projects which are put into operation before November 2021. After that the purchase price of electricity from grid-connected solar power projects is determined through the competition mechanism.
Status of policy	Implemented
Date of implementation	01-Nov-18
Date of completion	Not yet set
Implementing entity	Ministry of Industry and Trade
Objectives	To increase deployment of wind energy and increase energy security
Level of the policy	National
Geographic coverage	All of provinces in Vietnam
Sector targeted	Energy supply
Greenhouse gases targeted	Carbon dioxide
Other related policies of actions	No

CHAPTER 4. USE OF THE ICAT METHODOLOGIES FOR ASSESSING GHG AND SD IMPACTS OF THE SOLAR PV AND WIND POLICIES IN VIETNAM

4.1. Impact categorizing

The Renewable Energy (RE) and Sustainable Development (SD) methodologies are in the series of ICAT guides for assessing the impacts of policies and actions. The series of assessment guides is intended to enable users who choose to assess GHG, sustainable development and transformational impacts of a policy to do so in an integrated and consistent way within a single impact assessment process. The main emphasis of the RE methodology is the assessment of GHG impacts. On the other hand, the SD methodology focuses on SD impacts.

Impact assessment can also inform and improve the design and implementation of policies. Thus, intended users also include any stakeholders involved in the design and implementation of national RE policies, RE targets, NDCs, low emission development strategies and NAMAs, including research institutions, non-governmental organizations and businesses.

The impact classification of the solar and wind power policies is determined using the following renewable methods:

- Reduce GHG emissions from existing and new fossil fuel power plants.

- Increase the RE generation.

- Increase skill and jobs.

4.2. Identification of GHG impacts

4.2.1. Development of a causal chain

In order to achieve the goals, set out in the NDCs, while ensuring national energy security and avoiding dependence on imports of fossil fuels, Vietnam has encouraged the development of solar energy based on potential of the country.

- The positive impact: Reduced GHG emissions from existing and new fossil fuel power plants.

- The negative impact: Increased emissions from manufacturing of RE-based systems/equipment. However, most solar power plants and wind power plants in Vietnam today use equipment imported from abroad.

Figure 6 and ***Figure 7*** show a causal chain that is a conceptual diagram tracing the process by which the Solar PV and Wind energy policies leads to GHG impacts through a series of interlinked and sequential stages of cause-and-effect relationships.

Figure 6. Causal chain for Wind energy policies

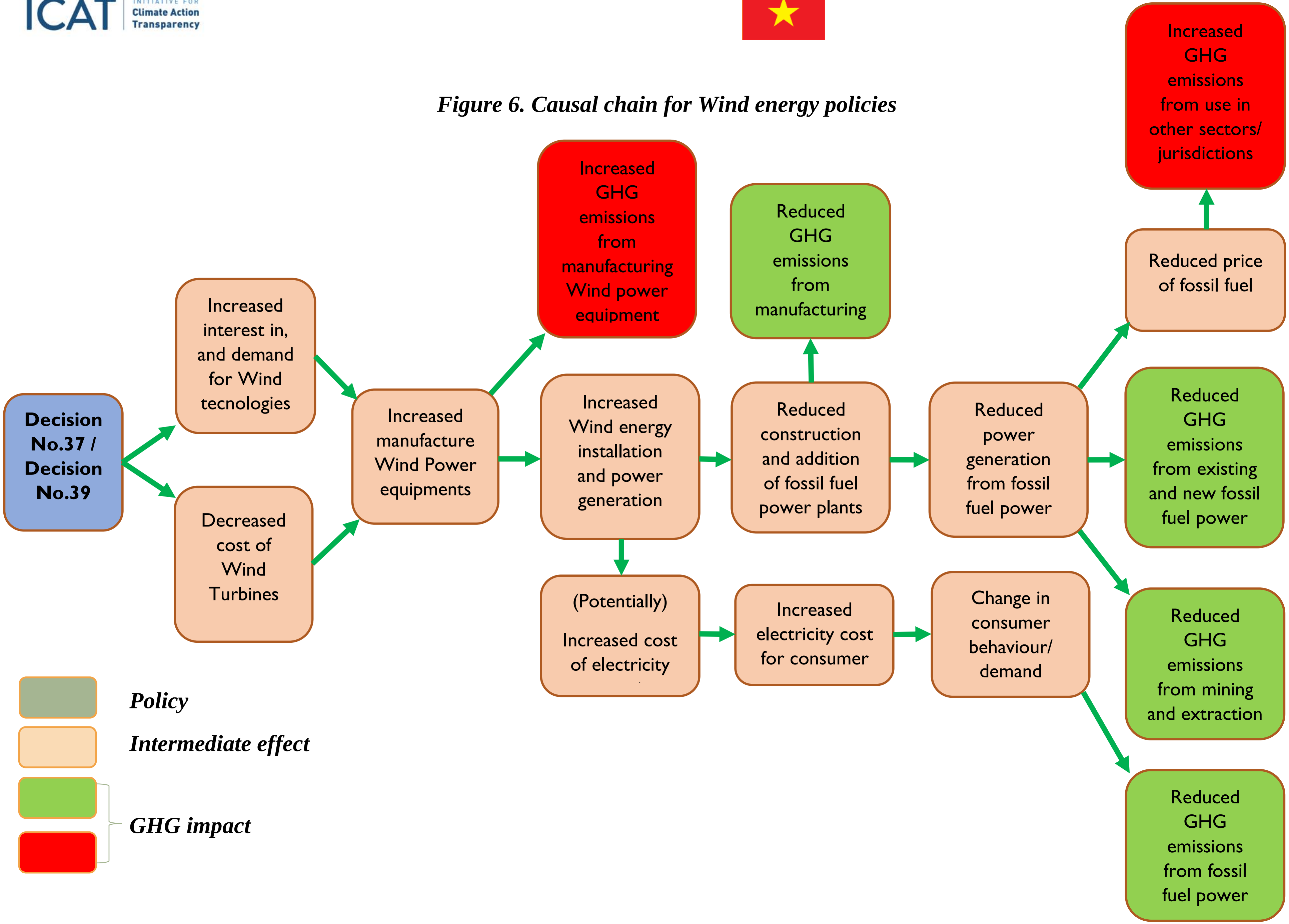
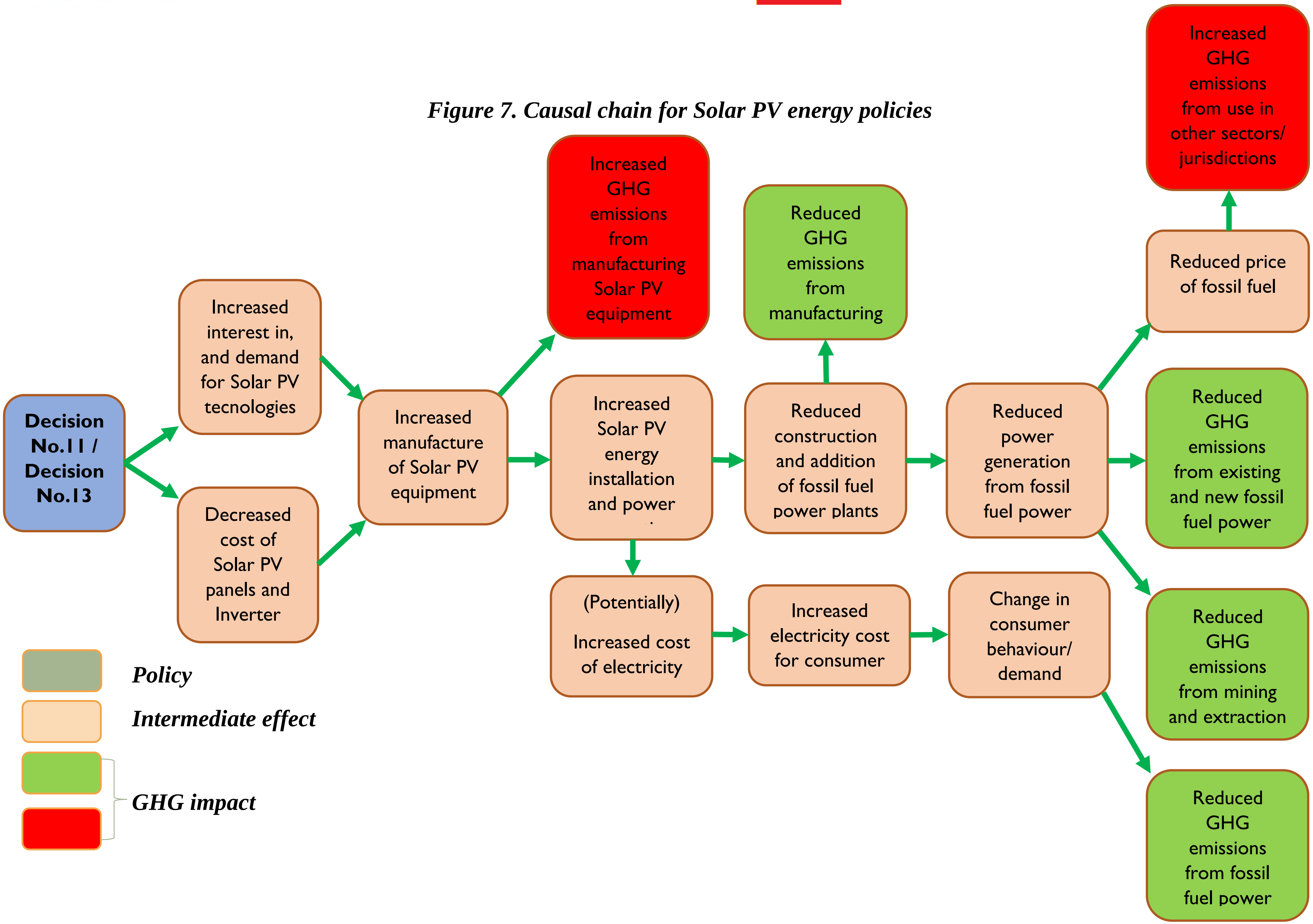


Figure 7. Causal chain for Solar PV energy policies



4.2.2. Define the GHG assessment boundary

For the Solar PV and wind energy policies, the GHG impact is likely to be significant – reduced GHG emissions from existing and new fossil fuel power plants. ***Table 8*** lists other GHG impacts and source categories.

Table 8. GHG impacts and source categories included/ excluded in the GHG assessment boundary

GHG impact	GHG	Likelihood	Relative magnitude	Included or Excluded
Reduced GHG emissions from existing and new fossil fuel power plants	CO_2	Very likely	Major	Included
Reduced emissions from mining of fossil fuel	CH_4	Possible	Minor	Excluded
Increased emissions from manufacturing of Solar PV equipment	CO_2, CH_4, N_2O	Possible	Minor	Excluded
Reduced emissions from construction of fossil fuel plants	CO_2, CH_4, N_2O	Possible	Minor	Excluded
Leakage emissions to other jurisdictions	CO_2, CH_4, N_2O	Possible	Minor	Excluded
Reduced emissions from lower energy use due to increased cost of electricity	CO_2, CH_4, N_2O	Possible	Minor	Excluded

4.3. Estimating impact ex-ante

4.3.1. Estimating Solar PV and Wind energy addition of the policy ex-ante

a. Solar PV energy

- Brief technology description

A solar cell is a semiconductor component that generates electricity when exposed to light. For practical reasons several solar cells are typically interconnected and laminated to (or deposited on) a glass pane in order to obtain a mechanical ridged and weathering protected solar panels. The photovoltaic (PV) panels are typically 1-2 m^2 in size and have a power density in the range 100-210 Wp/m^2. They are sold with a product guarantee of typically two-five years, a power warranty of minimum 25 years and an expected lifetime of more than 30 years.

PV panels are characterised according to the type of absorber material used:

- Crystalline silicon (c-Si); the most widely used substrate material is made from purified solar grade silicon and comes in the form of mono- or poly-crystalline silicon wafers. Currently more than 90 pct. Of all PV panels are wafer-based divided between multi- and mono-crystalline. This technology platform is expected to dominate the world market for decades due to significant cost and performance advantages[6]. Future improvements include development from mono-facial to bifacial panels, which convert light captured on both the front and the back of the cell into power[7]. Another trend is multilayer when area is a scarce resource.

- Thin film solar cells; where the absorber can be an amorphous/microcrystalline layer of silicon (a-Si/μcSi), Cadmium telluride (CdTe) or Copper Indium Gallium (di)Selenide (CIGS). These semiconductor materials are deposited on the top cover glass of the solar module in a micrometre thin layer. Tandem junction and triple junction thin film panels are commercially available. In these panels several layers are deposited on top of each other in order to increase the efficiency.

- Monolithic III-V solar cells; that are made from compounds of group III and group V elements (Ga, As, In and P), often deposited on a Ge substrate. These materials can be used to manufacture highly efficient multi-junction solar cells that are mainly used for space applications or in Concentrated Photovoltaic (CPV) systems.

- Perovskite material PV cells; Perovskite solar cells are in principle a Dye Sensitized solar cell with an organo-metal salt applied as the absorber material.

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[6] Leclanche. Lithium Ion Technology and Product Description, (2018). http://www.leclanche.com/technology-products/leclanche-technology/lithium-ion-cells/

[7] L. Kokam Co. Kokam Li-ion / Polymer Cell, (2017). http://kokam.com/data/Kokam_Cell_Brochure_V.4.pdf

Perovskites can also be used as an absorber in modified (hybrid) organic/polymer solar cells. The potential to apply perovskite solar cells in a multi stacked cell on e.g. a traditional c-Si device provides interesting opportunities.

In addition to PV panels, a grid connected PV system also includes Balance of System (BOS) consisting of a mounting system, dc-to-ac inverter(s), cables, combiner boxes, optimizers, monitoring/surveillance equipment and for larger PV power plants also transformer(-s). The PV module itself accounts for approximately 40% of the total system costs, inverters around 5-10%[8].

The capacity of a photovoltaic plant can be express in two ways: MWp is the rated DC capacity (installed panel capacity) of the solar power plants under solar Standard Test Condition (STC) and MWac is the output capacity deliver to the grid under STC.

PV units can be scaled from kW to MW installations. Economy of scale makes the specific investment costs lower for large plants. In the following text the focus is the utility scale PV (> 1 MW). Rooftop PV will typically have specific investment costs that are 50-100% higher than the larger plants.

- Input

Solar radiation. The irradiation, which the module receives, depends on the solar energy resource potential at the location, including shade and the orientation of the module (both tilting from horizontal plane and deviation from facing south).

The average annual solar energy received on a horizontal surface (Global Horizontal Irradiance, GHI) in Vietnam varies between approx. 800 kWh and 1700 kWh per m^2.

[8] StoraXe. StoraXe Industrial & Infrastructure Scalable battery storage system, (2018). https://www.adstec.de/fileadmin/download/doc/brochure/Datasheet_Energy_Industrial_EN.pdf

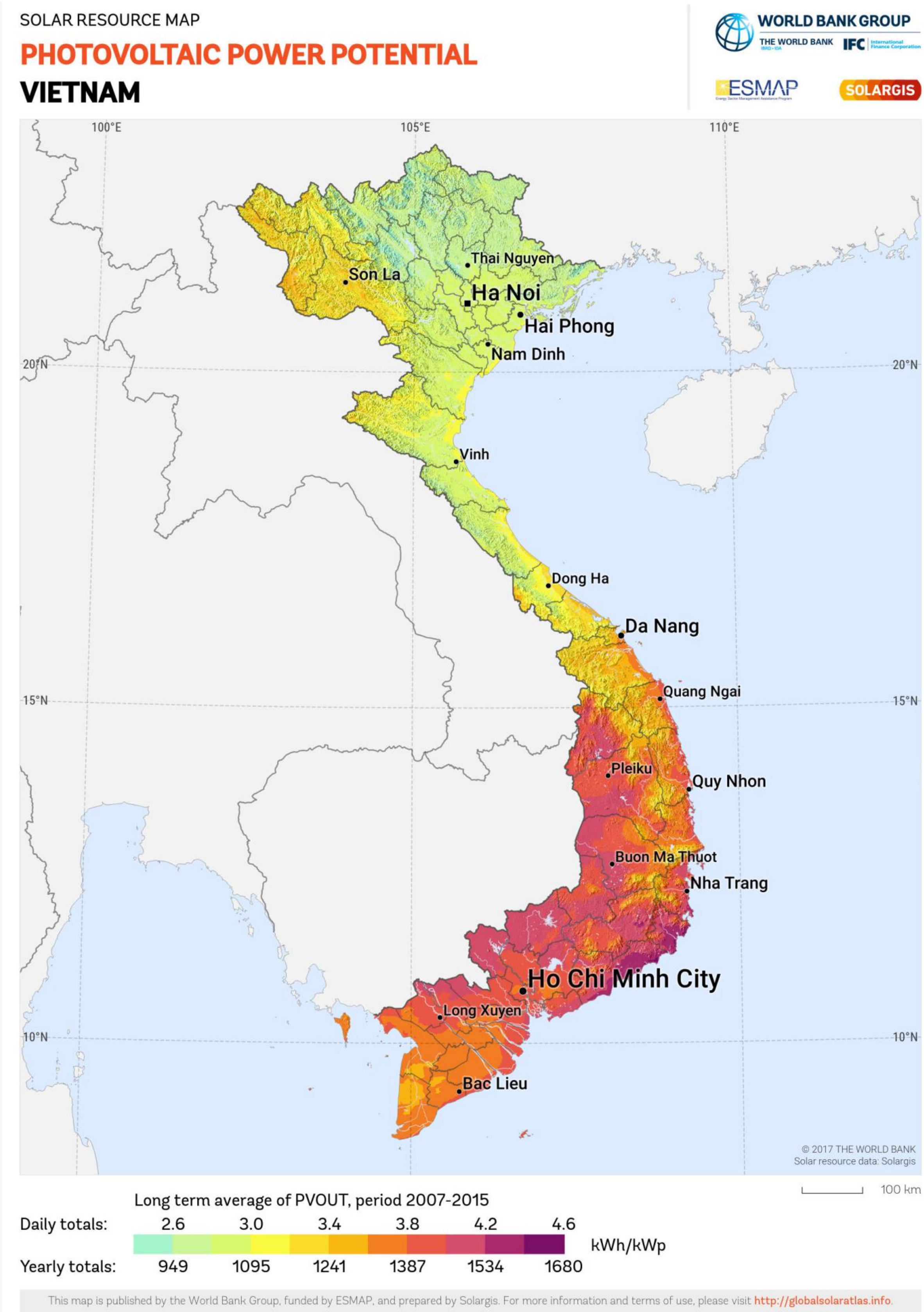


Figure 8. Full load hours (kWh/kWp) for PV in Vietnam

Table 9 lists available international public and private databases that provide either Solar PV energy potential for a region and technology or specific parameters needed for calculating the maximum Solar PV potential.

Table 9. Database on Solar PV energy resource availability

Name of databases	Private or Public	Main description
NASA Prediction of Renewable Energy Resources[9]	Public	NASA provides solar and meteorological data sets from NASA research for support of RE, building energy efficiency and agricultural needs in power programme. Data are accessible by multilayer maps, and up to 20 different parameters can be selected.
PVGIS[10]	Public	PVGIS is an online free tool to estimate the electricity yield of a PV system. It was developed by the joint Research Centre from European Commission. It gives the annual and monthly power production based on site and module specifics. The results can be visualized online or downloaded in CSV format.
PVSyst[11]	Private	PVSyst provides a software tool that allows users to analyse PV technology yields, based on different configurations. The goal is to develop an optimal and reliable PV system. The software can be purchased and downloaded from PVSyst's website.
SolarGIS[12]	Private	SolarGIS provides solar electricity data that are used in the whole life cycle of solar power plants, from prospecting to development and operation.

[9] https://power.larc.nasa.gov/data-access-viewe
[10] http://re.jrc.ec.europa.eu/pvg_tools/en/tools.html#PVP
[11] www.pvsyst.com
[12] https://solargis.com

Output

All PV panels generate direct current (DC) electricity as an output, which then needs to be converted to alternating current (AC) by use of an inverter; some panels come with an integrated inverter, so called AC panels, which exhibit certain technical advantages such as the use of standard AC cables, switchgear and a more robust PV module.

The electricity production depends on:

- The amount of solar irradiation received in the plane of the module.
- Installed module generation capacity.
- Losses related to the installation site (soiling and shade).
- Losses related to the conversion from sunlight to electricity (see below).
- Losses related to conversion from DC to AC electricity in the inverter.
- Grid-connection and transformer losses.
- Cable length and cross section, and overall quality of components.

Estimating technical potential

Table 10 shows the methodologies and tools applied to estimate the long-term Solar PV energy technical potential in Vietnam by using the databases from the resource that presented in ***Table 9***.

Table 10. Support tools to estimate Solar PV energy potential per technology

Technology	Needed/available information	Study/methodology for Solar PV energy potential calculation based on available information	Calculation complexity
Solar PV	- Total solar panel area (m^2); - Solar panel yield of efficiency (%); - Annual average solar radiation on tilted panels; - Performance ratio, coefficient for losses.	Photovoltaic-software.com, under Principles and Resources	Low
Solar PV	- System size (kW, DC); - Module type; - System losses (%); - Array type; - Tilt angle (degrees); - DC/AC ratio;	The methodology behind PVWatts calculations can be applied to data outside the PVWatts calculator. The methodology is available from the	Medium

Technology	Needed/available information	Study/methodology for Solar PV energy potential calculation based on available information	Calculation complexity
	- Inverter efficiency (%);	PVWatts manual (Dobos, 2013, 2014)	

Based on the data source and calculation method mentioned above, the GoV has calculated and set out specific targets for the development of solar energy according to the phases in the Revised PDP 7: **The solar power capacity will reach 850MW in 2020; reach 4,000MW in 2025 and reach 12,000MW in 2030**. The targets can be used such as the Solar PV energy technical potential of the policy ex-ante.

b. Wind energy

- Brief technology description

The typical large onshore wind turbine being installed today is a horizontal-axis, three bladed, upwind, grid connected turbine using active pitch, variable speed and yaw control to optimize generation at varying wind speeds.

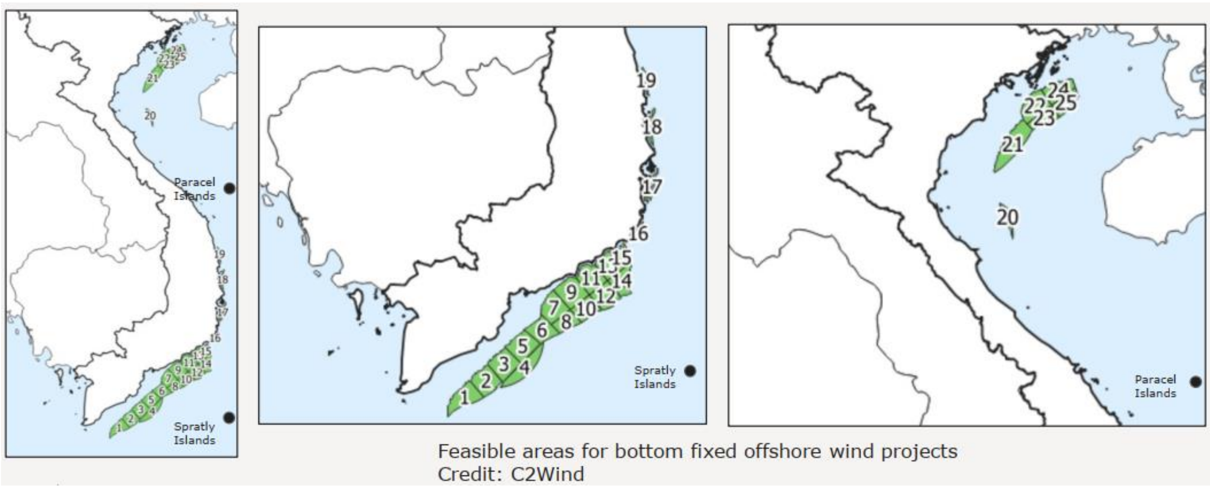
Wind turbines work by capturing the kinetic energy in the wind with the rotor blades and transferring it to the drive shaft. The drive shaft is connected either to a speed-increasing gearbox coupled with a medium- or highspeed generator, or to a low-speed, direct-drive generator. The generator converts the rotational energy of the shaft into electrical energy. In modern wind turbines, the pitch of the rotor blades is controlled to maximize power production at low wind speeds, and to maintain a constant power output and limit the mechanical stress and loads on the turbine at high wind speeds. A general description of the turbine technology and electrical system, using a geared turbine as an example, can be seen in the figure below.

Wind turbines are designed to operate within a wind speed range, which is bounded by a low “cut-in” wind speed and a high “cut-out” wind speed. When the wind speed is below the cut-in speed the energy in the wind is too low to be utilized. When the wind reaches the cut-in speed, the turbine begins to operate and produce electricity. As the wind speed increases, the power output of the turbine increases, and at a certain wind speed the turbine reaches its rated power. At higher wind speeds, the blade pitch is controlled to maintain the rated power output. When the wind speed reaches the cut-out speed, the turbine is shut down or operated in a reduced power mode to prevent mechanical damage.

Onshore wind turbines can be installed as single turbines, clusters or in larger wind farms.

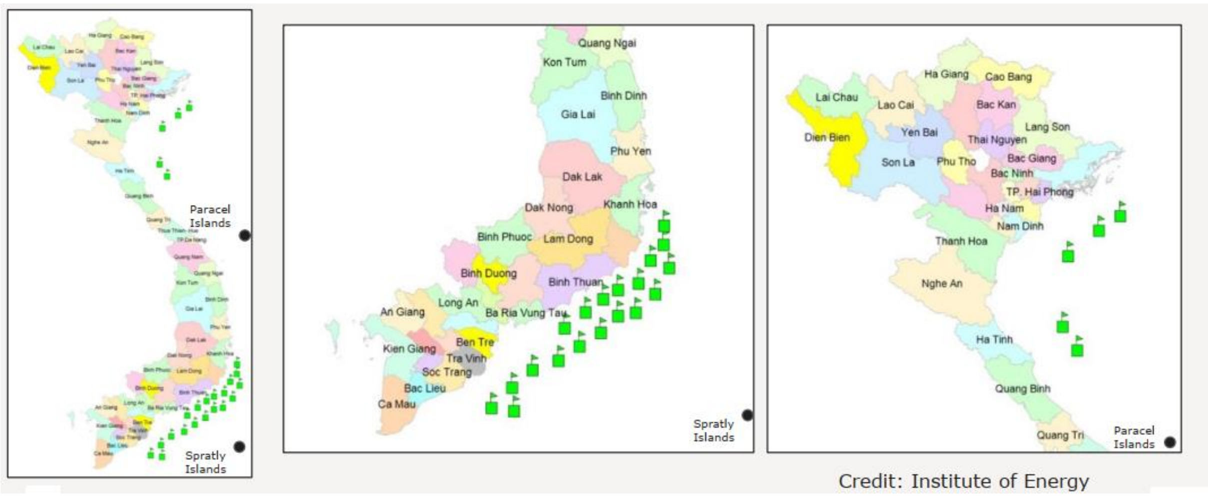
Offshore wind farms must withstand the harsh marine environment and installation and maintenance costs are higher (installation at sea, more expensive foundations and cabling, slower processes due to higher risks, dependency on weather). The electrical and mechanical components in the turbines need additional corrosion protection and the offshore foundations are costly. The high cost of installation, results in much higher investment costs than for onshore turbines of similar size. Hoverer, the offshore wind resource is better, and possible onshore sites are limited. According to the international conference documents on a roadmap for offshore wind development in Vietnam on September, 2020, there is 160GW of offshore wind potential in Vietnam. The site indentification and grid connection assessment showed in **Figure 9** and **Figure 10**.

Figure 9. Site Identification of 160 GW of Offshore Wind Potential



(Source: International conference on a roadmap for offshore wind development in Vietnam on September, 2020)

Figure 10. Grid Connection Assessment of 160 GW of Offshore Wind Potential



(Source: International conference on a roadmap for offshore wind development in Vietnam on September, 2020)

A nearshore wind farm is a special case of offshore wind which here is defined by a maximum depth of water and distance from shore which leads to lower investment cost compared to offshore wind but higher than onshore wind. Nearshore wind could be considered as intermediate between onshore and offshore. Nearshore wind farms are here defined as located in the water depth of maximum 10 m (foundation from 0 m to 10 m) and the distance from the coast is maximum 12 km. In the Vietnamese context only the near shore type of offshore wind is included and this technology is named offshore wind in the data tables later in this chapter.

Technological innovations such as floating foundations may reduce the costs in the future and allow offshore wind farms to be commissioned in deep water areas as well, though this technology is not yet deployed on a commercial basis.

Offshore wind farms are typically built with large turbines in considerable numbers.

Commercial wind turbines are operated unattended and are monitored and controlled by a supervisory control and data acquisition (SCADA) system.

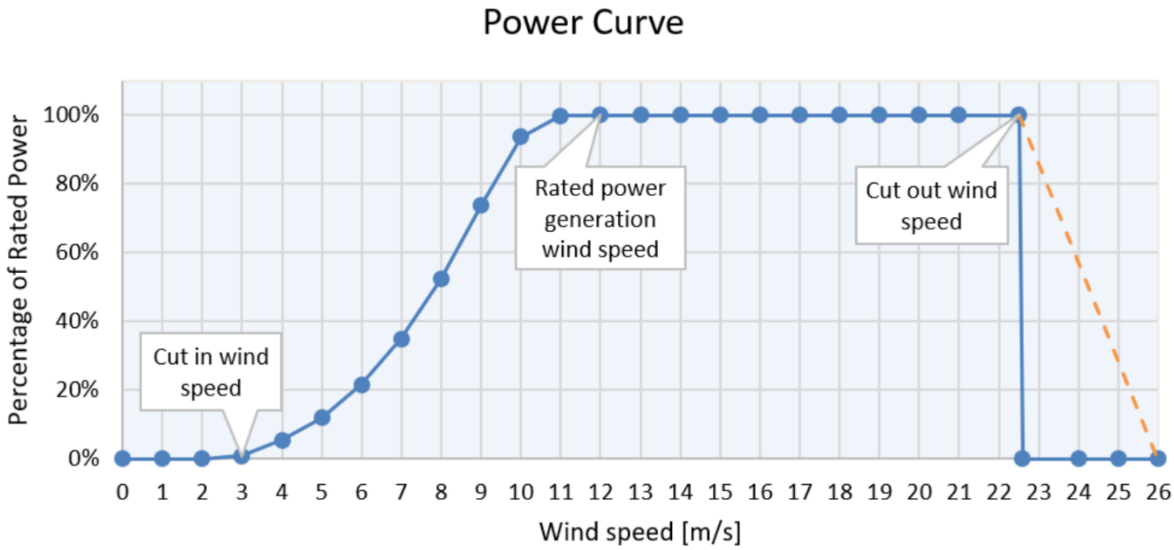
The arrangement of the technical requirements within grid codes varies between electricity systems. However, for simplicity the typical requirements for generators can be grouped as follows:

- Tolerance - the range of conditions on the electricity system for which wind farms must continue to operate;
- Control of reactive power - often this includes requirements to contribute to voltage control on the network;
- Control of active power;
- Protective devices; and
- Power quality.

- Input

Input is wind. Cut-in wind speed: 3-4 m/s. Rated power generation wind speed is 10-12 m/s. Cut-out or transition to reduced power operation at wind speed around 22-25 m/s for onshore and 25-30 m/s for offshore. Some manufacturers offer a soft cut-out for high wind speeds (indicated with dashed orange curve in the **Figure 11**) resulting in a final cut-out wind speed of up to 26 m/s for onshore wind turbines

Figure 11. Power curve for a typical wind turbine. Instead of the traditional cut out curve, some turbines have a gradual cut out curve (dashed line)



(source: Vietnam technology catalogue 2019)

Generally speaking, the onshore wind resource in Vietnam is scarce. However, a few sites have average wind speeds above 8 m/s, ***Figure 12.***

There are however locations, which demonstrate attractive wind speeds. Based on data from the Vietnamese wind resource map the typical capacity factor for a modern onshore turbine located at these good sites will be in the range of 35% corresponding to around 3,055 annual full load hours. The estimate is based on the power curve for a low wind speed turbine (with a large rotor relative to the capacity of the turbine) and the locations are chosen based on conditions at 100 m hub height.

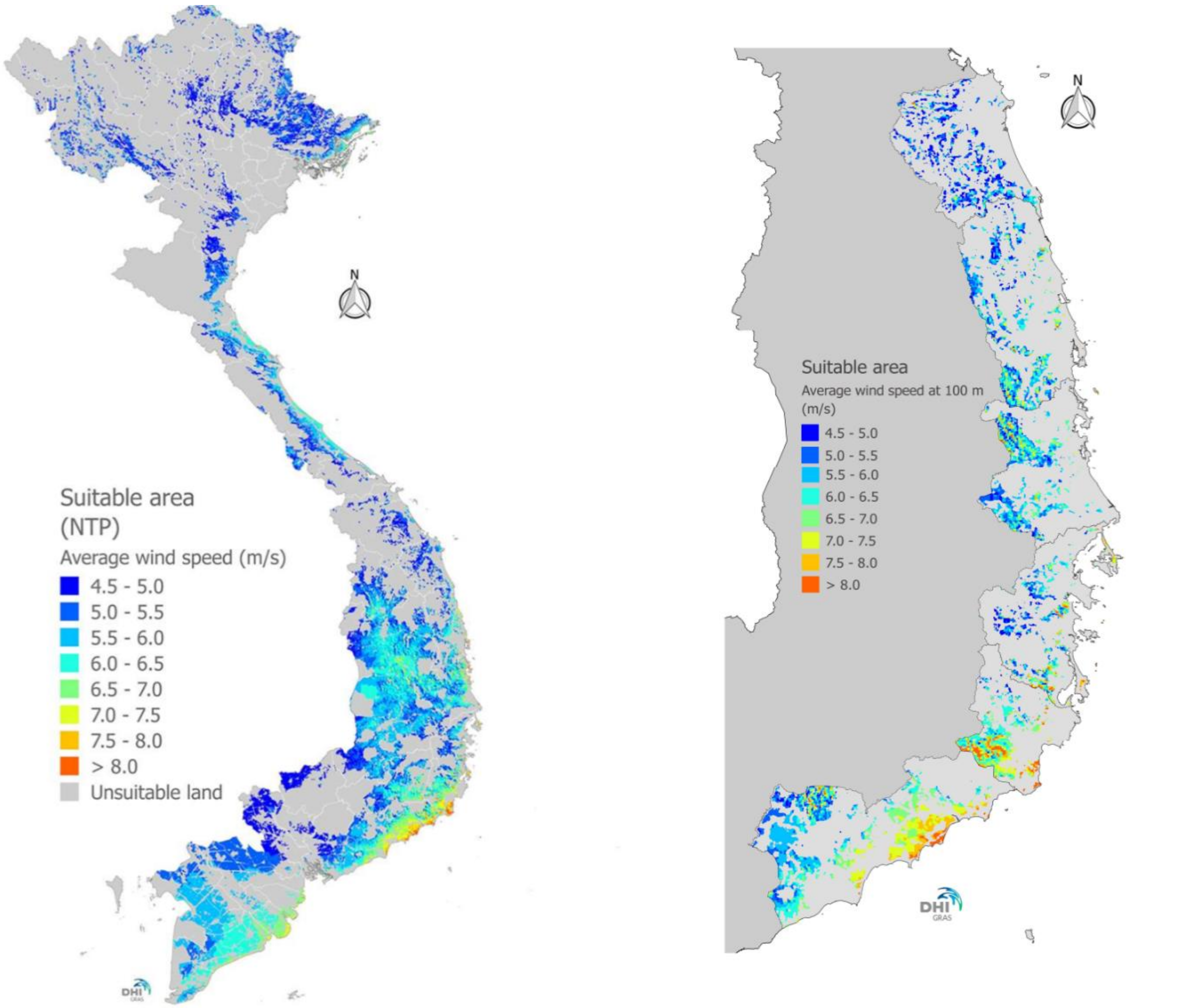


Figure 12. Suitable areas of f National Technical Potential (NTP) overlaid with average wind speed (left) and provincial technical potential (right).

The annual energy output of a wind turbine is strongly dependent on the average wind speed at the turbine location. The average wind speed depends on the geographical location, the hub height, and the surface roughness. Hills and mountains also affect the wind flow, and therefore steep terrain requires more complicated models to predict the wind resource, while the local wind conditions in flat terrain are normally dominated by the surface roughness. Also, local obstacles like forest and, for small turbines, buildings and hedges reduce the wind speed like wakes from neighbouring turbines. Due to the low surface roughness at sea, the variation in wind speed with height is small for offshore locations; the increase in wind speed from 50m to 100m height is around 8%, in comparison to 20% for typical inland locations.

Table 11 lists available international public and private databases that provide either wind energy potential for a region and technology or specific parameters needed for calculating the maximum wind energy potential.

Table 11. Database on wind energy resource availability

Name of databases	Private or Public	Main description
NASA Prediction of Renewable Energy Resources[13]	Public	NASA provides solar and meteorological data sets from NASA research for support of RE, building energy efficiency and agricultural needs in Power programme. Data are accessible by multilayer maps, and up to 20 different parameters can be selected.
WindSim[14]	Public	WindSim is used for wind farm optimization by identifying turbine locations with the highest wind speeds, to maximize power production It uses computational fluid dynamics and 3D models of the terrain to obtain the optimized wind park layout.
Wind Atlas Analysis and Application Program (Wasp) from Risoe National Laboratory[15]	Private	WAsP is a software tool for wind resource assessment for single wind turbines and wind farms. It includes features for different terrains, climatic stability on site and more the outputs consist of energy yield, wind farm efficiency, turbulence mapping and site assessment.
AWS True Power (UL Renewables)[16]	Private	The Wind Resource Grids provided by AWS True power through Wind navigator allow users to site meteorological towers, design preliminary layouts and obtain preliminary estimates of the wind energy generated for small to multi-turbine wind projects.

[13] https://power.larc.nasa.gov/data-access-viewe
[14] https://windsim.com
[15] www.wasp.dk
[16] https://aws-dewi.ul.com

Estimating technical potential

Table 12 shows the methodologies and tools that can be used to estimate the long-term wind energy technical potential in Vietnam by using the databases from the resource that presented in ***Table 11***.

Table 12. Support tools to estimate Wind energy potential per technology

Technology	**Needed/available information**	**Study/methodology for wind energy potential calculation based on available information**	**Calculation complexity**
Wind	- ρ = air density (kg/m^3) - A = roto sweep area (m^2) - Cp = coefficient of performance - V = wind velocity (m/s) - Ng = generator efficiency - Nb = gear box bearing efficiency	Several websites or papers available (e.g. MIT; Sarkar and Behera [2012]; Windpowerengineering.com	Low

Based on the data source and calculation method mentioned above, the GoV has calculated and set out specific targets for the development of solar energy according to the phases in the Revised PDP 7: **The wind power capacity will reach 800MW in 2020; reach 2,000MW in 2025 and reach 6,000MW in 2030**. The targets can be used such as the wind energy technical potential of the policy ex-ante.

4.3.2. Estimating GHG impacts of the policy ex-ante

a. Results of emission reduction scenarios in the Assessing Vietnam NDC Pathway – Energy sector final report (MOIT, 2020)

The Government of Vietnam (GoV) submitted its Intended Nationally Determined Contributions (INDC) under the Paris Agreement in 2015, which is committed to reducing greenhouse gas (GHG) emissions by 8 percent compared to the Business-As-Usual Case (BAU) by 2030 with domestic resources and 25 percent with international financial support. Under this context, Ministry of Natural Resources and Environment (MONRE) requested each key line ministry to submit their sectoral targets to achieve the NDC target, and propose new and more ambitious targets for the next round of NDC submission. The energy sector, comprising power generation, Industry, buildings in the Residential and Commercial sectors, and Transport is the single largest source for GHG emissions in Vietnam, accounting for more than 60 percent of GHG emissions now, and more than 85 percent by 2030. The Ministry of Industry and Trade

(MOIT) requested for World Bank support to assist them in developing its energy sector emission reduction targets and pathways contributing to the national NDC targets.

This World Bank study aims to support the development of the Roadmap for GHG Mitigation in the energy sector up to 2030. More specifically, the primary objectives of this analytical advisory are to support Vietnam in:

(1) Developing and reaching consensus on cost-effective low-carbon mitigation options and pathways both on the demand and supply sides to achieve the NDC target;

(2) Estimating the total costs and financing needs to achieve the NDC targets;

(3) Evaluating updated NDC targets for the energy sector to determine the least-cost roadmap to achieve the NDC target.

The study examined seven scenarios: one of which is BAU, two are unconditional and one is on EE and RE policies, the others are conditional.

- Business-As-Usual (BAU): Represents the baseline scenario in line with MONRE's revised NDC-2 BAU depiction of the power and other energy sector emission profiles, particularly with respect to sectoral emissions, generation mix, and electricity demand. Since MONRE requested different line ministries to develop their NDC targets, it is important to use the same BAU definition by MONRE to ensure consistency;

- 8 percent emission reduction below BAU by 2030 (NDC-8%): Models the original unconditional NDC target submitted under the Paris Agreement. [Later, for discussions at COP25 a 10% target was also examined, and is discussed as part of Section 11.]

- 15 percent emission reduction below BAU by 2030 (NDC-15%): An intermediate emission reduction scenario as requested by MOIT;

- Energy Efficiency (EE) and Renewable Energy (RE) Policy Scenario (EE&RE Policies): This scenario is based on the ambitious RE targets by 2030 (12 GW of solar PV and 6 GW of wind) set in GoV's latest Power Development Plan (PDP-7r) approved in March 2016 after the NDC submission, and the recently approved (in February 2019) Vietnam National Energy Efficiency Program (VNEEP) that set an EE target to reduce final energy consumption 8-10 percent below BAU from 2021 to 2030. MOIT regards this scenario as conditional, as they expect international support to implement the PDP-7r and VNEEP;

- 20 percent emission reduction below BAU by 2030 (NDC-20%): An intermediate emission reduction scenario as requested by MOIT;

- 25 percent emission reduction below BAU by 2030 (NDC-25%): Models the original conditional NDC target submitted under the Paris Agreement, and

- 30 percent emission reduction below BAU by 2030 (NDC-30%): This scenario explores a more aggressive scenario than the conditional NDC pledge, as requested by MOIT.

This report will show the results of Vietnam energy sector NDC analysis examines scenarios for various GHG reduction levels from the Business-as-Usual (BAU) projection with the goal of determining an appropriate cost-effective target for the country. Scenarios of 8%, 10%, 12% and 15% reductions from BAU by 2030 were examined in the context of an unconditional NDC target and the EE&RE policies scenario. The EE&RE policies scenario is based on implementation of the RE targets in the PDP-7r and the proposed VNEEP EE target to reduce final energy consumption 8-10 % below BAU from 2021 to 2030, which is defined as:

- ✓ PDP-7r RE targets for 2030, including:

  + 12 GW of installed solar power (central and distributed);

  + 6 GW of installed wind power;

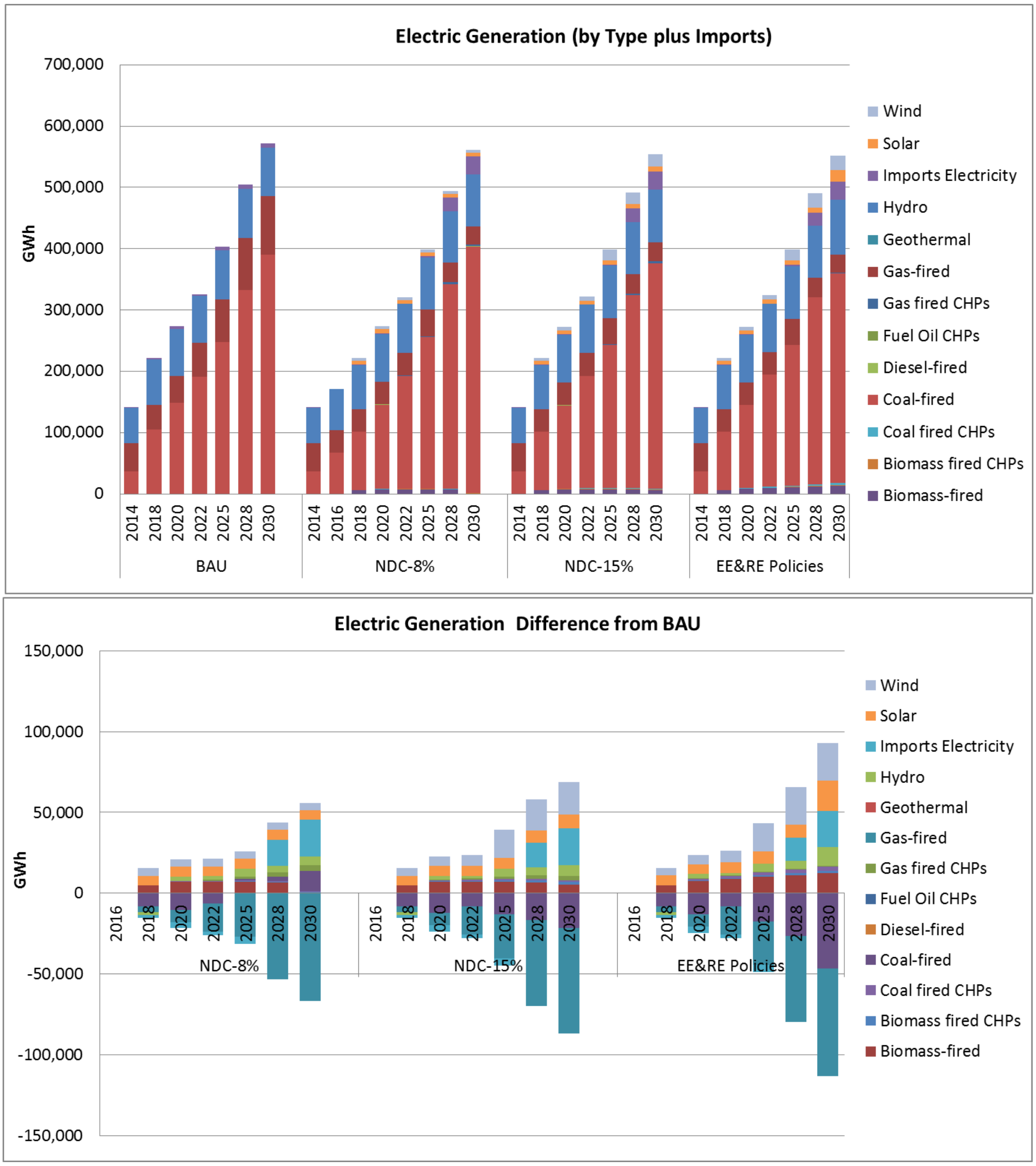
  + 3.28 GW of biomass-fired power;

  + 30 GW from large and small hydro, and

- ✓ 8-10% reduction in Final Energy Consumption (FEC).

Figure 13 shows the electricity generation (on the top) and the change in generation from the BAU scenario (on the bottom) for the Unconditional and EE&RE Policies scenarios. Total electricity generation decreases by only 2% to 3.6% percent, but in all scenarios, some coal and gas-fired generation is replaced by solar, hydropower, biomass and wind power plants. The NDC-8% scenario favours imports from China and Laos of wind over solar, but the cost of these imports if quite difficult to predict. The NDC-15% and EE&RE Policies scenarios grow both solar and wind generation, with the NDC-15% scenario adding more wind power, while the EE&RE policies scenario has more balanced generation from each.

Figure 13. Unconditional GHG Reduction Scenarios – Electricity Generation



As shown in ***Table 13***, the Power sector shows important growth in RE-based electricity, with the contributions from central RE power plants providing most of the additional RE-based electricity, with small hydropower, distributed solar and biomass CHP plants providing the remainder. Small hydropower grows to almost 2% of total supply in all the Unconditional scenarios, followed by bagasse cogeneration plants that grow in capacity as the GHG cap is strengthened. MSW and landfill gas power plants are built and operated in the NDC-15% and EE&RE policies scenarios, but make relatively small contributions. It should also be noted that natural gas does not play a major mitigation role in the Vietnam power sector, with its share of generation dropping from 17% in the BAU to 5.5% in the three reduction scenarios, because the gas is more valued in Industry to replace coal and increasingly serves to balance RE as needed.

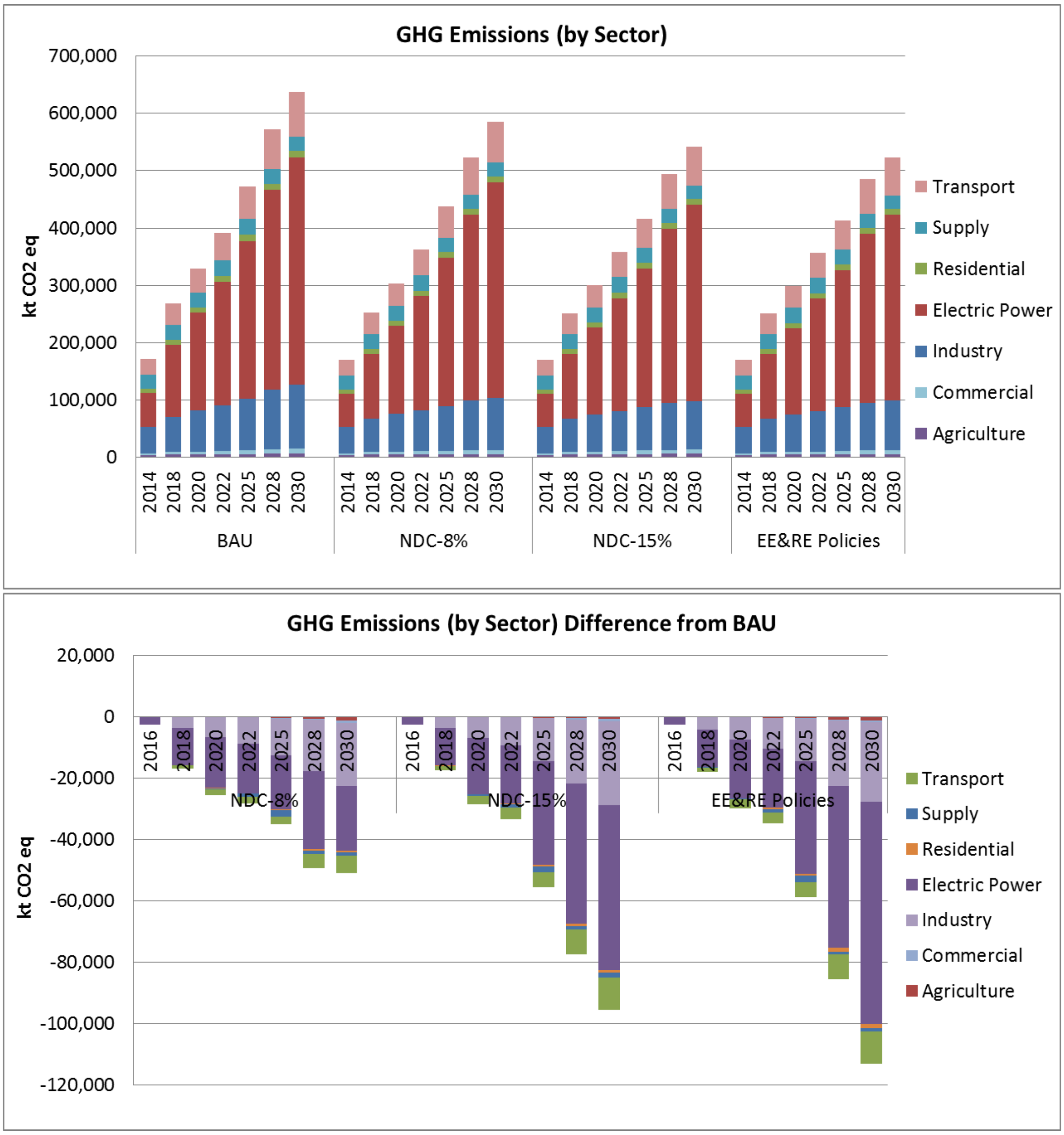
Table 13. Unconditional GHG Reduction Scenarios – Power Sector Measure Results

Measure	Description	BAU	NDC-8%	NDC-15%	EE&RE Policies
Promote RE-based electricity	Central RE electricity (GWh)	79,855	91,278	98,132	118,992
	Share of central supply	14.0%	14.3%	18.0%	21.9%
Promote wind	Wind generation (GWh)	0	4,653	20,091	23,180
	Share of total supply	0.0%	0.7%	3.7%	4.3%
Promote central solar	Central solar generation (GWh)	0	6,058	6,058	15,577
	Share of total supply	0.0%	0.9%	1.1%	2.9%
Biomass power plants [including bagasse]	Wood and bagasse generation (GWh)	806	701	2,637	9,506
	Share of total supply	0.1%	0.1%	0.5%	1.7%
Landfill gas power plants	Landfill gas generation (GWh)	0	0	218	218
	Share of total supply	0.00%	0.00%	0.61%	0.62%
MSW power plants	MSW generation (GWh)	0	0	3,361	3,361
	Share of total supply	0.0%	0.0%	0.6%	0.6%
Biogas power plants	Biogas generation (GWh)	0	0	0	0
	Share of total supply	0.0%	0.0%	0.0%	0.0%
Small hydro power plants	SHP generation (GWh)	3,300	10,441	10,441	14,912
	Share of total supply	0.6%	1.6%	1.9%	2.7%
Coal-biomass co-firing plants	Coal and biomass generation (GWh)	1,385	10,447	17,541	0
	Share of total supply	0.2%	1.6%	3.2%	0.0%
Super-critical coal power plants	Supercritical coal generation (GWh)	206,098	184,358	149,885	135,121
	Share of total supply	36.0%	28.8%	27.4%	24.8%

(Source: Assessing Vietnam NDC Pathways on March 2020 - The Energy sector final report)

Figure 14 shows the GHG emissions (on the top) and the change in emissions from the BAU scenario (on the bottom) for the three Unconditional scenarios. The figure shows that almost all emission reductions come from the Power and Industry sectors, followed by Transport. Total emissions reductions in 2030 grow from 51 million metric tons per year (Mt/yr) in the NDC-8% scenario to 95 Mt/year in NDC-15% and 113 Mt/year in the EE&RE Policies scenarios.

Figure 14. Unconditional GHG Reduction Scenarios – GHG Emissions



As shown in **Table 14**, the Power and Industry sectors are the main contributors to GHG emission reductions, in terms of both the share of total reductions in any scenario and the growth in GHG reductions as the NDC target is increased.

Table 14. GHG Emission Reductions (kt)

NDC Pathways Analysis: GHG Emissions (CO2eq) by Sector (kt)									
Scenario	**BAU**				**NDC-8%**				
Sector	**2014**	**2020**	**2025**	**2030**	**2014**	**2020**	**2025**	**2030**	**Diff BAU 2030**
Agriculture	4,413	5,368	6,213	7,338	4,413	5,247	5,821	6,291	-14.3%
Commercial	3,391	4,941	6,452	7,901	3,391	4,886	6,341	6,860	-13.2%
Industry	45,015	72,110	90,032	111,429	45,015	65,703	77,889	91,048	-18.3%
Power Sector	60,077	169,680	274,853	396,964	60,077	153,091	257,366	375,879	-5.3%
Residential	7,131	9,149	10,457	10,850	7,131	9,035	10,114	10,220	-5.8%
Supply	23,835	26,489	27,652	24,710	23,835	26,078	25,681	23,702	-4.1%
Transport	28,241	41,313	56,535	77,349	28,241	39,411	54,007	71,619	-7.4%
Total	**172,104**	**329,051**	**472,194**	**636,542**	**172,104**	**303,451**	**437,219**	**585,619**	**-8.0%**

NDC Pathways Analysis: GHG Emissions (CO2eq) by Sector (kt)										
Scenario	**NDC-15%**					**EE&RE Policies**				
Sector	**2014**	**2020**	**2025**	**2030**	**Diff BAU 2030**	**2014**	**2020**	**2025**	**2030**	**Diff BAU 2030**
Agriculture	4,413	5,377	5,889	6,748	-8.0%	4,413	5,266	5,723	6,240	-15.0%
Commercial	3,391	4,864	6,339	7,162	-9.4%	3,391	4,835	6,253	7,366	-6.8%
Industry	45,015	65,337	76,152	84,086	-24.5%	45,015	64,928	76,414	85,421	-23.3%
Power Sector	60,077	151,379	241,002	343,085	-13.6%	60,077	150,614	238,059	324,491	-18.3%
Residential	7,131	8,993	9,985	9,936	-8.4%	7,131	8,900	9,696	9,350	-13.8%
Supply	23,835	26,145	25,683	23,221	-6.0%	23,835	26,204	25,734	23,674	-4.2%
Transport	28,241	38,522	51,623	66,822	-13.6%	28,241	38,522	51,623	66,822	-13.6%
Total	**172,104**	**300,616**	**416,672**	**541,061**	**-15.0%**	**172,104**	**299,270**	**413,502**	**523,365**	**-17.8%**

(Source: Assessing Vietnam NDC Pathways on March 2020 - The Energy sector final report)

Table 15. Summary Results from Each Scenario by 2030

Metric	BAU	NDC-8%	NDC-15%	EE&RE Policies
Energy Sector GHG Reduction (Mt)	-	50.9	95.4	113.3
RE Share in power generation	14.0%	17.2%	22.0%	26.6%
Final energy consumption saving below BAU	-	4.8%	8.0%	9.3%

(Source: Assessing Vietnam NDC Pathways on March 2020 - The Energy sector final report)

<u>b. Results of Emission reduction scenarios by using the GACMO model</u>

GACMO is a spreadsheet model which can calculate Business-As-Usual (BAU) projections, as well as GHG reduction and cost for mitigation options with the technology used in the BAU *(For details the Data arrangement for operation of GACMO in Appendix)*. With the Solar PV and Wind energy technical potential of the policy ex-ante, results of GHG emission reduction potential using GACMO model are as follows:

Table 16. GHG emission reduction potential of the policy ex-ante using GACMO model

Type	**2020**		**2025**		**2030**	
	Capacity (MW)	**Emission reduction (kt/year)**	**Capacity (MW)**	**Emission reduction (kt/year)**	**Capacity (MW)**	**Emission reduction (kt/year)**
Solar PV energy	850	1,416.29	4,000	6,664.90	12,000	19,994.70
Wind energy	800	2,410.32	2,000	6,025.80	6,000	18,077.40
Total	**1,650**	**3,826.61**	**6,000**	**12,690.70**	**18,000**	**38,072.10**

4.4. Estimating impact ex-post

4.4.1. Estimating Solar PV and wind energy addition of the policy ex-post

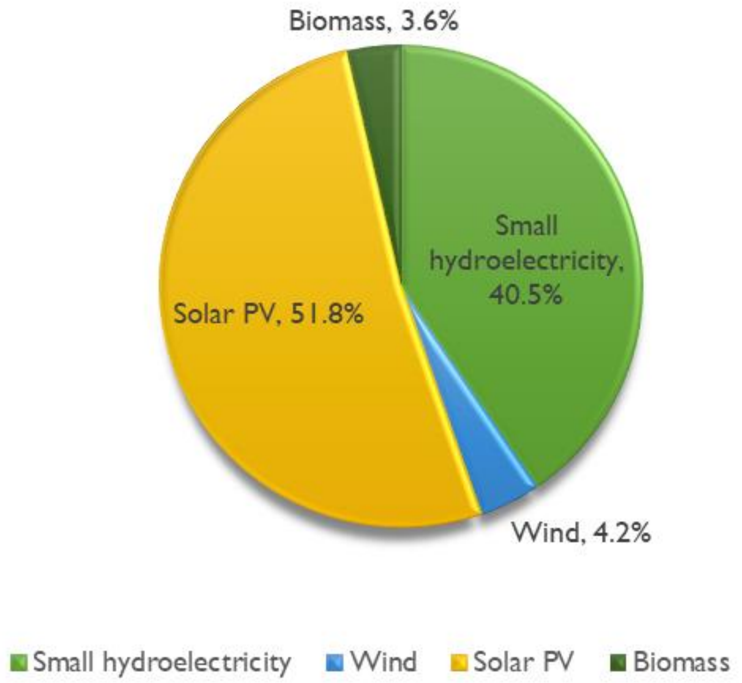
According to the end of 2019 report by EVN, the total installed power source capacity of the whole system reached 54,880MW, of which 4,696MW of solar power accounted for 8.48% and 377MW of wind power accounted for 0.68%.

Table 17. Power capacity structure of Vietnam by the end of 2019

Type of power source	**Capacity (MW)**	**Rate (%)**
Hydroelectric	16,958	30.63%
Coal thermal power	20,267	36.61%
Gas turbines	7,446	13.45%
Small hydroelectricity	3,674	6.64%
Wind	377	0.68%
Solar PV	4,696	8.48%
Biomass	325	0.59%
Oil thermal power	1,579	2.85%
Gas thermal power	21	0.04%
Diesel	24	0.04%
Total	***55,367***	***100%***

(Source: Report on the implementation results of the plan in 2019. Objectives, tasks and plans for the year 2020)

Figure 15. RE power capacity structure of Vietnam by the end of 2019



During the period 2017-2019, the Feed-in tariff (FIT) polices and the development of technology has helped Vietnam attract investors to participate in the development of renewable energy sources from the solar and wind, the capacity of these two energy sources has increased significantly.

4.4.2. Estimating GHG impacts of the policy ex-post

With the Solar PV and Wind power capacity in 2019, results of GHG emission reduction potential using GACMO model are as follows:

Table 18. GHG emission reduction potential of the policy ex-post using GACMO model

Type	**2019**	
	Capacity (MW)	**Emission reduction (kt/year)**
Solar PV energy	4,696	7,824.59
Wind energy	377	1,135.86
Total	**5,073**	**8,960.45**

4.5. Baseline estimation

4.5.1. The capacity of Solar PV and Wind energy in the base year

Although the base year for the Vietnam's NDCs in 2015 process is 2010, the base year of the Vietnam's NDCs update in 2020 was selected to be 2014.

According to the Statistical energy of Vietnam in 2015[17], the total installed power source capacity of the whole system reached 34,488MW, of which 46MW of Wind energy accounted for 0.14% and 45MW of Biomass accounted for 0.13%. In 2014, the capacity of Solar PV energy is very small and mainly using in civil and not connected to national grid.

Table 19. Power capacity structure of Vietnam by the end of 2014

Type of power source	Capacity (MW)	Rate (%)
Hydroelectric[18]	15,394	45.31%
Coal thermal power	9,873	29.06%
Gas turbines	7,650	22.52%
Wind	46	0.14%
Solar PV	0	0.00%
Biomass	45	0.13%
Oil thermal power	925	2.72%
Diesel	39	0.11%
Total	***33,972***	***100%***

(Source: The Statistical energy of Vietnam in 2015)

Note: In the energy statistics of 2015, only one category of hydroelectricity is calculated (i.e. large hydropower and small hydropower plants are in the same category). However, in 2017, the energy statistics separated the capacity of these two types of hydroelectricity, small hydroelectric plants are defined as those with capacity below 30MW and only small plants are included in RE category.

4.5.2. Estimating GHG impacts in the base year

With the Solar PV and Wind power capacity in 2014, results of GHG emission reduction potential using GACMO model are as follows:

[17] The Statistical energy of Vietnam in 2015 Energy statistics are performed by the Institute of Energy, under the chaired by the Energy Efficiency and Sustainable Development Department, Ministry of Industry and Trade;
[18] Small hydroelectric is included;

Table 20. GHG emission reduction potential in 2014 using GACMO model

Type	2014	
	Capacity (MW)	Emission reduction (kt/year)
Solar PV energy	0	0
Wind energy	46	138.59
Total	**46**	**138.59**

4.5.3. The capacity of Solar PV and Wind energy in Vietnam's NDCs update in 2020 and GHG emission reduction potential

Based on the targets of the Solar PV and Wind energy capacity in Vietnam's NDCs update in 2020, results of GHG emission reduction potential using GACMO model are as follows:

Table 21. GHG emission reduction potential for the targets in Vietnam's NDCs update in 2020 using GACMO model

Type	2020		2030	
	Capacity (MW)	Emission reduction (kt/year)	Capacity (MW)	Emission reduction (kt/year)
Solar PV energy	5,000	8,331.13	5,000	8,331.13
Wind energy	1,010	3,043.03	1,010	3,043.03
Total	**6,010**	**11,374.16**	**6,010**	**11,374.16**

4.6. Qualitative sustainable development impacts assessment

RE policies generate multiple sustainable development impacts in addition to their GHG impact. Sustainable development impacts are changes in environmental, social or economic conditions that result from a policy or action, such as: energy security, employment, education benefits, public health, air quality.

According to the ICAT Renewable Energy Methodology, there are some main indicators and sustainable development impacts that may be associated with RE policies.[19]

[19] More information at: https://climateactiontransparency.lemon-solutions.net/wp-content/uploads/2020/10/Renewable-Energy-Methodology_ch6.pdf

4.6.1. Increased access to electricity

This chapter details qualitative assessment of sustainable development impacts quantitatively of the solar PV and Wind energy to communities in the national targets. The approach involves describing the impacts of a policy or action on the selected impact categories in qualitative terms.

In the past years in Vietnam, renewable energy has not really developed strongly due to lack of supportive policies, underdeveloped technology and high equipment costs despite Vietnam's huge potentials. However, in the past few years, the Government has issued a lot of policies to encourage the development of renewable energy, especially solar and wind power. Along with that, advances in science and technology have helped reduce equipment costs, therefore, several solar and wind power plants are put into operation and generate electricity on the national grid, contributing much to ensuring national energy security.

In 2019, solar power capacity reached 4,696 MW, accounting for 8.48% of the total installed capacity of the whole system and wind power reached 377 MW, accounting for about 0.68%.

4.6.2. Employment opportunities and education benefits

In a study conducted by Co-benefits project in October 2019 named “Future skills and job creation through renewable energy in Vietnam”, the report presents the resulting employment effects, presuming that the electricity sector focuses on all power generation technologies outlined in the government’s official power sector plan. It also provides an initial assessment of the skill requirements, attainment levels and technical training required for Vietnam’s present power sector plans and future low-carbon power sector ambitions.

By issuing the Decision to increase the share of renewables from 6% to 10.7% in the current power sector plan (PDP7 rev), the government paved the way to creating 315,000 job-years through the power sector by the year 2030. With renewables creating twice as many jobs as the fossil-fuel sector per average installed MW, the government can further boost employment by adopting a more ambitious low-carbon power sector plan.

For wind and solar, around 25% of jobs created are for high-skilled workers. The tendency for high-skilled workers in the power sector is expected to further increase over the next decade in Vietnam. Therefore, the training capacities at the universities and technical schools need to be reconciled in consideration with this development, in order to generate more jobs as well as to meet the country’s expected demand.

The Government can actively manage a just transition to low-carbon energy sources by redeveloping vocational training curricula and university programmes towards the new energy world of renewables while supporting affected workers and communities domiciled in the coal-power-generating regions of the country, such as the Mekong Delta.

Replacing coal power plants with solar or wind will more than double the number of jobs per average MW capacity. Replacing coal with gas alone will lead to job losses of around 0.5 job losses per average installed MW. Up to 1.94 million job-years can be created in the country through the power sector transformation between 2015-2020.

- For each direct job created in the power sector in Vietnam, two additional jobs (indirect & induced) are created in the country irrespective of the scenario assessed. More than 60 % of jobs created through changes in the power sector are positive-increase employment opportunities in the broader Vietnamese economy.

- In the ambitious renewable energy (RE) scenario by Green ID, solar and wind power contribute over 20% of the jobs created in the power sector by 2030; coal and hydropower are established technologies in Vietnam and are projected to constitute about 60 % of gross employment in the power sector.

- A shift to Green ID's ambitious RE scenario (Base & Renewable Energy) will increase gross employment in the RE sector to approximately 434,000 job-years, a 38 % increase from the PDP 7 (rev) scenario of 315,000 job-years. These jobs are created in the solar, wind and biomass sectors.

- By the year 2030, the demand for higher-skilled workers in the power sector is expected to grow by 31% for jobs during the construction and installation phase, and 25% for jobs in operation and maintenance. This change is partially associated with the growth in demand for RE sources, especially solar and wind, which have lower demand for unskilled or low-skilled labour during the construction and installation phases.

- There is still limited availability of local technical expertise in the solar and wind power sector. To meet the present demand, project developers in the power sector currently recruit engineers who are not specifically trained for the renewable energy sector, or else rely on foreign-trained experts. However, RE companies are willing to recruit skilled local workers if training at Vietnamese universities and technical schools is aligned with the technical skills demanded in the RE sector.

4.6.3. Improved air quality

A large number of solar and wind power plants contribute to generating electricity in the system, giving the national electric dispatching centres more options to mobilize power sources for the system load, which invisibly reduces mobilization level power from coal-fired power plants. Additionally, policy makers are assisted to have grounds to limit the construction of new coal-fired power plants. Consequently, it will help to reduce greenhouse gas emissions, improve air quality and people health.

Table 22 lists details of the sustainable development impact categories and indicators that may be associated with RE policies.

Table 22. Sustainable development impacts and indicators relevant to Solar PV and Wind energy policies

Impact categories	Indicators
Environmental impacts	
Air quality and health impacts of air pollution	- Emissions of air pollutants such as particulate matter (PM25, PM10), ammonia, ground-level…
	- Air pollutants concentration (mg/m3);
	- Indoor and outdoor air quality;
	- Aerosol particles concentration (mg/m3)…
Energy	- Energy consumption;
	- Energy efficiency;
	- Energy generated by source;
	- RE share of total final energy consumption;
	- Primary energy intensity of the economy.
Depletion of non-renewable resources	- Consumption of mineral resources;
	- Consumption of fossil fuels;
	- Scarcity of resources.
Social impacts	
Access to clean, reliable and affordable energy	- Percentage of population with access to clean, reliable and affordable energy;
	- Price of energy;
	- Emissions per unit of energy;
	- Number and length of service interruptions.
Economic impacts	
Job	- Number of people employed;
	- Number of people unemployed;
	- Employment rate; Unemployment rate;
	- Number of jobs.
	- Number of new companies;

Impact categories	Indicators
New business opportunities	- Revenue and profit;
	- Amount of new investment;
Growth of new sustainable industries	- Amount of investment in clean technology sector;
	- Number of projects.

Source: Renewable energy methodology – ICAT series of assessment guides

4.6.4 Negative impacts

In fact, the massive development of solar and wind power in recent years has created new challenges in the operation of the power system. Because the generating capacity of this type of energy is unstable, difficult to predict accurately and only emits during the day (from 6 to 18h daily, peaks at 12h noon with solar power), it is required to have a power supply system which have large redundancy.

Also, according to EVN's calculations, when renewable energy accounts for 20% of the total power source, the system operation will face many new challenges in stability compared to traditional power sources. In addition, with peak electricity consumption in the morning and evening on the system is nearly equal, so if there are 4,696 MW of solar power on the system as active, meeting the electricity demand at peak light, then that also means having available other power sources to replace solar power to meet the dark peak if there is no power cut. However, when more than 4,696 MW of other power sources are idle while solar power is generated, the initial investment cost must still be included in the electricity production cost of the whole system.

It should be realized that all solar panels in Vietnam markets are imported, mainly from China. The case of wind power market is nearly the same whereas only few parts could be manufactured domestically. At present, therefore, the more Vietnam develops its renewable energy, the higher profit the foreign traders get from selling equipment.

CHAPTER 5. MEASUREMENT, REPORTING AND VERIFICATION FOR KEY INDICATORS

5.1. Establishment of a national GHG inventory system, and Measurement, Reporting and Verification (MRV) system at all levels

Consultations with Vietnam's National Load Dispatch Centre indicate that Vietnam has the technical capability to record the power transactions which are sufficiently granular and transparent to satisfy the expectations of Direct Power Purchase Agreement (DPPA) Consumers. Presently metered data at sub-hourly intervals (30-minute) is collected daily from all GENCOs delivering into the Vietnam Wholesale Electricity Market (VWEM) as shown in ***Figure 16*** below. Metered data is displayed on a web portal so that the electricity buyer can check validity. Before being used for financial settlement purposes, the metered values must be accepted by RE GENCOs, the Metering Data Management Service Provider (MDMSP), and registered market buyers. This network and database can provide the credible and transparent metered data source needed for a RE registry for Vietnam.

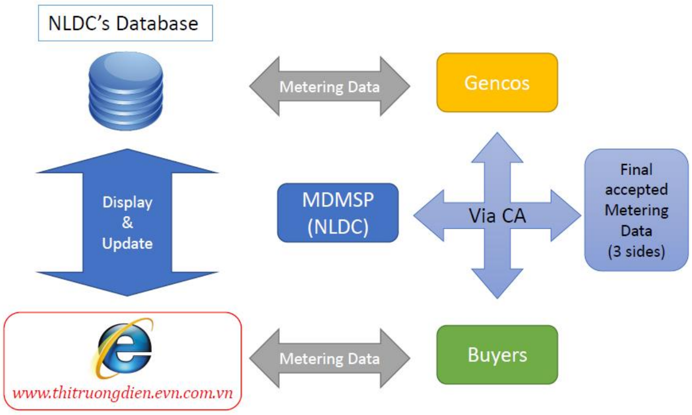


Figure 16. Model for RE Registry in Vietnam

Experience in managing a Renewable Energy Certificates (RECs) tracking system or introducing a local RECs tracking system in Vietnam will help equip GOV with the skills to establish systems for measuring, reporting and verification of emissions at the national and sectoral levels to monitor and supervise RE and GHG emissions activities by sectors and to meet the data requirement for examination and periodic reports as required by the UNFCCC.

5.2. Proposal for a Measurement, Reporting and Verification (MRV) system with key indicators for NDC tracking of progress in the energy sector

5.2.1. Key performance indicators

To estimate RE addition and GHG impacts ex-post, users collect data on a broad range of indicators and parameters to be monitored during the implementation period. There are three key indicators: Installed RE capacity (MW), Net electricity supplied to the electricity grid from RE (GWh), RE Share in the Power Generation Mix (%) to help track the performance of the policy. In addition, there are other indicators like: Grid emission factor (tCO_2e/MWh), Operating margin (%) and Build margin (%). These indicators are very useful for calculating GHG impacts using grid emission factor method and building a tender policy. However, the main indicators that are used for tracking implementation of the RE target in Vietnam's NDCs update, are the three key indicators mentioned above.

5.2.2. Measurement

Measurements are required to evaluate the policy's performance in order to understand if the policy is on track and is being implemented as planned. Taking measurements with the indicators is usually done at the facilities/sites level (at each plant).

Table 23. Measurement for three key indicators

Parameter and unit	Potential sources of data	Parameter type	Monitoring frequency
Installed RE capacity (MW)	Monitoring reports and surveys, installation registers data from RE GENCOs, EVN or MOIT	Measured	Monthly
Net electricity supplied to the electricity grid from RE (GWh)	Meter readings taken jointly by grid utility and power producer representatives. Data from RE GENCOs or EVN, all of the data is managed by EVN.	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 points connecting solar and wind power plants to the grid	Continuous measurement; monthly recording
Electricity mix (%)	Monitoring reports and surveys, installation registers by federal energy agencies, electricity market regulator	Measured and Calculated	Monthly

- *The installed RE capacity (MW):* After the construction is completed, the solar or wind power plants will be put into operation to generate electricity and then sell the electricity back to EVN through the transmission grid. The capacity of factories is recorded as installed capacity. EVN and the management agency (specifically MOIT) will synthesize the capacity of factories across the country for monitoring, evaluation and reporting. The construction of new power plants completely must comply with the approved Power Plan (revised PDP 7 and upcoming PDP 8).

In addition, there is a difference in generating capacity of solar and wind power plants compared to thermal and hydroelectric plants. The generating capacity of solar and wind power plants also depends on weather factors such as the number of sunny hours or the wind speed of each time in unit days.

- *The net electricity supplied to the electricity grid from RE (GWh):* Power generation companies (including RE GENCOs) sell electricity to EVN through signing power purchase agreements (PPA). Therefore, information on electricity output is connected to the grid, and EVN and the power generation company both manage and monitor. In which, EVN will have information on the commercial electricity output of all power sources connected to the transmission grid system of Vietnam. This parameter is measured and monitored regularly, continuously and summarized every month through electricity bills.

- *Electricity mix (%):* Based on the electricity supplied to the grid form all the power plants in the system every month, EVN will measure and calculate the power contribution rate of each type of power source for monitoring and reporting to regulatory authority (including MOIT) when is required.

5.2.3. Reporting

Reporting the results is important to ensure that the impact assessment is transparent, and provide decision makers and stakeholders with the information they need to properly interpret the results. In Vietnam, the draft decision of the Prime Minister to promulgate a national system for measuring, reporting and verification greenhouse gas emissions is being promptly prepared by the Ministry of Natural Resources and Environment of Vietnam. In Appendix 1 of that Decision, there is a report form for sector-level GHG emission reduction report.

The ICAT Series of Assessment Guides (including renewable energy methodology) provides a list of information that is recommended for inclusion in an assessment report. The information is very specific, clear and very useful to policy makers.

There are three types of reports: facility report, sectoral report and national report. However, for the three key indicators, we pay much attention to facility report.

Table 24. Reporting for three key indicators

Indicators	Reporting Agency	Reporting frequency
Installed RE capacity (MW)	RE GENCOs make reports or hire a consultant (with licensed functions) to prepare their reports.	Monthly
Net electricity supplied to the electricity grid from RE (GWh)	RE GENCOs make reports or hire a consultant (with licensed functions) to prepare their reports.	Monthly or Quarterly
Electricity mix (GWh per technology)	EVN make reports or hire a consultant (with licensed functions) to prepare their reports.	Monthly or Quarterly

5.2.4. Verification

Verify (V) by periodically subjecting the reported information to some form of review or analysis or independent assessment to establish completeness and reliability. Verification helps to ensure accuracy and conformance with any established procedures, and can provide meaningful feedback for future improvement.

- For the measurement at facilities lever, there are 3 types of verification:

+ Evaluation of measurement method;

+ Validation of measurement process;

+ Verify measurement results.

=> This appraisal is assigned to the consultants with the function and capacity of appraisal. The consultants and facilities are responsible for the verification results.

- For the verification of reports at facilities lever: This appraisal is assigned to the authorities to manage by sector and related fields (specifically the Department of Electricity and Renewable Energy, Ministry of Industry and Trade).

CHAPTER 6. CONCLUSIONS

In a global perspective and in order to pursue the 1.5-degree target set out in the Paris Agreement, global emissions must reach net zero around 2050. This requires huge efforts from all countries, including emerging economies like Vietnam. Locally, air pollution especially from coal is growing, which both imposes large costs on the society and spurs public resistance towards coal power plants. Both CO_2 emissions and other pollutants are expected to grow quickly in the future. The development pathways outlined in the EOR19 show a trend of increasing CO_2 emissions towards 2050.

Vietnam's NDCs update in 2020 has set a target of reducing 9% of total GHG emissions by 2030 compared to BAU by country efforts, and the reduction can increase to 27% compared to BAU, when receiving international assistance through bilateral and multilateral cooperation as well as implementation of mechanisms in the new Global Climate Agreement.

Energy sector regulation is complex and implies a large array of system inter-dependencies ranging over several ministries. It is important to consider the harmonization and alignment of policies across sectors to ensure an efficient effort in emission reduction. This includes a continuous comparison of RE targets, energy system efficiency, and emission targets.

The ICAT Series of Assessment Guides, especially the renewable energy methodology provides a stepwise approach for estimating the effects of policy design characteristics, economic and financial factors, and other barriers on the potential for RE policies to achieve their technical potential for the assessment period.

There are four assumptions for mitigation options (about RE) in the energy sector in the NDCs update 2020 report. Based on existing data from Vietnam, the expert group gave the parameters to evaluate the achievement of the RE's targets.

Currently, the installed capacity of solar power plants has reached the set target, the target for installed capacity of wind power plants is being implemented. However, the development of renewable energy sources still needs the synchronization of the development of the power grid to satisfy capacity release for power plants. It is important to avoid the situation that power plants though rapidly blooming but cannot generate maximum capacity, to ensure their financial plans.

In addition, the evaluation of policy and its impact help policy-makers and other decision makers to develop effective and transformational strategies for achieving GHG mitigation and broader sustainable development objectives through a better understanding of the impacts of policies and actions.

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APPENDIX

Appendix A: Fossil fuel energy balance in 2014

TJ units	LPG	Gasoline	Jet Fuel	Diesel	HFO	Kerosene and other	Total oil products	Coal	Lignite	Natural Gas	Coke	Petrocoke	Total energy
Unit	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ
Total	57,160	197,090	37,850	319,270	32,810	1,120	645,300.0	780,330	0	439,470	0	0	1,865,100
Fossil power plants	0	0	0	2,370	4,960	0	7,330.0	385,300	0	323,490	0	0	716,120
FINAL CONSUMPTION	57,160	197,090	37,850	316,900	27,850	1,120	637,970.0	395,030	0	115,980	0	0	1,148,980
Industry - steel	940	0	0	5,910	5,260	0	12,110.0	4,110	0	6,420	0	0	22,640
Industry - chemical	570	0	0	3,940	5,030	10	9,550.0	40,530	0	76,820	0	0	126,900
Industry - non metallic mineral		0	0			0	0.0		0		0	0	0
Industry - food processing and beverage	2,000	0	0	2,100	780	0	4,880.0	5,500	0	1,030	0	0	11,410
Industry - construction	2,730	0	0	21,850	2,430	30	27,040.0	174,730	0	9,150	0	0	210,920
Industry - mining		0	0			0	0.0		0		0	0	0
Industry - machinery		0	0			0	0.0		0		0	0	0
Industry - non ferrous metals		0	0			0	0.0		0		0	0	0
Industry - paper and pulp	140	0	0	7,140	510	70	7,860.0	83,730	0	430	0	0	92,020
Industry - transport equipment		0	0			0	0.0		0		0	0	0
Industry - textile and leather	190	0	0	2,010	50	0	2,250.0	20,710	0	3,570	0	0	26,530
Industry - miscellaneous	2,790	0	0	70	60	180	3,100.0	13,170	0	18,560	0	0	34,830
Transport - road		192,250	0	196,018	9,700	0	397,968.0		0		0	0	397,968
Transport - rail		0	0	1,616		0	1,616.0		0		0	0	1,616
Transport - domestic air		0	37,850	13,746		0	51,596.0		0		0	0	51,596
Transport - navigation		0	0			0	0.0		0		0	0	0
Households	29,390	0	0	640		700	30,730.0	38,720	0		0	0	69,450
Services	18,410	0	0	12,330		130	30,870.0	13,130	0		0	0	44,000
Agriculture & Fishery		4,840	0	49,530	4,030	0	58,400.0	700	0		0	0	59,100
Non energy - chemical feedstocs		0	0			0	0.0		0		0	0	0

Appendix B: Growth from start year 2014[20]

Growth from the start year	Annual % increase in the period		
Growth and multiplication factors	**2014-2020**	**2020-2025**	**2025-2030**
Population growth	1.05%	0.87%	0.69%
GDP growth	6.73%	7.00%	7.00%
Industry - fuel in steel	7.0%	7.0%	7.0%
Industry - fuel in chemical	7.0%	7.0%	7.0%
Industry - fuel in non metallic mineral	7.0%	7.0%	7.0%
Industry - fuel in food and beverage	7.0%	7.0%	7.0%
Industry - fuel in construction	7.0%	7.0%	7.0%
Industry - fuel in mining	7.0%	7.0%	7.0%
Industry - fuel in machinery	7.0%	7.0%	7.0%
Industry - fuel in non ferrous metals	7.0%	7.0%	7.0%
Industry - fuel in paper and pulp	7.0%	7.0%	7.0%
Industry - fuel in transport equipment	7.0%	7.0%	7.0%
Industry - fuel in textile and leather	7.0%	7.0%	7.0%
Industry - fuel in miscellaneous	7.0%	7.0%	7.0%
Industry - electricity consumption	7.0%	7.0%	7.0%
Transport - fuel in road	7.0%	7.0%	7.0%
Transport - fuel in rail	7.0%	7.0%	7.0%
Transport - fuel in air	7.0%	7.0%	7.0%
Transport - fuel in navigation	7.0%	7.0%	7.0%
Transport - electricity consumption	7.0%	7.0%	7.0%
Households - LPG	7.0%	7.0%	7.0%
Households - Kerosene	7.0%	7.0%	7.0%
Households - electricity consumption	7.0%	7.0%	7.0%
Services - fuel	7.0%	7.0%	7.0%
Services - electricity consumption	7.0%	7.0%	7.0%
Agriculture - fuel	6.0%	6.0%	6.0%
Agriculture - electricity consumption	6.0%	6.0%	6.0%
Non energy - fuel in chemical feedstocs	7.0%	7.0%	7.0%
Livestock emissions	6.4%	1.8%	1.8%
Rice emissions	-2.0%	0.2%	0.2%
N2O from agricultural soils	0.0%	0.0%	0.0%
Biomass burning	5.3%	0.7%	0.7%
Forestry emission	0.0%	-20.6%	0.6%
Solid waste emissions	12.6%	14.1%	14.1%
Liquid waste emissions	6.6%	2.9%	2.9%
Industrial processes	0.0%	0.0%	0.0%

[20] Vietnam Population Forecast 2009-2049 of the General Statistics Office in 2011;
Prime Minister's Directive 18 / CT-TTg of April 13, 2020 on elaboration of the socio-economic development plan Meeting in 2021-2025.

Appendix C: Assumptions

Country:		Vietnam	
Start year (latest inventory):		2014	
Currency:		VND	
Exchange rate used:	1 US$=	21285.71062	VND
Discount rate =		10.0%	

Energy prices used for the whole period[21]:		
Crude oil	51.52	US$/bbl
Crude oil	0.32	US$/litre
LNG	4.4	US$/MBTU
Natural gas	4.170616114	US$/GJ
Coal	60	US$/ton

Fuel prices

2020 prices	Destillate price/crude oil price (litre/litre)	US$/liter	US$/GJ	t/m3	GJ/t
LPG	0.90	0.29	11.4	0.54	47.3
Gasoline	1.40	0.45	13.5	0.75	44.8
Bioethanol		0.83		0.76	26.8
Jet Fuel	1.40	0.45	12.7	0.80	44.6
Diesel Oil	1.20	0.39	10.7	0.84	43.3
Biodiesel		1.20		0.88	26.8
Heavy Fuel Oil	0.80	0.26	6.6	0.98	40.2
Kerosene	1.40	0.45	12.7	0.80	44.8
Coal			2.5		25.0
Coke			2.5		28.0
Petroleum coke			2.5		31.0
Lignite					18.3
Natureal Gas			4.2	(MJ/Nm3)	39.0

Electricity	Isolated grids	Grid 1	Grid 2
US$/kWh		0.07	
	tCO2/MWh (=kCO2/kWh)		
Operating margin (OM)			

[21] The Statistics Portal http://www.statista.com/statistics/262858/change-in-opec-crude-oil-prices-since-1960/

Build Margin (BM)			
Combined Margin (CM) Solar & Wind		0.9130	
Combined Margin (CM) Other[22]		**0.9130**	
Heat	District heat	Industry	
US$/GJ	6.7	8.7	
Electricity grid losses & own consumption	18.6%		

kg/GJ	**Emission factors**	CO2	CH4	N2O
Power plant	Fuel oil	77.4	0.003	0.0006
	Diesel oil	74.1	0.003	0.0006
	Gasoline	69.3	0.003	0.0006
	Jet fuel	71.5	0.003	0.0006
	Kerosene	71.9	0.003	0.0006
	LPG	63.1	0.001	0.0001
	Natural gas	56.1	0.001	0.0001
	Coal	94.6	0.001	0.0014
	Lignite	101.2	0.001	0.0014
Industry	Oil	as	0.002	0.0006
	Natural gas	above	0.005	0.0001
	Coal		0.010	0.0014
	Charcoal		0.200	0.0040
Residential	Oil	as	0.010	0.0006
	Natural gas	above	0.005	0.0001
	Coal		0.300	0.0014
	Charcoal		0.200	0.0040

Global warming potentials:	SAR	AR4	AR5	GWP used		TAR
1 Ton CH4 =	21	25	28	21	Ton CO2	23
1 Ton N2O =	310	298	265	310	Ton CO2	296

[22] Document No. 263 / Climate Change-TTBVTOD of the Department of Climate Change, Ministry of Natural Resources and Environment dated March 12th, 2020 on notification of emission factors of Vietnam's electricity grid in 2018

Appendix D: Wind power plants[23]

General inputs:		
Discount rate	10%	
Reference electricity price	0.07	US$/kWh
CO2-eq. emission coefficient	0.91	tCO2/MWh
Reduction option: Wind Power		
O&M	2.50%	
Activity	1	MW
Investment in Activity	1600	US$/kW
Capacity factor	3300	Full time hours
Electricity production	3300	MWh/ year
Cost of electricity produced	0.069	US$/kWh
Reference option: No wind turbines		

1 MW Wind turbines connected to main grid (on-shore)			
Costs in US$	Reduction Option	Reference Option	Increase (Red.-Ref.)
Total investment	1600000		
Project life	20		
Lev. investment	187935		187935
Annual O&M	40000		40000
Annual fuelcost		214500	-214500
Total annual cost	227935	214500	**13435**
Annual emissions (tons)	Tons	Tons	Reduction
Fuel CO2-eq. emission		3012.9	3012.9
Other			
Total CO2-eq. emission	0.0	3012.9	**3012.9**
US$/ton CO2-eq.			**4.5**

[23] Technology Handbook 2019 – Institute of Energy, 2019;

Appendix E: Solar PV power plants[24]

General inputs:		
Discount rate	10%	
Reference electricity price	0.07	US$/kWh
CO2-eq. emission coefficient	0.91	tCO2/MWh
Activity: Solar PV		
Size of solar PV	1.0	MW
Investment in Activity	1100	US$/kW
Daily insolation	5	hours
Annual capacity factor	1825	Full time hours
Efficiency factor	1	
O&M	1.0%	Of investment
Electricity production	1825	MWh
Cost of electricity produced	0.077	US$/kWh
Reference option: No solar PVs		
Electricity production	1825	MWh

Solar PVs, large grid, 1 MW			
Costs in US$	Reduction Option	Reference Option	Increase (Red.-Ref.)
Total investment	1,100,000		
Project life	20		
Lev. investment	129,206		129,206
Annual O&M	11,000		11,000
Annual fuelcost		118,625	-118,625
Total annual cost	140,206	118,625	**21,581**
Annual emissions (tons)	Tons	Tons	Reduction
Fuel CO2-eq. emission		1,666	1,666
Other			
Total CO2-eq. emission	0	1,666	**1,666**
US$/ton CO2-eq.			**13.0**

[24] Technology Handbook 2019 – Institute of Energy, 2019;