Vietnamese Rooftop Solar PV Technical and Financial Analysis – Case of Industrial Zones

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Executive Summary

Under the framework of the Global Climate Action Initiative (GCAI), the Global Environmental Institute (GEI) is collaborating with its Vietnamese partner, a non-governmental organization (NGO) called Green Innovation and Development Centre (Green ID), to accelerate the development of rooftop solar photovoltaic (PV) systems in 18 industrial zones in Vietnam. This report adopts the Renewable Energy Implementation (REI) toolkit to conduct an analysis of rooftop solar PV policy, and to assess the technical potential and environmental benefits of the selected 18 industrial zones. In addition, this report takes the Quan Ngang (1 and 2) industrial zone as an example to evaluate its financial performance under the baseline scenario.

Solar energy has become one of the most significant potential renewable energy sources in Vietnam. Once solar energy was prioritized in the adjustment of the Power Development Plan VII (PDP7), the deployment of rooftop solar systems expanded dramatically in recent years, with a total installed capacity of 9,730 MWp, including 105,212 rooftop solar systems by 2020. Supportive policies and attractive fiscal incentives have been considered the main reason for this expansion. However, many supportive policies and regulations have become outdated recently: for example, the Fit-in-Tariff (FiT) 2 for solar energy expired at the end of 2020. In the next 10 years, energy development will be determined by the Power Development Plan VIII (PDP8), which is expected to be officially released at the end of 2022. The draft of PDP8 mentioned that new finance and capital mobilization mechanisms would be developed to attract foreign and private investment in solar energy. The competitive auction mechanism, direct

power purchase agreement, and range price will allow the free negotiation of tariff and power purchase agreements between rooftop solar generators and commercial buyers.

This report analyses the technical potential of 18 industrial zones in terms of their rooftop solar PV systems and the environmental benefits they might bring. Regarding the technical potential, the result shows that in total, the 18 industrial zones have 5,021 available rooftops, with a total area of around 7,079,574 m^2. The potential installed capacity of all rooftops' solar PV is 732 MW, with a potential annual electricity production of around 808.99 GWh. With the rooftop solar PV installed, they have the potential to reduce fossil energy consumption by 364,047 tons of coal equivalent per year. From the perspective of greenhouse gas (GHG) emission reduction, their use of rooftop solar PV might reduce CO_2 equivalent by 489,396 tons per year.

The financial analysis shows that the rooftop system in Quan Ngang (1 and 2) industrial zones is still profitable under the current policy. The rooftop solar PV project in the Quan Ngang (1 and 2) industrial zone has an internal rate of return (IRR) of 13.9%, with a payback period (PBP) of around 5.42 years, and the discounted PBP of around 7.25 years. The levelized cost of electricity (LCOE) of the rooftop solar projects is 0.044USD/kWh which is lower than the LCOE of the coal-fired plant (0.0764 USD/kWh), and the return on investment (ROI) is 50.1%.

However, when implementing the rooftop solar PV projects in Vietnam, GEI observes that they face policy risks, capital risks and operational risks. Vietnam lacks a market mechanism in the solar PV industry, and the current policies are uncertain and inconsistent. The capital risk of rooftop solar PV projects is due to the unstable electricity price and its cost. The performance of equipment and power load capacity can also have an impact on the projects. Therefore, GEI suggests that the sub-national governments should incorporate rooftop solar PV into their regional planning, and set the minimum utilization ratio of rooftop solar PV in industrial zones. In addition, the national government should enact renewable energy law, improve the consistency of solar PV policy instruments, and implement policies to promote green industrial zones. Most importantly, with a growing pool of international sustainable finance, Vietnamese governments should create favourable business models and diverse financial recourses, to facilitate the scale-up of solar PV projects in Vietnam.

List of Abbreviations

BOT: Build-operate-transfer projects
CCS: Center for Climate Strategies
CIT: Corporate income tax
COP 26: 26th session of the Conference of the Parties
DCF: Discounted cash flow
DoIT: Departments of Industry and Trade
DPB: Discounted payback period
DPPA: Development of direct PPAs
EPC: Engineering, procurement and construction
ERAV: Electricity Regulatory Authority of Vietnam
EVN: Electricity of Vietnam
FCF: Fixed cost factor
FDI: Foreign direct investment
FiT: Feed-in tariff
FiT1: First FiT
FiT2: Second (new) FiT
FOM: Fixed operation and maintenance cost
GCAI: Global Climate Action Initiative
GDP: Gross domestic product
GEI: Global Environmental Institute
GHG: Greenhouse gas
GIEC: Guangzhou Institute of Energy Conversion
GIS: Geographic information system
Green ID: Green Innovation and Development Centre
GW: Gigawatts
IIC: Initial investment cost
IPP: Independent power producers
IRR: Internal rate of return
LCOE: Levelized cost of electricity
MARR: Minimum acceptable rate of return
MoF: Ministry of Finance
MoIT: Ministry of Industry and Trade
NDC: Nationally Determined Contribution
NGO: Non-governmental organization
NREL: National Renewable Energy Laboratory
PBP: Payback period
PDP7: Power Development Plan VII
PDP8: Power Development Plan VIII
PPA: Power purchase agreement
PV Power: Petrovietnam Power
RE: Renewable energy
REI: Renewable energy implementation
ROI: Return on investment
TKV Power: Vinacomin Power
VOM: Variable operation and maintenance cost

Table of Contents

Executive Summary 1
List of Abbreviations 2
Table of Contents 3
List of Figures 4
List of Tables 4
1. Introduction 5
2. Overview of the Renewable Energy Implementation (REI) Toolkit 7
3. Country Overview 8
3.1 Energy Sector Governance 8
3.2 Energy Demand and Supply 8
3.3 Renewable Energy Sector Status and Trend 9
3.4 Solar PV 10
3.4.1 Overview 10
3.4.2 Rooftop Solar 10
4. Solar PV Energy Policy 11
4.1 Overview 11
4.2 Key Policies 12
4.3 Targets 13
4.4 Policy Support and Incentives 14
4.4.1 Feed-in Tariff 14
4.4.2 PPA and DPPA 15
4.4.3 Tax Exemption 17
4.4.4 Private and International Investment 17
4.4.5 Project Development 17
5. Technical Assessment and Environmental Benefits of Rooftop Solar PV 18
5.1 Overview of the Industrial Zones 18
5.2 Solar PV Technical Potential of the Industrial Zones 19
5.2.1 Method 19
5.2.2 Result 20
5.2.3 Environmental Benefits 20
6. Financial Analysis of Rooftop Solar Photovoltaic Systems in Vietnam in the Case of Quan Ngang Industrial Zone 22
6.1 Business Model 22
6.2 Financial Analysis Indicators 23
6.3 Input of Financial Analysis 24
6.4 Financial Analysis Results for the Industrial Rooftop Photovoltaic Project 26
6.5 Uncertainty and Sensitivity Analysis of Rooftop Solar PV Projects in Quan Ngang (1 and 2) Industrial Zones 27
7. Risk Analysis 30
7.1 Policy Risk 30
7.2 Capital Risk 30
7.3 Operational Risk 30
8. Policy Recommendations 32
8.1 Strengthen Planning 32
8.2 Improve Relevant Regulations 32
8.3 Expend Financial Resources 32
References 33

List of Figures

Figure 1 Renewable Energy Technical Potential theory proposed by the National Renewable Energy Laboratory (NREL). 7
Figure 2 Governance structure of the power sector in Vietnam. 8
Figure 3 Total final energy consumption by sector in Vietnam from 2000 to 2019. 8
Figure 4 Share of final energy consumption by sector in Vietnam from 2000 to 2019. 9
Figure 5 Share of energy supply by source in Vietnam from 2000 to 2019. 9
Figure 6 Total energy supply by source in Vietnam from 2000 to 2019. 9
Figure 7 Installed capacity of renewable energy by sources in Vietnam from 2011 to 2020 9
Figure 8 Share of installed capacity of renewable energy by sources in Vietnam from 2011 to 2020 10
Figure 9 Total number and total installed capacity of rooftop solar systems in Vietnam by the end of 2020. 10
Figure 10 Total number and total installed capacity of rooftop solar systems by customer group in Vietnam by the end of 2020 10
Figure 11 Vietnam's power structure in 2020, 2025 and 2030, proposed in the adjustment of PDP 7. 14
Figure 12 FiT and weighted average LCOE for solar power in Vietnam 15
Figure 13 Conventional business model of solar PV projects 16
Figure 14 Roof leasing model of solar PV projects when the investor/developer sells the electricity via the meter of the roof owner 16
Figure 15 Roof leasing model of solar PV projects when the investor/developer sells the electricity via the meter separately from the roof owner. 16
Figure 16 Business model of DPPA for rooftop solar power projects 17
Figure 17 The process for developing a rooftop solar PV project 17
Figure 18 Locations of the 18 industrial zones. 18
Figure 19 Identification of the rooftops of. Quan Ngang (1 and 2) indusial zone. 20
Figure 20 Two financing models of rooftop photovoltaic power generation projects 22
Figure 21 Discounted cash flow of overall photovoltaic systems in industrial zone 27
Figure 22 Cumulative discounted net cash flow probability density 27
Figure 23 Spider chart of net cash flow sensitivity analysis 28
Figure 24 Tornado chart of net cash flow sensitivity analysis 28

List of Tables

Table 1 Overview of policy instruments for rooftop solar PV in Vietnam. 11
Table 2 Key policies regarding solar energy in Vietnam. 12
Table 3 Vietnam's power development targets proposed in the adjustment of PDP7, the draft of PDP8 and the Approval of the Rooftop Solar PV Promotion 13
Table 4 Feed-in tariff for solar power 15
Table 5 Industrial zones analysed in this study in Bac Lieu, Quang Tri, Dong Thap and Hai Phong provinces in Vietnam. 18
Table 6 Industrial zones with Chinese capital investment in Vietnam. 19
Table 7 Solar PV technical potential of the industrial zones in Vietnam. 20
Table 8 Project input data of rooftop solar PV system in Quan Ngang industrial zone, Vietnam. 24
Table 9 Financial input data of rooftop solar PV system in Quan Ngang 1 and 2 industrial zone, Vietnam 25
Table 10 Cost-benefit analysis results of rooftop solar PV project in industrial zone under the baseline scenario 26
Table 11 Input and output values of sensitivity analysis 28

1. Introduction

Vietnam has been experiencing rapid economic growth and development, with an annual gross domestic product (GDP) growth rate of around 7% for the past decade.[1] Due to a growing population, rising incomes, and the rapid rate of urbanization and industrialization, it is predicted that the demand for energy in Vietnam will increase by 8% by 2023.[2,3] Meanwhile, the energy sector in Vietnam is reported to account for about 65% of national greenhouse gas (GHG) emissions.[4] The energy supply in Vietnam heavily depends on fossil fuels, amounting to 85% of the primary energy system in 2019.[10]

To promote energy transition, the Vietnamese government has made bold pledges. Vietnam's Prime Minister Pham Minh Chinh stated at the 26th session of the Conference of the Parties (COP 26) that Vietnam would reach its net-zero carbon emission target by 2050. Also, Vietnam aims to reduce GHG emissions by 9% with domestic resources, and 27% with international support, by 2030, as per the Nationally Determined Contribution (NDC). Vietnam had already identified transitions to renewable energy as a prerequisite for achieving the government's commitment to energy availability and international climate change treaties.[5] Government officials have stated that they will double the installed wind and solar power generation capacity to 31–38 gigawatts (GW) by 2030.

Rooftop solar systems have experienced rapid expansion since 2020 in Vietnam, achieving a total installed capacity of 9,730 MWp, with 105,212 rooftop solar systems by the end of 2020.[7,8] Its installed capacity succeeds that of solar power plants, accounting for around 59% of the total solar photovoltaic (PV) capacity in 2020. Solar energy has been considered the most significant potential renewable energy source in Vietnam due to its expansive solar resources and competitive price.[6] In Vietnam, the weighted-average levelized cost of electricity (LCOE) declined by 58%, and the weighted-average total installation cost reduced by 58%, between 2016 and 2020.[9]

Industry is the largest energy consumer, with a share of more than 50% of the total energy consumption in recent years. In addition, it is the most significant contributor to the increase in energy consumption in Vietnam.[10] Thus, releasing the potential of rooftop solar PV in industrial areas is vital to Vietnam's green energy transition. The development of industrial zones in Vietnam has accelerated significantly in recent years, due to the continued improvement of fiscal and non-fiscal incentives. By the end of 2021, Vietnam had 564 industrial zones in the stage of planning, with a total area of 211,700 hectares; 400 industrial zones have been established, with a total area of 123,500 hectares; of these, 292 industrial zones have been put into operation, and 108 industrial zones are under construction.[11]

Developers of industrial zones in Vietnam are showing great interest in partnering with solar companies to build rooftop solar PV systems for industrial zones. For example, Sojitz Corporation, Hong Duc Industry JSC (part of DEEP C Industrial Zone) and Bamboo Capital Group signed a triparty cooperation agreement to develop a US$250 million industrial zone and ancillary infrastructure. They set the goal of developing the first fully energy-independent industrial zone in Vietnam by installing rooftop solar power systems.[12] However, studies that examine the technical and financial feasibility of rooftop solar PV systems in industrial zones are still limited.

This report aims to accelerate the development of rooftop solar PV systems in industrial zones in Vietnam by adopting the REI toolkit to conduct an analysis of rooftop solar PV policy, to assess its technical and financial potential. It evaluates the technical potential and environmental benefits of rooftop solar PV systems in 18 selected industrial zones, and employs the Quan Ngang (1 and 2) industrial zone as an example, to examine its financial performance under the baseline scenario. Based on the assessments, this report also analyses the potential risks, and proposes policy recommendations for promoting rooftop solar systems in industrial zones of Vietnam.

The report contains the following sections:

- Chapter 2 introduces the REI toolkit.
- Chapter 3 describes the state quo of renewable energy development in Vietnam, including energy sector governance, energy demand and supply, and the status and trend of renewable energy and rooftop solar PV.
- Chapter 4 presents the policy analysis of rooftop solar PV development.
- Chapter 5 presents the assessment of rooftop solar PV's technical potential; environmental benefits of the 18 industrial zones, including the number and area of

available rooftops; potential installed capacity; annual electricity production; possible fossil fuel reduction and carbon dioxide reduction.

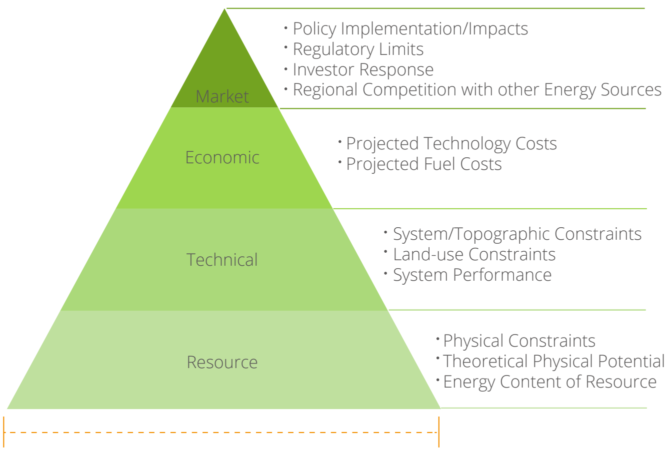
- Chapter 6 presents the financial potential assessment of Quan Ngang (1 and 2) industrial zone.
- Chapter 7 conducts a risk analysis of rooftop solar PV project in Quan Ngang (1 and 2) industrial zone.
- Chapter 8 proposes policy recommendations.

2 Overview of the Renewable Energy Implementation (REI) Toolkit

The Global Environmental Institute (GEI), together with the Center for Climate Strategies (CCS) and the Guangzhou Institute of Energy Conversion (GIEC) of the Chinese Academy of Science, developed the Renewable Energy Implementation (REI) Toolkit.

The research logic of the REI Toolkit is based on the Renewable Energy Technical Potential theory proposed by the National Renewable Energy Laboratory (NREL) (Figure 1). The four levels of energy potential are resource, technical, economic, and market. 'Resource' refers to theoretical natural potential, which is the total amount of the specific energy resource. 'Technical' means the available potential of techniques, with the considerations of technical implementation. 'Economic' represents the available potential to generate profit after evaluating economic feasibility. Finally, 'market' is the resource potential that is competitive in the market and groundable, while considering the market preference. Each ascending level of energy potential is based on the underlying potential, and is further reduced.

Figure 1 Renewable Energy Technical Potential theory, proposed by the National Renewable Energy Laboratory (NREL).



Based on the demand consultation with a Vietnamese partner, Green Innovation and Development Centre (GreenID), this report focuses on the technical and financial potential, and the environmental benefits assessments, of rooftop solar PV projects in the industrial zones.

The REI Toolkit includes Microsoft Excel-based workbooks, document templates and guidance documents, to assist different levels of jurisdictions (including cities, provinces/states and countries) in the evaluation, implementation and scale-up of renewable energy (RE) projects and programmes. To complete the above-mentioned assessments, the following tools of REI toolkits are developed and applied:

1. Spatial Analysis Tool: to recognize the number and area of the available rooftops using an open-source geographic information system (GIS) (see 5.2.1).
2. Technical Potential Calculation Tool: to calculate potential installed capacity and annual electricity production (see 5.2.1).
3. Environmental Benefit Estimation: to calculate fossil fuel reduction and carbon dioxide reduction, based on the annual electricity production, Vietnamese standard coal consumption rate for generation, and Vietnamese emission factors (see 5.2.1).
4. Financial Risk and Return Assessment Tool: to evaluate key financial performance by collecting system cost data, project description data, and financing data, to estimate financial performance (see 6.2).

3. Country Overview

Vietnam is located at the eastern edge of mainland Southeast Asia. It covers 311,699 square kilometres. With a population of over 97 million, it is the world's fifteenth most populous country.[13] About 63.2% of the population lives in rural areas.[14]

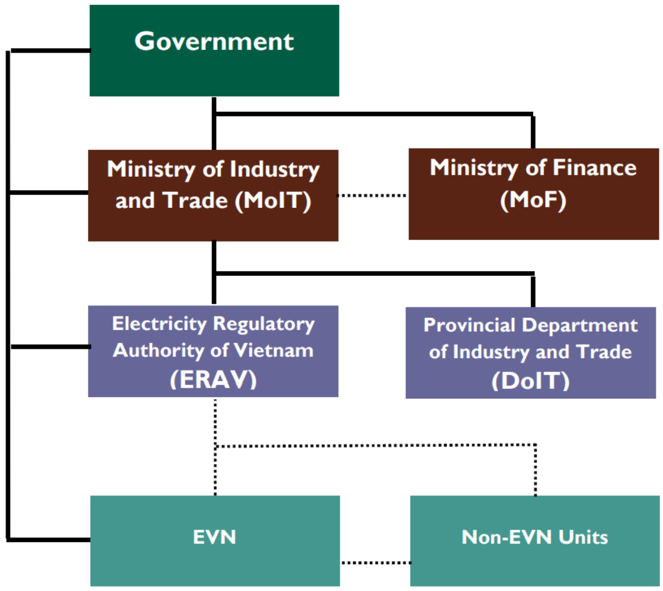
Vietnam has experienced rapid economic growth over the past two decades, making it one of the strongest and fastest-growing economies in Southeast Asia.[15] The annual growth rate of GDP has been around 7% for the past decade, while the poverty headcount has declined from nearly 60% to 20% in the past 20 years.[1] Meanwhile, as one of the countries most at risk of climate change threats, Vietnam has seen a steep increase in GHG emissions that contribute to climate change, and a steadily growing energy demand.[1,3] It is reported that the energy sector accounts for about 65% of national GHG emissions.[4]

3.1 Energy Sector Governance

In Vietnam, the government and the prime minister issue decrees, regulations and mechanisms to manage energy activities, approve energy development strategies, and decide on policies for energy tariffs, large-scale projects, and especially important projects. The governance structure of the power sector in Vietnam is demonstrated in Figure 2.

The Ministry of Industry and Trade (MoIT) is the institution that manages issues related to energy. The Ministry of Finance (MoF) is responsible for setting tariffs, fees and tax policies related to the energy sector. The Electricity Regulatory Authority of Vietnam (ERAV) is the agency that performs the function of advising and assisting MoIT in state management and the implementation of state management tasks in the fields of electricity, energy and renewable energy. At the local level, the provincial Departments of Industry and Trade (DoIT), subject to the inspection and guidance of MoIT, manage local energy issues, including electricity and renewable energy. Electricity of Vietnam (EVN), a state-owned company, occupies more than 61% of the national electricity capacity.[16] Other main players in the power production market are Vinacomin Power (TKV Power), Petrovietnam Power (PV Power), build-operate-transfer projects (BOT), and independent power producers (IPP). Meanwhile, EVN holds a monopoly on transmission.

Figure 2 Governance structure of the power sector in Vietnam.



3.2 Energy Demand and Supply

It is predicted that the demand for energy in Vietnam will increase by 8% by 2023.[2] As shown in Figure 3 and Figure 4, industry is the largest energy consumer, with a share of more than 50% of total energy consumption in recent years, while it is also the largest contributor to the increase in energy consumption in Vietnam. To fulfil the increasing energy demand, Vietnam requires a capacity growth of 6–7 GW annually by 2030.[2] According to MoIT, a total investment of approximately USD 150 billion by 2030 will be needed to meet such demand.

Figure 3 Total final energy consumption by sector in Vietnam from 2000 to 2019.[10]

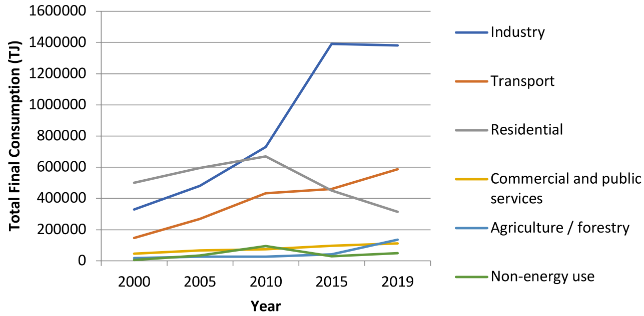
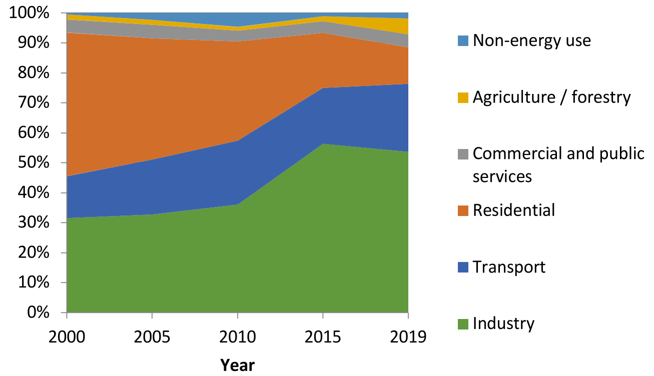


Figure 4 Share of final energy consumption by sector in Vietnam from 2000 to 2019.[10]



As shown in Figure 5, the energy supply in Vietnam heavily depends on fossil fuels. In 2019, the share of coal, oil, and natural gas in the energy supply structure was 51%, 24%, and 9% respectively. As shown in Figure 6, except for biofuels and waste, the generation capacity of all energy sources increases continuously from 2000 to 2019. However, the share of fossil fuel increases from 46% to 84% in this period, while the share of renewable energy decreases from 53% to 16%, as the deployment of fossil fuel surpasses that of renewable energy.

Figure 5 Share of energy supply by source in Vietnam from 2000 to 2019.[10]

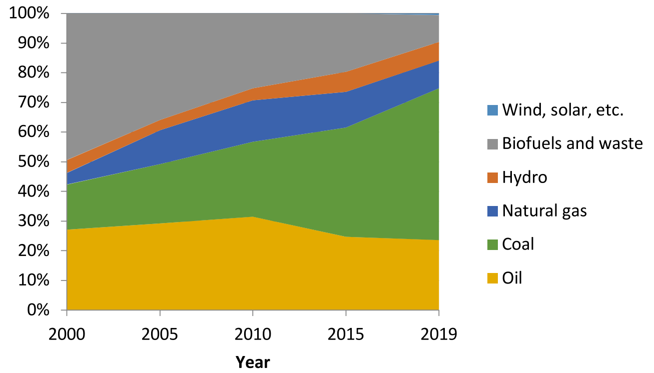
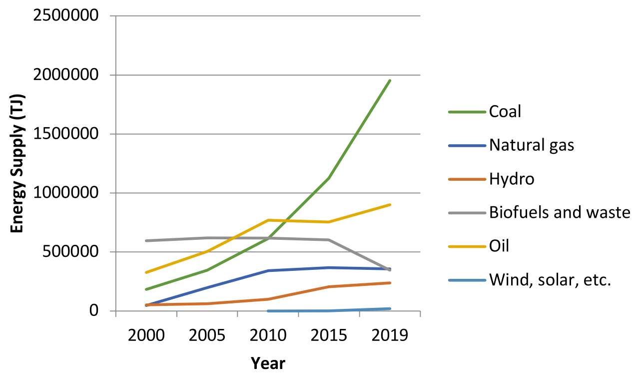


Figure 6 Total energy supply by source in Vietnam from 2000 to 2019.[10]

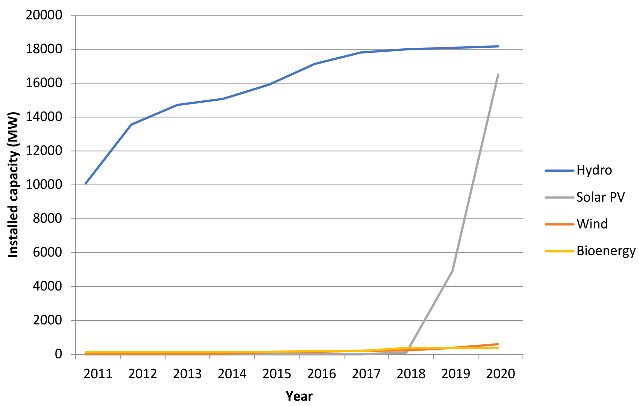


3.3 Renewable Energy Sector Status and Trend

From 2011 to 2020, the total installed capacity of renewable energy in Vietnam increased from 10,241 MW to 35,650 MW (Figure 7). Hydropower was the dominant source of renewable energy in Vietnam before 2018. As shown in Figure 8, it accounted for over 95% of the installed capacity, while wind, solar PV, and bioenergy only amounted to around 1% of the total. Vietnam has a high potential for hydropower, due to an abundance of rivers and suitable topography. However, the hydropower potential has already been almost exploited in Vietnam.[16] Moreover, nearly half of the proposed hydropower projects have not been approved by the government since 2012, due to social and environmental tensions.[16]

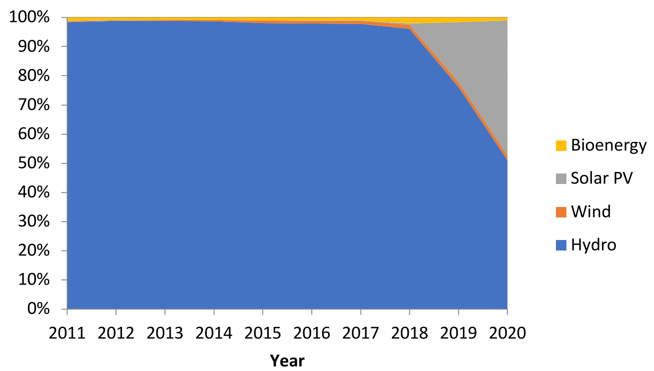
It is predicted that the share of hydropower in Vietnam's energy supply will continue to decrease, while the share of solar PV will increase dramatically, indicating a willingness to shift towards less risky investments in terms of contributing to climate change, social resistance, and geopolitical tensions, given that almost 60% of Vietnam's rivers originate from outside its borders.[17] From 2018 to 2020, the installed capacity of solar PV experienced dramatic growth, with a 157-fold increase; this accounts for nearly 97% of the renewable energy capacity growth. In 2020, the installed capacity of solar PV reached 16,505 MW, amounting to 46% of the installed capacity of renewable energy in Vietnam.

Figure 7 Installed capacity of renewable energy by sources in Vietnam from 2011 to 2020.[18]



Vietnam currently ranks in the top 20 destinations of renewable energy investment.[39]

Figure 8 Share of installed capacity of renewable energy by sources in Vietnam from 2011 to 2020.[18]



Renewable energy investment in Vietnam reached USD 4.1 billion, up seven-fold from 2017, with the emergence of the solar PV market worth over USD 1.6 billion.[38,40] It is also noted that private investment and foreign investment has expanded largely in the power market of Vietnam since 2018. Domestic and foreign private investments contributed to over 45% of the installed capacity growth of power generation, while 35% of capacity growth involved foreign direct investment (FDI), either alone or in partnership with local companies and governments.[41]

3.4 Solar PV

3.4.1 Overview

Solar energy has been considered the most significant potential renewable energy source in Vietnam.[6] With its average solar radiation reaching up to 5 kWh/m²/day, Vietnam has expansive solar resources that could be used to successfully develop the solar energy sector.[19] Since 2005, Vietnam's installed capacity, project scale and grid connection have been increasing. Before 2005, the installed capacity of solar PV in Vietnam was only around 1.1 MWp, with 10,000 small-scale off-grid stations.[21] These stations were mainly for residential use in rural and remote areas, with a capacity from 40 Wp to 220 Wp.[19] By 2015, the installed capacity of PV solar power increased up to roughly 5 MWp, and many medium-scale and large-scale stations were developed. Approximately 80% of the total capacity was deployed off-grid through around 10,000 to 15,000 small-scale applications, such as Solar Home Systems or smaller systems for public use, and some larger-scale off-grid systems.[20] Only 20% of the total PV capacity, around 900 kWp, is connected to the grid, through a few medium and large size systems of more than 50 kWp.[20] By the end of 2019, the total installed capacity had increased sharply to around 5 GWp, including about 4.5 GWp of newly grid-connected solar power plants.[22] In 2020, the total capacity increased nearly fourfold, to around 16.5 GWp (Figure 7). Furthermore, registered solar PV projects with a total capacity of up to 32 GWp are in stages of planning, construction, or awaiting authorization.[22]

3.4.2 Rooftop Solar

As shown in Figure 9, rooftop solar systems in Vietnam increased dramatically in 2020, reaching a total installed capacity of 9,730 MWp, with 105,212 systems by the end of that year.[8] Rooftop installed capacity succeeds that of solar power plants, accounting for around 59% of the total solar PV capacity in 2020. Most rooftop solar systems installed by the end of 2020 are connected to the national grid, and they are mainly concentrated in the central and southern provinces.[19] Most of them are household systems (Figure 10), while the industry sector has the highest installed capacity, due to the large system size. The systems in the industry sector have an average capacity of around 150 kWp, while the commercial sector, public buildings, and household systems have average capacities of around 30 kWp, 45 kWp, and 6.5 kWp respectively.

Figure 9 Total number and total installed capacity of rooftop solar systems in Vietnam by the end of 2020.[8]

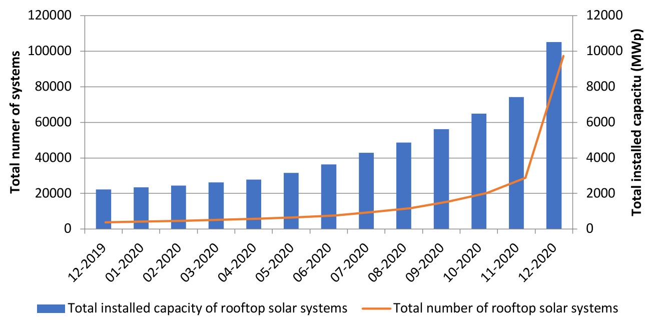
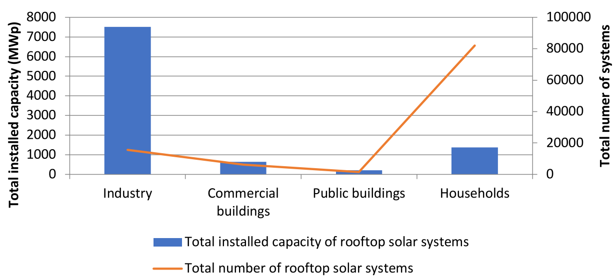


Figure 10 Total number and total installed capacity of rooftop solar systems by customer group in Vietnam by the end of 2020.[8]



4. Solar PV Energy Policy

The government's commitments to energy availability, climate change mitigation, and the competitiveness of the solar industry are the main drivers of solar PV energy policies development in Vietnam.[23,24] In this section, the main policy instruments for rooftop solar PV in Vietnam will be discussed.

Section 4.1 summarizes targets, key regulatory instruments and fiscal incentives; then, sections 4.2, 4.3, and 4.4 discuss the key policies and proposed targets, policy support, and incentives respectively.

4.1 Overview

Table 1 Overview of policy instruments for rooftop solar PV in Vietnam.

Targets	Renewable energy target (PDP 7)	Renewable energy installed capacity reach: - 24,000 MW by 2020, accounting for 40% of the total installed capacity - 3,2398 MW by 2025, accounting for 34% of the total installed capacity - 53,742 MW by 2030, accounting for 41% of the total installed capacity
	Solar energy target (PDP 7)	Solar power installed capacity reach: - 850 MW by 2020, accounting for 2% of the total installed capacity - 4,000 MW by 2025, accounting for 4% of the total installed capacity - 12,000 MW by 2030, accounting for 9% of the total installed capacity
	Rooftop solar energy target (Mechanisms to promote the development of solar power projects in Vietnam)	100,000 rooftop solar systems (or the equivalent of 1,000 MWp) shall be installed and in operation in the country by 2025.
	Climate targets	Nationally Determined Contributions: emission reduction of 9% by Vietnam's own effort, and up to 27% with international support by 2030. Compromise of net-zero emission by 2050 in COP26.
Regulatory instruments	Feed-in tariff (FiT)	FiT2 of 8.38 US cent/kWh for rooftop solar power projects was applied and expired at the end of 2020. An auction scheme is under development.
	Power purchase agreements (PPA)	Standardized PPA is applied while a direct power purchase agreement (DPPA) is under development.
Fiscal incentives	Import duty exemption	Exemption from import duty for imported goods that serve project production, including raw materials, supplies, and semi-finished products which have not been domestically produced.
	Corporate income tax	Preferential corporate income tax (see 4.4.3).

4.2 Key Policies

Vietnam has a series of strategic and planning documents, which are translated into a comprehensive suite of decisions and circulars.

Renewable energy became one of the strategic pillars for tackling energy issues in Vietnam, after the enactment of the National Energy Development Strategy in 2007.[15] However, the government's renewable energy policies had focused on wind energy, biomass production and hydropower, while solar energy received little attention. At that time, mainly off-grid solar PV projects in rural areas were developed.[20,26] Solar PV started to attract more attention since the Renewable Energy Development Strategy (2016–2030, with a vision for 2050) was enacted in 2015. This is the first national policy to highlight the importance of solar energy in achieving socio-economic development targets, and adopts economic instruments to encourage the development of solar energy.[23]

In 2016, the adjustment of PDP7 prioritized the development of solar power, including large ground-mounted and small rooftop solar PV systems. Since 2017, a series of targets and regulations on market mechanism, supportive incentives, and project development procedures have been enacted, leading to solar PV's high-speed development, especially rooftop solar PV. The relevant policies are listed in Table 2, and the policies still in validation will be discussed in 4.4 and 4.5.

In the next 10 to 20 years, Vietnamese energy development will be mainly guided by the PDP8, which is expected to be released in 2022. In the latest draft of PDP8, new mechanisms to promote finance and capital mobilization are proposed; these include a competitive auction mechanism for selecting investors for renewable energy projects, a direct power purchase agreement, a renewable portfolio standard mechanism, and a mechanism for renewable energy certificates sale and purchase, to promote liberalization of the renewable energy market.

Table 2 Key policies related to solar energy in Vietnam. MoIT, EVN, CPV refer to the Ministry of Industry and Trade, Vietnam Electricity Corporation, and Central Committee of the Communist Party of Vietnam respectively.

Year	Policies	Issued by	Contents
2007	Decision No.1855/QD TTg	Prime Minister	National Energy Development Strategy (up to 2020, with 2050 vision)
2015	Decision No.2068/QD-TTg	Prime Minister	Renewable Energy Development Strategy (2016–2030 with a vision for 2050)
2016	Decision 428/QD-TTg	Prime Minister	Power Master Plan VII (adjusted)
2017	Decision 11/QD-TTg	Prime Minister	Support mechanisms for the development of solar power projects in Vietnam
2017	Circular 16/TT-BCT	MoIT	Regulation on project development and standard power purchasing agreement for solar power projects
2019	Decision 02/QD-TTg	Prime Minister	Amending and supplementing some articles of Decision 11/2017/QD-TTg
2019	Circular 05/TT-BCT	MoIT	Amending and supplementing some articles of Circular No. 16/2017/TT-BCT
2019	Document 1532/EVN-KD	EVN	Guidance for the implementation of rooftop solar PV projects
2019	Document 3450/EVN-KD	EVN	Guidance for the settlement of outstanding issues of rooftop solar power
2019	Decision 2023/QD-BCT	MoIT	Approval of the rooftop solar PV promotion programme
2020	Decision 13/QD-TTg	Prime Minister	Mechanisms to promote the development of solar power projects in Vietnam
2020	Circular 18/TT-BCT	MoIT	Regulation on project development and standardized power purchasing agreements for solar power projects
2020	Circular 21/TT-BCT	MoIT	Regulation on the application process and requirements for the issuance of electricity generation licences

Year	Policies	Issued by	Contents
2020	Document 7088/BCT-DL	MoIT	Guidance for the development of rooftop power
2020	Resolution 55/NQ-TW	CPV	Orientations of Vietnam's National Energy Development Strategy to 2030 and outlook to 2045
2021	Proposal No. 1682/TTr-BCT	MoIT	Draft Power Plan VIII

4.3 Targets

As shown in Table 3, solar power is expected to be the renewable energy source that expands most rapidly. In the adjustment of PDP7, the targets for solar power's installed capacity by 2020, 2025, and 2030 are 850 MW, 4,000 MW, and 12,000 MW respectively, accounting for 2%, 4%, and 9% of the total installed capacity respectively. The tentative targets proposed in the PDP8 draft for solar energy are more ambitious than the formal targets in the adjustment of PDP7. The targets for solar power installed capacity by 2025, 2030, and 2045 are 17,240 to 18,540 MW, 18,640 to 22,040 MW, and 51,540 to 63,640 MW respectively, accounting for around 17%, 15%, and 19% of the total installed capacity respectively. However, it is believed that the targets could be more ambitious, given that the solar power installed capacity of 16,505 WM by the end of 2020 nearly reaches the target for 2025 proposed in the draft PDP8.[23] It is also noted that Vietnam proposes a specific target for rooftop solar PV. As proposed in the Approval of the Rooftop Solar PV Promotion, it aims to install 1,000 rooftop solar PV projects by 2025.

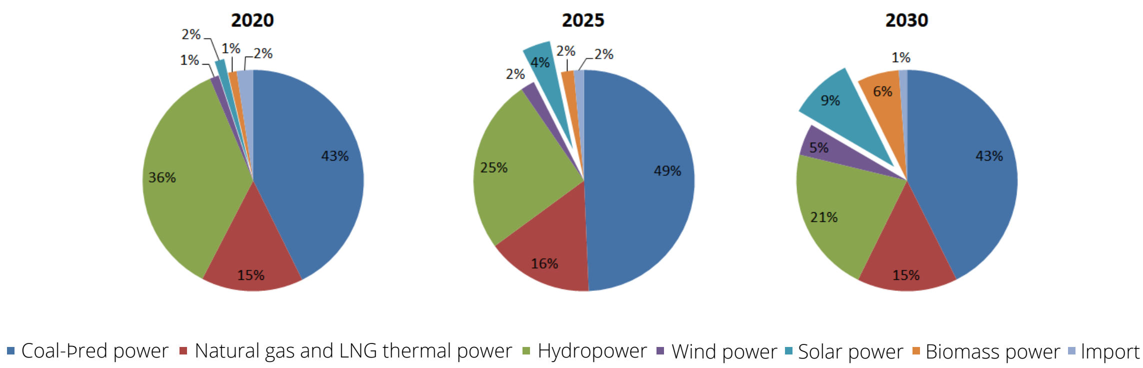
Table 3 Vietnam's power development targets proposed in the adjustment of PDP7, the draft of PDP8, and the Approval of the Rooftop Solar PV Promotion.

Source	Policies	2020		2025		2030		2045	
		Installed capacity (MW)	Share (%)	Installed capacity (MW)	Share (%)	Installed capacity (MW)	Share (%)	Installed capacity (MW)	Share (%)
Coal-fired power	PDP 7	25,620	42.70	47,600	49.3	55,167	42.6	-	-
	PDP 8 draft	-	-	29,429	27.96 – 28.67	40,649	28.3 – 31.2	50,699	15.4 – 19.4
Natural gas and LNG thermal power	PDP 7	8,940	14.90	15,054	15.6	19,037	14.7	-	-
	PDP 8 draft	-	-	13,841 – 14,294	13.45 – 13.89	27,471 – 32,071	21.1 – 22.3	61,900 – 88,700	23.64 – 26.94
Hydropower	PDP 7	21,600	36.00	24,600	25.5	27,800	21.5	-	-
	PDP 8 draft	-	-	25,323 – 25,389	24 - 24.73	26,684 – 27,898	19.39 – 20.47	29,077 – 30,077	12.58 – 13.62
Wind power	PDP 7	800	1.33	2,000	2.1	6,000	4.6	-	-
	PDP 8 draft	-	-	11,320 – 11,820	11 – 11.22	11,820 – 13,820	9 – 9.6	48,110 – 68,720	18.36 – 20.84
Solar power	PDP 7	850	1.42	4,000	4.1	12,000	9.3	-	-
	PDP 8 draft	-	-	17,240 – 18,540	16.79 – 17.61	18,640 – 22,040	14.3 – 15.32	51,540 – 63,640	19.3 – 19.67
	Mechanisms to promote the development of solar power projects in Vietnam	-	-	1,000 (rooftop solar PV)	-	-	-	-	-

Source	Policies	2020		2025		2030		2045	
		Installed capacity (MW)	Share (%)	Installed capacity (MW)	Share (%)	Installed capacity (MW)	Share (%)	Installed capacity (MW)	Share (%)
Biomass power	PDP 7	750	1.25	1,799	1.9	7,942	6.1	-	-
Import	PDP 7	1,440	2.40	1,448	1.5	1,554	1.2	-	-

Despite the promising expectations for solar PV, fossil fuels still dominate the energy supply structure targets, which raises doubts among civil society and energy experts. As shown in Figure 11, in the adjustment of PDP7, fossil fuels account for 58%, 65%, and 58% in 2025, 2030, and 2045 respectively, and coal is the main fossil fuel source. Even though the target share of fossil fuel proposed in the draft PDP8 will decrease, gas and coal are still expected to account for around 45% of the total installed capacity from 2025 to 2045, while it prioritizes gas power to replace coal.

Figure 11 Vietnam's power structure in 2020, 2025 and 2030, proposed in the adjustment of PDP 7.



4.4 Policy Support and Incentives

The main supportive instruments and incentives for solar PV development in Vietnam, including FiT, PPA, tax exemption, international and private investment and project development, are discussed below.

4.4.1 Feed-in Tariff

The feed-in tariff (FiT) is an effective mechanism to encourage the development of solar energy and increase its competitiveness with fossil fuels.[27,28] In 2017, the prime minister issued the 'Support Mechanisms for the Development of Solar Power Projects in Vietnam' under Decision 11/QD-TTg. This launched the first FiT (FiT1) in Vietnam; its rate of VND 2.086/kWh (USD cents 9.35/kWh, exclusive of VAT) is applicable for 20 years, for grid-connected solar power projects that started before 30 June 2019. According to 'Amending and Supplementing Some Articles of Decision 11/QD-TTg', adopted by the prime minister under Decision 02/QD-TTg, grid-connected rooftop solar projects must adopt a direct consumption/supply method[1] to replace the net-metering scheme.

1. **A direct consumption/supply method: Rooftop power projects are allowed to separately apply electricity transaction mechanisms based on the input and output of the two-way electricity meter.**

Standardized FiTs for solar projects were replaced by differentiated FiTs based on installation type (Table 4), according to 'Mechanisms to Promote the Development of Solar Power Projects in Vietnam', which was issued by the prime minister under Decision 13/QD-TTg in 2020. This new FiT (F1T2) is applicable for grid-connected solar power projects that achieved a commercial operation date from 1 July 2019 to the end of 31 December 2020. FiT2 is applied for 20 years from the commercial operation date.

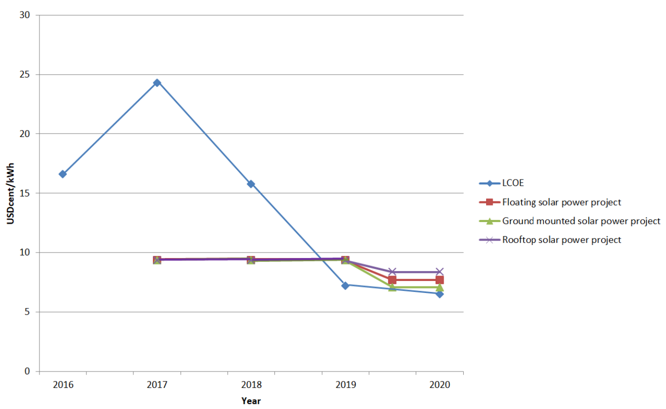
Table 4 Feed-in tariff for solar power.

No.	Solar Power Technology	Feed-in Tariff	
		VND/kWh	Equivalent to USD cent/kWh
1	Floating solar power project	1,783	7.69
2	Ground-mounted solar power project	1,644	7.09
3	Rooftop solar power project	1,943	8.38

Note: For grid-connected solar PV projects in Ninh Thuan province with total accumulative capacity up to 2,000 MW, FiT is 2,086 VND/kWh (equivalent to 9.35 US cents/kWh). The FIT does not include VAT and is subject to adjustment according to exchange rate fluctuations of the VND and USD (equivalent to US cents/kWh), as published by the State Bank of Vietnam on the day the invoice is issued by the electricity seller.

FiT1 was issued in 2017. However, the total installed capacity of solar PV was still low, with around 105 MWp by 2018. One of the main reasons is that the gap between the FiT1 and weighted-average LCOE prices in 2017 and 2018 was quite large (Figure 12). The weighted-average LCOE prices in Vietnam decreased rapidly since 2017. The weighted-average LCOE prices became lower than FiT1 and FiT2 prices in 2019 and 2020, even though the FiT2 prices, which took into effect from July 2019, are nearly 30% lower than FiT1 prices. The FiT prices were attractive for investors in 2019 and 2020, given that LCOE prices in regions with good solar potential are even lower than the average. Thus, a huge increase in the installed capacity of solar PV in 2019 and 2020 is observed (Figure 6). As shown in Table 5, FiT2 prices for floating and rooftop solar power projects are higher than for ground-mounted ones. The preference for rooftop and floating solar is partly due to land issues, and the challenges of agreeing on compensation with local authorities for the construction of resettlement areas. FiT2 prices that are designed to favour rooftop solar projects have led to a 25-times higher installed capacity by the end of 2020, compared to 2019 (Figure 8).

Figure 12 FiT and weighted average LCOE for solar power in Vietnam.[29]



FiT mechanisms in Vietnam have effectively promoted solar energy investment. However, this led to the imbalanced geographical distribution of solar power projects.[8,30,31] Under a nationally uniform FiT, projects will be concentrated in high solar potential areas, rather than areas with high load demand and convenient access to the transmission system.[25] In the case of Vietnam, most of the solar power projects are concentrated in the southern region, where the solar potential is high but population density and energy demand are low.[9] As the transmission grid systems are not prepared for the large penetration of solar energy, it will potentially cause grid overload and power loss.[25] Moreover, FiT prices do not offer a timely market-based image of costs, and they lack tools to manage the market size for long-term planning.

Thus, the Vietnamese government plans to switch from the FiT mechanism to a competitive bidding mechanism.[18] With the aid of the World Bank, the government conducted a solar pilot auction programme, whose main objective was to strengthen the enabling environment for the private sector.[32] The draft 'Guidance on the Selection of Investors Implementing Solar Power Projects under the Bidding Mechanism' was issued by MoIT in January 2021. Since FiT2 applied to solar power projects with commercial operation data by 31 December 2020, it is expected that the Draft will soon be finalized and become effective; this will give solar energy developers, as well as relevant government authorities, guidelines for projects with commercial operation data from 2021.[33] However, it has not been issued at the time of this report's publication.

4.4.2 PPA and DPPA

In Vietnam, the trading of solar power is performed via a power purchase agreement, if the buyer is EVN or its authorized member companies. PPAs are predominant in the solar power market, as they are mandatory when dealing with EVN. The PPA of solar power projects is valid for 20 years from the date of commercial use. After 20 years, the PPA may be extended or renewed by both parties according to existing regulations.

Under the PPA scheme, there are two business models. In addition to the conventional business model, where the owner of the rooftop invests in the rooftop solar power project and sells all of the electricity generated by the project to EVN (Figure 13), the roof leasing model is frequently used in the commercial sector. This model of solar PV projects, when the investor/developer sells the electricity via the meter of the roof owner or via a separate meter, is shown in Figure 14 and Figure 15 respectively.

Figure 13 Conventional business model of solar PV projects. EPC means engineering, procurement and construction in a solar company, and O & M refers to operation and maintenance.

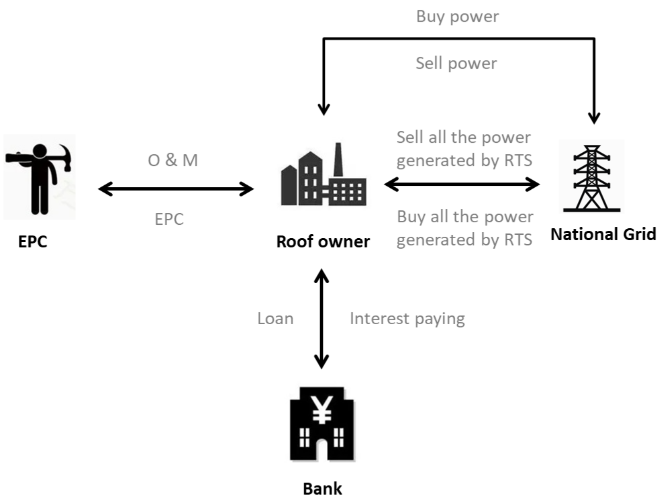


Figure 14 Roof leasing model of solar PV projects when the investor/developer sells the electricity via the meter of the roof owner. EPC means engineering, procurement and construction in a solar company, and O & M refers to operation and maintenance.

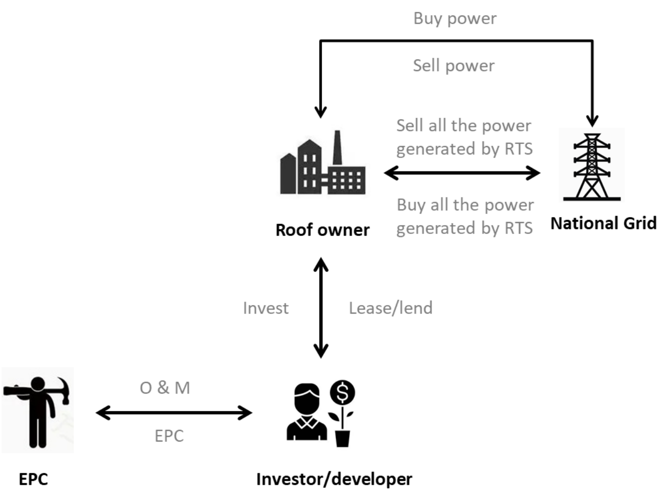
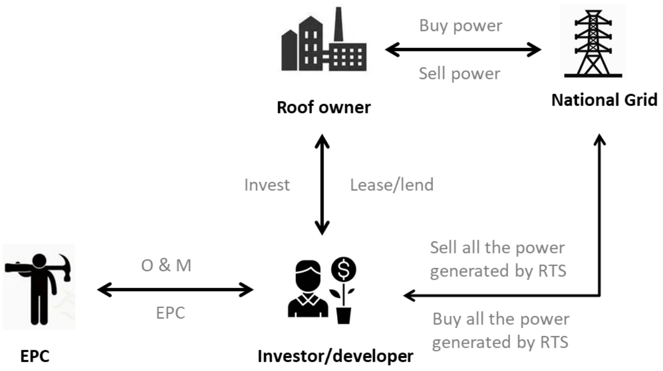
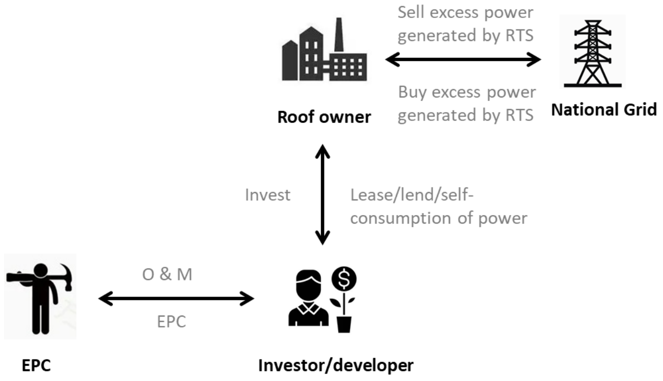


Figure 15 Roof leasing model of solar PV projects when the investor/developer sells the electricity via the meter separately from the roof owner. EPC means engineering, procurement and construction in a solar company, and O & M refers to operation and maintenance.



In 2020, DPPA was introduced in the solar PV market. Before then, EVN and its authorized affiliates were the only solar electricity buyers, and the usage of EVN's grid was mandatory for the purchase of solar electricity. In 2020, Decision 13/QD-TTg stated that small-scale rooftop solar power systems with a capacity less than 1 MWp are allowed to sell a part or whole of the generated energy to EVN, or to other electricity buyers, directly. Circular 18/TT-BCT, issued in 2020, further clarified that EVN shall make payment for the quantity of solar power generated from the rooftop solar power systems sold to the national power grid, at the price of FiT2, via PPA; whereas the FiT and the PPA are decided by negotiations between the buyer and the seller if the power buyer is not EVN. This represents a key milestone in Vietnam's solar power market, as it initiates the development of DPPA (Figure 16), which allows free negotiation of the tariff and PPA between rooftop solar generators and non-EVN buyers. This is part of the wholesale electricity market liberalization reforms that are currently underway in Vietnam. The DPPA pilot scheme is expected to run for two years, from 2022 to 2024. In the PDP 8 draft, DPPA is also recognized as one of the key mechanisms that will promote resource mobilization for the solar energy market in the next 10 years. It is anticipated that DPPAs will be introduced into the market permanently from 2025 onwards.[34]

Figure 16 Business model of DPPA for rooftop solar power projects. EPC means engineering, procurement and construction in a solar company, and O & M refers to operation and maintenance.



4.4.3 Tax Exemption

The main fiscal incentives for solar power projects in Vietnam are import tax exemption and preferential corporate income tax (CIT).

Under Decision 11/QD-TTg, all solar projects shall be exempted from import duty for imported goods as fixed assets of the projects. It applies to imported goods that serve project production, including raw materials, supplies, and semi-finished products which have not been domestically produced.

The normal CIT rate in Vietnam is 20%.[35] Solar power projects enjoy preferential CIT. For instance, projects which qualify for particular conditions in terms of their scale, standards of personnel, basis of demand for granted land, requirements for facilities, capacity, and technology, will be regarded as a 'socialization project in the field of environmental protection'. Such projects are subject to a corporate income tax rate of 10% for the whole project lifetime, and enjoy tax holidays:

- If the project is located in difficult/especially difficult socio-economic areas, a four-year CIT exemption followed by a nine-year 50% CIT reduction will be implemented.
- If the project is located in other areas, a four-year CIT exemption followed by a five-year 50% CIT reduction will be implemented.[36]

If solar power projects are not eligible to be socialization projects in the field of environment protection, they will have a 10% CIT rate for 15 years. This could be extended to a maximum of 30 years for large-scale projects and those using new or advanced technology, subject to the prime minister's approval. In addition, a four-year CIT exemption followed by a nine-year 50% CIT reduction will be implemented.

4.4.4 Private and International Investment

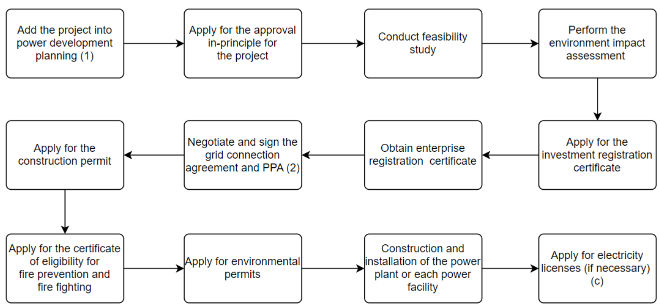
Solar PV is attracting a growing share of investment interest in Vietnam, especially for rooftop solar systems.[40] Unlike many Southeast Asian countries, Vietnam permits foreign investors to own up to 100% of the equity in renewable energy projects, which can be structured as wholly owned firms, build-operate-transfer (BOT) projects, public-private partnerships, or joint ventures. In the case of solar power projects, investors are required to maintain an equity ratio of at least 20% of the total investment.[37] However, private enterprises have not yet been allowed to transmit and distribute power, and they can only participate in the construction of power infrastructure and power production.[38]

To attract more private and foreign funding sources, the adjustment of PDP 7 and Resolution 55/NQ-TW propose financial and administrative instruments; these include issuing bonds in domestic and overseas markets, publishing the plan and list of available investment projects, creating an open investment regime, and reforming administrative procedures. Also, the DPPA for rooftop solar power projects, which allows power buyers who are non-EVN, and free negotiation of the tariff and PPA, will become an attractive solution for international investors (see 4.5.2).

4.4.5 Project Development

The process of developing a rooftop solar PV project in Vietnam is transparent and operative (Figure 17). The government has simplified the developing process for small-scale rooftop solar PV projects, which have a capacity of under 1 MW, to promote their development. The small-scale rooftop solar projects are exempted from applying for an electricity licence. Instead of being approved by the competent authorities, the owners of small-scale rooftop PV power projects only need to register the connecting terminal with a provincial power company and provide general information about expected capacity, specifications of solar panels, and the power inverter.

Figure 17 The process for developing a rooftop solar PV project.[42,43]



5. Technical Assessment and Environmental Benefits of Rooftop Solar PV

5.1 Overview of the Industrial Zones

Eighteen industrial zones were analysed in this report, including one industrial zone in Bac Lieu province, three industrial zones in Quang Tri province, five industrial zones in Dong Thap province, six industrial zones in Hai Phong province, and three industrial zones with Chinese capital investment (Figure 8, Table 6 and Table 7). Hai Phong province, located in northern Vietnam, is one of the country's industrial centres. Quang Tri province is the transport hub of central Vietnam, and is dedicated to regional economic cooperation in the industrial sector. Bac Lieu province and Dong Thap province have emerged as rising locations for investment, production and growth in the Mekong Delta region.

Figure 18 Locations of the 18 industrial zones.

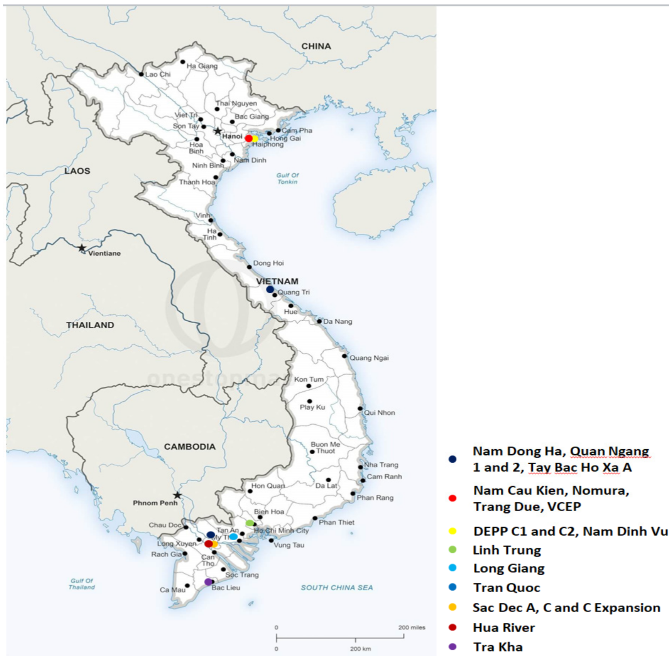


Table 5 Industrial zones analysed in this study, in Bac Lieu, Quang Tri, Dong Thap and Hai Phong provinces of Vietnam.

Province	Name	Total area (ha)	Occupancy (%)	Priority Industry
Bac Lieu	Tra Kha	65	57	Garments, leather shoes industry; electrical, electronics, communication; producing wine, beer and soft drinks.
Quang Tri	Nam Dong Ha	99	82	Wood processing, fertilizer, seafood processing, solar batteries, alcohol, beverages, garments.
	Quan Ngang (1 and 2)	201	73	As above.
	Tay Bac Ho Xa A	201	0	As above.
Dong Thap	Hau River	66	60	-
	Sa Dec A1	40	95	Seafood processing, feed, cattle and poultry; building materials, agricultural engineering, power, electronics; garments, leather shoes, consumer products, canned foods of all kinds.
	Sa Dec C	30	98	As above.
	Sa Dec C Expansion	62	75	As above.
	Tran Quoc Toan	58	85	As above.

Province	Name	Total area (ha)	Occupancy (%)	Priority Industry
Hai Phong	Nam Cau Kien	263	100	All fields without pollution; electrical and electronic products, hi-tech products; construction materials, processing industry.
	Nomura	153	100	Robots, electronic components, Lunicins Land paper, processing adornments.
	Trang Due	402	90	Electrical and electronic products, hi-tech products; heavy industry, construction materials, processing industry; shoes, textiles and garments.
	Nam Dinh Vu 1	370	60	Heavy industry, food industry, light industry; specific industries such as oil industry.
	DEPP C 1 Hai Phong	541	95	Electrical and electronic products, hi-tech products; heavy industry, construction materials, processing industry (especially petrochemical industry).
	DEPP C 2 Hai Phong	645	20	Electrical and electronic products, hi-tech products; heavy industry, construction materials; processing industry (especially electronics industry).

Table 6 Industrial zones with Chinese capital investment in Vietnam.

Province	Name (English)	Name (Chinese)	Total area (ha)	Priority Industry
Tien Giang	Long Giang Industrial zone	越南龙江工业园	540	Plastics, garments, food, furniture, etc.
Hồ Chí Minh	Linh Trung Export Processing Zone and Industrial Zone	越南铃中加工出口区和工业区	325	Light industry
Hai Phong	China-Vietnam (Shenzhen-Haiphong) Economic and Trade Cooperation Park (VCEP)	中国越南（深圳 - 海防）经济贸易合作区	200	Light industry

5.2 Solar PV Technical Potential of the Industrial Zones

5.2.1 Method

(1) The available rooftop area (Ar) and number were identified by manual identification through ArcGIS.

The satellite image data were derived from Locaspace Viewer. The parameters of the satellite images are listed as follows:

Spatial resolution: 0.29 m

Band: R, G, B

Colour depth: 24 bits

Coordinate system: GCS_WGS_1984

Datum: D_WGS_1984

Using planning maps of the industrial parks, KML files of the boundaries of the industrial zones were created in Google Earth; then they were transformed into shapefiles in ArcGIS. The rooftops within the boundaries of the industrial zones were manually identified, and the data of the rooftops were extracted in ArcGIS.

(2) System size means the potential installed capacity, calculated following the formulation below:

$$\text{System size } (S)\text{:}\quad S = \frac{Ar \cdot RCR}{PF} / (1 - \text{loss})$$

Where:

Ar: Rooftop area (m^2)

RCR: Percentage of rooftop area that will be covered by solar panels. This report assumes it is 0.7.

PF: Packing Factor (m^2/MW). In Vietnam, the packing factor is around 6,700–7,000 m^2/MW. This report assumes the packing factor is 6,850 m^2/MW.

Loss: the technical loss except . This report assumes it is 1.25%.

(3) The annual electricity generation is estimated following the formulation below:

$$\text{Annual Electricity Generation (G): } G=S\cdot PCF\cdot h\cdot(1-loss_{DA})$$

Where:

PCF: Plant capacity factor. PCF of each province is based on the calculation of Green ID.

$loss_{DA}$: DC–AC Inversion Losses. This report assumes it is 1.25%.

h: All-year power generation hours. This report assumes it is 8,760 h.

(4) Fossil fuel reduction is calculated following the formulation below:

$$\text{Fossil fuel reduction} = \text{Annual Electricity Generation}\cdot\text{Coal Consumption Rate}$$

Coal consumption rate: this report assumes it is 0.45 kg coal equivalent/kWh.

(5) Carbon Dioxide Reduction is calculated following the formulation below:

$$\text{Carbon Dioxide Reduction} = \text{Annual Electricity Generation}\cdot\text{Emission Factor}$$

Emission factor: this report assumes it is 0.6 kg CO_2equivalent/kWh based on the research of Green ID in 2020.

5.2.2 Result

Figure 19 shows the result of rooftop identification for the Quan Ngang (1 and 2) industrial zone. Table 8 presents the technical solar PV potential of the 18 industrial zones selected in this study. In total, the 18 industrial zones have 5,021 available rooftops, with a total area of around 7,079,574 m^2. The result of the technical potential analysis shows that the potential system size of all rooftops solar PV is 732 MW, with a potential annual electricity production of around 808.99 GWh.

Figure 19 Identification of the rooftops of. Quan Ngang (1 and 2) indusial zone.

5.2.3 Environmental Benefits

Following the results in 5.2.2, the rooftop solar PV in the 18 industrial zones can produce electricity of 808.99 GWh annually, which is equivalent to coal reduction producing by 364,047 tons per year. In terms of carbon dioxide reduction, the rooftop solar PV of 18 industrial zones can reduce CO_2 equivalent by 485,396 tons per year. Table 8 presents the fossil fuel reduction and carbon dioxide reduction of rooftop solar PV in the 18 industrial zones respectively.

Table 7 Solar PV technical potential of the industrial zones in Vietnam.

Province	Name	Rooftop Number	Rooftop Area (m^2)	System Size (MW)	Plant Capacity Factor	Annual Electricity Production (GWh)	Fossil Fuel Reduction (Tons of coal equivalent)	Carbon Dioxide Reduction (Tons of CO_2 equivalent)
Bac Lieu	Tra Kha	115	73,252	7.58	0.15	9.84	4,426	5,902
Quang Tri	Nam Dong Ha	241	177,754	18.39	0.131	20.85	9,308	12,412
	Quan Ngang (1 and 2)	193	121,594	12.58		14.26	6,417	8,490
	Tay Bac Ho Xa A	17	11,414	1.18		1.34	602	797

Province	Name	Rooftop Number	Rooftop Area (m²)	System Size (MW)	Plant Capacity Factor	Annual Electricity Production (GWh)	Fossil Fuel Reduction (Tons of coal equivalent)	Carbon Dioxide Reduction (Tons of CO_2 equivalent)
Dong Thap	Hau River	160	161,534	16.72	0.15	21.69	9,761	13,014
	Sa Dec A1	182	130,132	13.47		17.47	7,863	10,484
	Sa Dec C	139	88,919	9.20		11.94	5,373	7,164
	Sa Dec C Expansion	212	215,800	22.33		28.98	13,040	17,386
	Tran Quoc Toan	249	119,274	12.34		16.02	7,207	9,609
Hai Phong	Nam Cau Kien	261	328,305	33.97	0.11	32.33	14,548	19,397
	Nomura	479	614,759	63.62		60.54	27,241	36,321
	Trang Due	499	1,129,776	116.91		111.25	50,062	66,749
	Nam Dinh Vu 1	77	114,548	11.85		11.28	5,076	6,768
	DEPP C 1 Hai Phong	778	1,244,805	128.82		122.58	55,159	73,546
	DEPP C 2 Hai Phong	94	123,026	12.73		12.11	5,451	7,269
Tien Giang	Long Giang	337	963,960	99.75	0.15	129.44	58,247	77,663
Hồ Chí Minh	Linh Trung Export Processing Zone & Industrial Zone	878	1,215,874	125.82	0.15	163.26	73,469	97,959
Hai Phong	VCEP	110	244,848	25.34	0.11	24.11	10,850	14,466
Total		5021	7,079,574	732		808.99	364,047	485,396

6. Financial Analysis of Rooftop Solar Photovoltaic Systems in Vietnam in the Case of Quan Ngang (1 and 2) Industrial Zone

The project team took the Quan Ngang (1 and 2) industrial zone in Vietnam as an example to carry out the financial analysis of the industrial rooftop solar PV projects. Quan Ngang (1 and 2) industrial zone is located in the Quang Tri province, in the central region of Vietnam. Quang Tri province is ambitious to develop socially and economically, and has made an important mark on economic growth and investment attraction; in particular, its industrial zones are actively leading the way, with attractive incentives for investors to locate their projects. Furthermore, the Quan Ngang (1 and 2) industrial zone benefits from the central region's essential technical infrastructure, as well as labour resources in specialized fields or high-level positions.

Project financial analysis covers financial risks, benefits and impacts. The three types of related financial risks are market risk, policy risk, and credit risk. Market risk refers to the risk that the project owners and lenders face due to changes in the market environment that affect the feasibility of technology application. Policy risk considers that changes in government policy may have a significant impact on the financial feasibility of the project (similarly, on project owners and creditors). For solar PV power generation projects, potential policy risks include the government's adjustments to production subsidies or the sales price. Credit risk is the risk incurred by the lender due to the expansion of credit scale to the borrower, and the lender must bear the risk that the borrower cannot repay the loan.

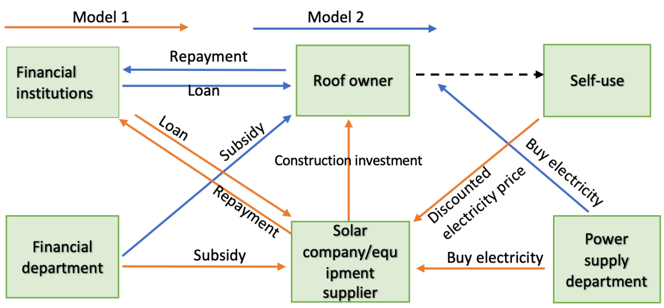
The financial analysis includes a cost-benefit analysis and a sensitivity analysis. The research team conducted a financial evaluation of rooftop PV power generation potential, using Microsoft Excel tools for discounted cash flow analysis. Furthermore, this report analysed the uncertainties affecting financial indicators and the sensitivity of various financial parameters by using Argo, which is included in Excel, for additional functionality. An introduction to the indicators, the financial model, and the results are demonstrated below.

6.1 Business Model

There are at least three basic configuration modes for rooftop solar photovoltaic power generation systems. The first configuration mode is self-use with a feed-in tariff. The second configuration mode is 100% self-use, or 'off-grid' systems. The third configuration mode can be considered as a hybrid system which combines a gas turbine or diesel engine electric generator with a solar PV system. Normally, the mode of 'self-use with feed-in tariff' is adopted in industrial and commercial buildings. However, the FiT2 expired at the end of 2020, and the DPPA and auction mechanism had not yet been launched at the time of the research. Therefore, this report adopts the second configuration mode of 100% self-use for the following analysis.

Regarding the financial resources in Vietnam, the potential financing sources for industrial and commercial rooftop are equity, debt, and financial incentives from domestic governments and international organizations. Different financing resources can be combined; Figure 9 presents the combination of two most common financing models (the orange is Model 1 and the blue is Model 2):

Figure 20 Two financing models of rooftop photovoltaic power generation projects



In Financing Model 1, a solar company (or equipment supplier) obtains a loan from financial institutions (banking, insurance, guarantee, securities, or financial lease companies), and then directly provides a roof owner with all services (design, installation, follow-up operation and maintenance); the solar company (or equipment supplier) sells surplus electricity to the power supply department, while the solar company (or equipment supplier) charges the industrial and commercial roof owner's self-used electricity at a discounted rate.

In Financing Model 2, a roof owner obtains a bank loan and then signs the system design and system installation/ operation and maintenance contract themselves; then the power supply department buys the surplus electricity from the roof owner.

Based on a consultation with the local partner, the project team chose the second financing model to carry out the financial analysis for the rooftop solar PV projects in the Quan Ngang (1 and 2) industrial zone, Vietnam.

6.2 Indicators

The indicators related to project financial evaluation are discounted cash flow (DCF) and discounted payback period (DPB). The indicators related to financial institutes are internal rate of return (IRR) and return on investment (ROI). The cost indicators applied in this analysis are initial investment cost (IIC), fixed operation and maintenance cost (FOM), variable operation and maintenance cost (VOM), and levelized cost of electricity (LCOE).

Discounted Cash Flow (DCF): The discounted present value of the sum of all future planned costs and revenues.

$$\mathrm{DCF} = \sum_{t=0}^{N} \frac{\mathrm{FV}_t}{(1+r)^t}$$

Where:

DCF is the discounted present value of future cash flows

FV is the nominal value of cash flows in the following year

r is the discount rate

t is the number of years in the future

Internal Rate of Return (IRR): Refers to a discount rate that makes the net present value (NPV) of all cash flows equal to zero in a discounted cash flow analysis. It can represent the maximum annual interest rate at which a project owner can afford to borrow money to invest in a project.

$$\mathrm{NPV} = \mathrm{CF}_0 + \frac{\mathrm{CF}_1}{(1+\mathrm{IRR})^1} + \frac{\mathrm{CF}_2}{(1+\mathrm{IRR})^2} + \cdots + \frac{\mathrm{CF}_n}{(1+\mathrm{IRR})^n} = 0$$

Return on Investment (ROI): Shows the ratio of the net benefit to the total cost of the project.

ROI = (Total Benefit – Total Cost) / Total Cost

Risk-adjusted ROI (discounted benefits and costs) is favoured as it provides a more conservative ratio. This is because benefits are usually higher than costs after construction, and risk-adjusted ROI uses the time value of money to calculate discounted benefits and costs over operation time, with the discounted benefits and the calculated rate at a relatively lower level.

Discounted Payback Period (DPB): The time required to recover the accumulated investment in the project.

Discounted Payback Period = Investment Cost/Annual Net Cash Flow

Initial Investment Cost (IIC): According to the following formula, the expected plant operational costs are annualized and expressed in units of year/MWh:

Annual IIC = IIC * FCF * 1,000 / (8,760 * C_f)

Where:

IIC: Initial investment cost, including the capital cost of land and equipment, and any other initial costs of planning, engineering and construction (USD/KW)

FCF: Fixed cost factor

1,000: USD/KW converted to USD/MW

8,760: Number of hours per year

C_f: Capacity factor (%)

Fixed Operation and Maintenance Cost (FOM): According to the following formula, the annual cost of operating a system can be estimated in units of USD/MWh:

Annual FOM= FOM * 1,000 / (8,760 * C_f)

Where:

Fixed Operational and Maintenance Cost (FOM): FOM (USD/ KW· year. Note: It is subject to an annual growth rate equal to or higher than the rate of inflation)

1,000: USD/KW converted to USD/MW

8,760: Number of hours per year

C_f: Capacity factor (%)

Variable Operation and Maintenance Cost (VOM) is the annual cost generated by the operating revenue of the project.

All annual costs estimated above are discounted as follows:

Discounted Annual Cost =[PV_{GEN} * DR * $(1+DR)^t$] / [$(1 + DR)^t$ – 1]

Where:

PV_{GEN}: The present value of the sum of all power generating costs

= Annual IIC + FOM + VOM and fixed cost (USD/MWh, annual cost over the system life cycle)

DR: Discount rate

Levelized Cost of Electricity (LCOE): The weighted cost of generated electricity through the whole system life cycle (USD/MWh).

LCOE = Sum of Costs of PL /Sum of Electricity Production of PL

Where:

Levelized Electricity Cost = LCOE (USD/MWh)

PL: Plant life (year)

6.3 Input

The research team conducted the investigations and assumptions for the Quan Ngang (1 and 2) industrial zone in Vietnam, based on rooftop solar PV applications in other regions, and local development data in Vietnam. The total cost of installing rooftop solar PV systems in Vietnam can be as low as 1.36×10^7VND/kWp through Chinese suppliers, and as high as 2.7×10^7VND/kWp through German or Japanese suppliers. The total cost is usually kept in the range of 1.36×10^7~1.4×10^7VND/kWp, which is approximately equivalent to 619.47 USD/kWp.

Table 8 presents the project input data for the rooftop solar PV system in Quan Ngang (1 and 2) industrial zone in Vietnam.

Table 8 Project input data of rooftop solar PV system in Quan Ngang industrial zone, Vietnam.

Parameter	Value	Unit	Notes and references
Analysis of the first year	2022	Year	Assumption
Power station life	20	Year	According to the validation of PPA and electricity licence
Total installed capacity	12.58	MW	According to the above technical potential analysis
Net installed capacity	12.42	kW	Data adjusted according to conversion efficiency 98.75%
Project installation cost	0.502	$/W	GreenID survey of local company Solartech
Grid connection of power station	0	$	Included in the total project cost
Total project cost	6,316,641	$	Including equipment, construction, permits, and all other costs associated with initial construction and start-up, as described in the cost statement above
Subsidy	0	$	All subsidies are not applicable to the project
Power station capacity factor	0.131	-	Calculated by Green ID
Rooftop rental fee	-	$/MW - year	Not applicable to this project
Fluctuation rate of rooftop rental fee	-	%	Not applicable to this project
Net generating capacity – the first year	14,259,194	kWh/ year	Calculated
Output performance degradation rate of PV power generation system	0.50	%/year	Green ID's expert, Mr Khanh Nguyen
Other variable operation and maintenance cost	0.00	$/kWh	Green ID's expert, Mr Khanh Nguyen

Parameter	Value	Unit	Notes and references
Self-used power generation	100	%	FiT2 expired at the end of 2020, and the self-use ratio should be set to 100%
Fixed operation and maintenance cost	8.7	$/kW - year	GreenID survey of local company Solartech
Fluctuation rate of operation and maintenance cost	0	%/year	
Levelized cost of electricity benchmark	0.0763	$/kWh	LCOE of coal-fired power stations in Vietnam.
DC: AC conversion loss	1.25	%	Data source: https://ens.dk/sites/ens.dk/files/Globalcooperation/gr_vietnam_-_vietnam_technology_catalogue_-_english.pdf

Table 9 presents the financial input data of the rooftop solar PV system in Quan Ngang 1 and 2 industrial zone, Vietnam

Table 9 Financial input data of rooftop solar PV system in Quan Ngang 1 and 2 industrial zone, Vietnam.

Parameter	Value	Unit	Notes and references
Power station owner's principal	30	%	Assumed according to the minimum value of the range (30%–70%) required by lending institutions
Feed-in tariff	-	$/kWh	No longer sold to the power grid since 2021
Electricity price	0.0738	$/kWh	Based on EVN's retail electricity price, the team assumes the voltage is between 6 and 22 KV
Annual growth rate: value of electricity generation	2	%/year	Assumption from Green ID's expert, Mr Khanh Nguyen
Carbon neutrality subsidy	-	$/t$CO_2$e	Not applicable to this analysis
State subsidy	-	$/kWh	Not applicable to this analysis
City subsidy	-	$/kWh	Not applicable to this analysis
Inflation rate	2.09	%	From State Bank of Vietnam (March 2022)
Project construction time	0.5	Year	Assumption
Corporate income tax: Phase 1	0	%	Based on the tax exemption policy in 4.5.3.
Corporate income tax: Phase 2	5	%	
Corporate income tax: Phase 3	10	%	
Discount rate (nominal)	10	Per year	Assumptions: one of the metrics used in financial analysis is the weighted average cost of capital (WACC), which varies from business to business and depends on its cost of equity capital, cost of debt, market value of business liabilities and equity, and corporate income tax. Assumed that the discount rate for this analysis is in the range of 3.0–10%
Interest rate	8.00	%/year	Assumed that the loan is from the domestic banks

Parameter	Value	Unit	Notes and references
Loan period	12	Year	Assumed that the loan is from the domestic banks
Capital recovery factor (CRF)	0.13	-	Calculated based on interest rate and loan period
Residual value	-	$	Not applicable to this analysis

6.4 Results

A cost-benefit analysis was conducted based on the current policy support and investment environment in Vietnam. In this project, there is a 12.58 MW rooftop solar PV system in Quan Ngang (1 and 2) industrial zone in Vietnam, with a crystalline silicon module fixed array, 80% output guarantee for 20 years, and 100% of electricity for self-use. The expected return on investment for the rooftop solar PV project in the Quan Ngang (1and 2) industrial zones is shown in the table below:

Table 10 Cost-benefit analysis results of rooftop solar PV project in the industrial zone under the baseline scenario.

Total initial investment ($)	6,316,641	Rooftop solar photovoltaic power generation system; including cost of equipment, installation and grid connection
Discounted net cash flow (NCF) $-2022	3,444,729	2022–2041; owners' net income
Internal rate of return (IRR) %	13.9%	2022–2041; should be greater than the cost of capital
Minimum acceptable rate of return (MARR) %	8.0%	Cost of capital
Return on investment (ROI) %	50.1%	2022–2041
Payback period (PBP) year	5.42	Recovery based on underlying equity
Discounted investment payback period (DPB) year	7.25	Recovery based on risk-adjusted underlying equity
Cost-benefit ratio	1.50	2022–2041 discounted
Levelized cost of electricity ($/kWh)	0.044	Undiscounted; benchmark is traditional coal cost of $0.0763/kWh
Net present value of implementation cost ($)	6,880,737	2022–2041; shareholders' equity, principal and interest repayment, operation and maintenance

In the first 20 years of the project, the project owners' net income can reach $3.44 million. From the results, we can notice that the internal rate of return (IRR) is 13.9%, which is higher than the minimum acceptable rate of return (MARR) of 8.0%; this can meet the investment requirement, with a remaining profit margin of 5.9%.

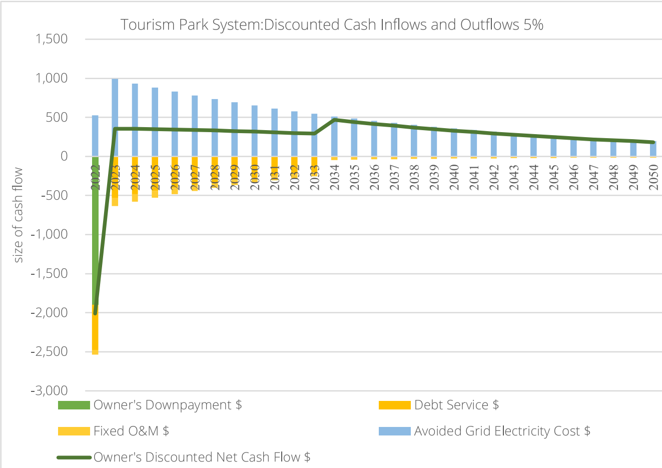
The overall ROI is 50.1%. The fixed operation and maintenance cost of the rooftop photovoltaic systems in Vietnam is $8.7/kW per year, which is lower than that of such projects in other Asian countries and regions (about $20/kW per year). This is an advantage of the investment and financing of industrial rooftop PV projects in Vietnam.

The PBP is 5.42 years and the discounted PBP is 7.25 years, which can be compared with the cutoff period of investment to measure the investment return of the project. The cutoff period of investment is the expected value of the project owner's investment recovery. The PBP obtained from the investment and financing analysis should be less than the cutoff period of investment given by the owner. The discounted net cash flow (NCF) and the discounted payback period (DPB) are the analysis results adjusted according to the risk of currency value.

The net present value of implementation cost refers to the total cost of the project, including the owner's initial input, financing, and operation and maintenance. The net present value of industrial zone project's implementation cost is $6.88

million. The discounted cash inflows and outflows from 2022 to 2050 are demonstrated in Figure 21.

Figure 21 Discounted cash flow of overall photovoltaic system in the industrial zone (5%).



6.5 Uncertainty and Sensitivity Analysis

This report conducted a sensitivity analysis of the discounted net cash flow of rooftop solar PV projects in Quan Ngang (1 and 2) industrial zones. The principal variables that cause inaccurate calculation in the sensitivity analysis include: plant capacity factor, value for self-use, owner's principal, loan period, inflation rate, interest rate, fixed O&M cost, and discount rate. The variables with their possible distribution are presented below.

- **Plant capacity factor:**

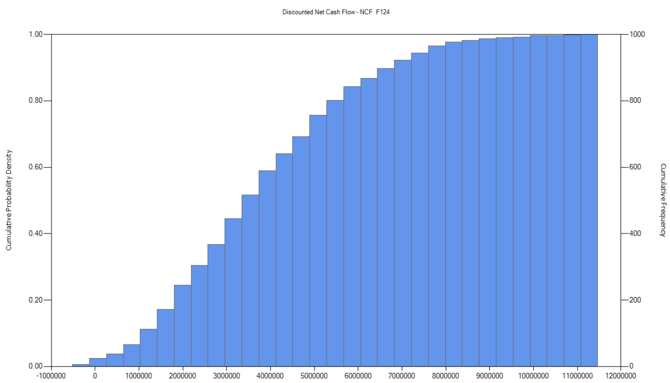
In order to promote the project's implementation, this research further explored the important factors affecting project planning and implementation. The share of self-used electricity, the period of self-use in a day, installed coefficient, discount rate, and fixed operation and maintenance cost, are often important factors affecting the financial performance of a project. The project team conducted the sensitivity analysis of variable factors. The main process of analysis consists of three steps: determining the numerical variation range of variable factors, the calculation based on Monte Carlo simulation, and the chart analysis of simulation results.

According to the different probability of variable factor values, variable distribution can be uniform or triangular (if the possibility of variable values matching any given value within the range is the same, it is assumed to be a uniform distribution; if the variable values are most likely to be found in the centre of the range, it is assumed to be a triangular distribution). The range of variable factor values is determined by the reference values provided by GreenID, used in the baseline scenario as the mode (triangular distribution) and the expected value (uniform distribution) of the range of values. Therefore, variable factors are divided into two categories: Category A includes value for self-use, city subsidy, discount rate, interest rate, loan period, electricity price, power station capacity factor, and self-used power generation. The values of these factors are usually concentrated near a certain value, so triangular distribution is adopted. Category B includes the power station owner's principal input and the fixed operation and maintenance cost; the values of these variables have equal probabilities within a small range, so uniform distribution is adopted.

The Monte Carlo simulation can repeat the permutation and combination of these variable factors, calculated 1,000 times; it can output the corresponding results, and finally obtain the probability distribution of the project's NCF value.

Based on the 1,000-test summary statistical data of the constructed distribution, the average discounted net cash flow of the project is about $3,876,729; the maximum is $11,464,618, and the minimum is -$515,746. Figure 22 shows the cumulative probability density chart based on the Monte Carlo simulation of net cash flow. As the chart shows, regardless of any combination of variable factors, the possibility that the discounted NCF is not less than total initial investment is greater than 15.8%.

Figure 22 Cumulative discounted net cash flow probability density.



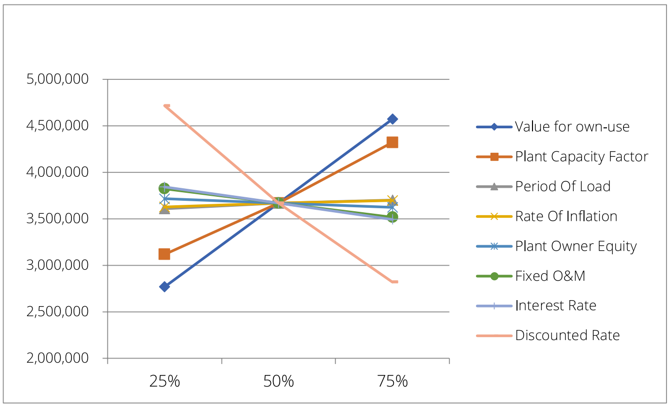
Sensitivity analysis can help to explain what factors increase the uncertainty of net cash flow valuation, and their impact on the upward and downward risks to net cash flow.

Table 11 shows the input and output values of the sensitivity analysis. Figure 23 shows a spider chart of the sensitivity analysis, and Figure 24 shows a tornado chart.

Table 11 Input and output values of sensitivity analysis.

	Spider chart: Discounted net cash flow (NCF)						Tornado chart: Discounted net cash flow (NCF)		
	Input			Output					
Variables	25%	50%	75%	25%	50%	75%	Lower limit	Upper limit	Scope
Plant capacity factor	0.13	0.13	0.14	3,117,097	3,669,901	4,321,745	3,117,097	4,321,745	1,204,648
Value for self-use	0.06	0.07	0.08	2,768,052	3,669,901	4,571,750	2,768,052	4,571,750	1,803,698
Owner's principal	0.40	0.50	0.60	3,716,510	3,669,901	3,623,292	3,716,510	3,623,292	-93,218
Loan period	10.65	11.74	12.71	3,608,255	3,667,148	3,701,413	3,608,255	3,701,413	93,157
Inflation rate	0.01	0.02	0.02	3,627,272	3,667,706	3,697,620	3,627,272	3,697,620	70,348
Interest rate	0.07	0.08	0.09	3,842,369	3,669,901	3,492,656	3,842,369	3,492,656	-349,713
Fixed O&M cost	7.31	8.60	9.89	3,823,407	3,669,901	3,516,396	3,823,407	3,516,396	-307,011
Discount rate	0.09	0.10	0.11	4,716,851	3,669,901	2,819,229	4,716,851	2,819,229	-1,897,622

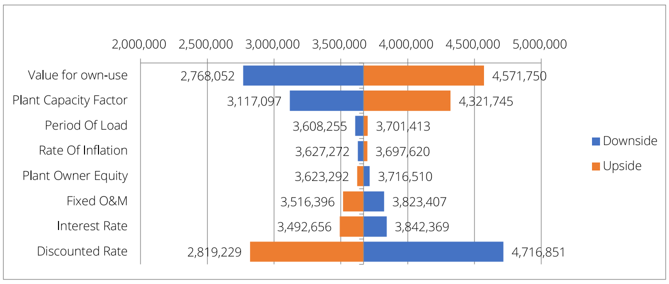
Figure 23 Spider chart of net cash flow sensitivity analysis.



In Figure 23, the X-axis represents the variable values of the sensitivity analysis. For example, 50% is the median of each variable, and 25% is the value corresponding to the 25^{th} percentile. A variable with a positive slope has a greater upward effect than a downward effect; a variable with a negative slope has a more downward than upward effect. Among the variables, the plant capacity factor and the value for self-use (retail electricity cost offset by PV systems) are the important variables that have a greater upward effect than downward effect. The variables with more downward effect than upward effect include discount rate and fraction of self-use. Table 11 and Figure 23 show that the fraction of self-use and the value for self-use are more sensitive variables to the estimated discounted net cash flow (as shown by the slope in Figure 23).

A downward variable refers to the variable that drives the result down when the variable itself rises, while an upward variable drives the result up when the variable rises. Lending institutions and project owners may be more concerned about downward risk variables. For example, a sharp drop in cash flow indicates that a lender is facing increased risk of loan non-repayment.

Figure 24 Tornado chart of net cash flow sensitivity analysis.



As for the upward variables in Figure 24, the increase of their values makes the net cash flow higher, while the increase of the downward variables in the lower part of figure makes the net cash flow lower. Important downward risk variables are interest rate, discount rate, and fixed O&M cost.

As the FiT2 expired at the end of 2020, the project earnings are closely related to the value for self-use. Therefore, due to self-use PV power generation meeting its own power demand, the avoided grid electricity cost has become the total earnings of the current project. Changes in the value for self-use will have a significant impact on the avoided grid electricity cost and the project earnings.

As can be seen from Figure 24, there is little difference between the upper and lower limits of discounted net cash flow, when affected by inflation rate, loan period and owner's principal. This shows that the project earnings are less affected by these three factors.

Discount rate reflects the future value of currency at present; the discounted analysis can exclude the fluctuations of currency value over time, and thus avoid any distractions that might impair the investment and financing judgment. The discount rate in the figure is a downward variable that significantly affects the net cash flow results. This is because of the high construction cost of the project, and the inability to make profits through the grid; as a result, the project takes longer to recover capital and accumulate profits.

7. Risk Analysis

For potential business investment projects, in addition to financial, social and environmental benefits, there are investment-related challenges and risks that must be properly managed. The possible policy risk, capital risk and operational risk of these proposed projects, and the corresponding management measures, are analysed below.

7.1 Policy Risk

The uncertainty and inconsistency of policy on solar PV poses risks for the financial sector when seeking to invest rooftop solar PV; especially for the larger-scale projects in Vietnam. For example, the validity period of FiT was short, limited to projects built during 2017–2019, and FiT2 was valid for projects built in 2019–2020. This has increased the uncertainty regarding the business model and profitability. As no new FiT has been launched after the expiration of FiT2, and the auction mechanism is still in the trial phase, there is a lack of a market mechanism in the solar PV industry.

7.2 Capital Risk

In the case that a local factory owner or enterprise applies for a loan to implement the proposed project, the lender will be exposed to the risk of default, i.e., the factory owner/enterprise may fail to repay the principal and interest on time, due to a poor financial situation or lagging project implementation. This risk can be controlled through effective legal guarantees and the increased enthusiasm of project developers. The core earnings of distributed photovoltaic power stations come from electricity fee income. Thus, if the electricity price drops sharply, the yield rate of distributed PV power stations will decline significantly. Meanwhile, the procurement cost of solar PV modules accounts for a large proportion of the power station investment. If the price of modules rises in the future, the investment cost of the company's new projects will increase correspondingly, which may adversely affect the future business performance.

7.3 Operational Risk

In addition to the above challenges, there are other variables that will affect the operating cash flow of a proposed solar PV project during the implementation process.

Factory performance factor is a key variable that affects the power generation. Based on the data provided by solar power companies, the performance factor of a proposed project is estimated at 85%. This means that the project is influenced by natural factors (such as temperature, dust and rainwater), equipment factors (e.g. equipment compatibility, efficiency, failures and line losses), and human factors (such as design and cleaning). Reasonable design, high-quality equipment, and good operation and maintenance will improve performance factors and generate capacity. Therefore, it is recommended to select professional solar power generation companies for implementing and operating rooftop solar PV systems. Third-party international audit and certification institutions can also be introduced, to ensure project quality and power generation efficiency.

Power load capacity will directly affect whether the power generated by the proposed project can be fully and effectively utilized. If the power load capacity is reduced due to industrial mismanagement, the power generated will not be used efficiently, thus affecting the operation of the system and the return on investment. Therefore, it is necessary to fully understand the initial planning and design of industry and commerce, as well as potential fluctuations in electricity demand, to match the needs of users through the better design of solar PV systems.

Electricity price is a key variable that affects the return on investment of rooftop solar PV projects. When DPPA covers large-scale solar PV projects, the electricity price will be negotiated between the producers and the buyers. Thus, the project's ROI will be very sensitive to the changes in electricity price. Therefore, it is crucial to set a reasonable electricity price or price range through careful negotiations, while taking into account the actual situation of the project location and the development planning of the power grid. In this way, the interests of all stakeholders can be guaranteed, and the possibility of undesirable situations can be minimized.

The unit investment cost of solar power projects is mainly influenced by equipment and material costs, construction cost, and other related expenses. Based on local market prices provided by solar companies, the unit investment cost of the proposed project is estimated at around $0.60 per watt. With the rapid development of the global solar industry, the prices of solar photovoltaic panels, brackets, inverters and supporting equipment have been declining. Unit investment cost is expected to continue decreasing as equipment and material prices fall.

The fixed operation and maintenance cost of solar power projects mainly includes the routine maintenance, cleaning, monitoring and testing of solar power systems. The operation and maintenance cost of a solar PV project in Vietnam is estimated at $8.6 per kilowatt per year; this cost can be reduced by cooperating with professional solar power companies for operation and maintenance, and improving the efficiency of local employees through reasonable incentives. With the maturity and popularity of remote monitoring and cloud platform technologies in the solar energy industry, the need for on-site manpower can be reduced, thus further reducing the operation and maintenance cost of PV power generation projects.

The risk of the worsening epidemic situation. If the epidemic worsens, the business expansion, installation, and follow-up operation and maintenance of rooftop solar PV projects will be directly affected; this will lead to a lower growth rate of the distributed PV industry's installed capacity, and a decline in the yield rate of existing power stations.

8. Policy Recommendations

8.1 Strengthen Planning

This report's technical analysis shows that the range of the potential installed capacity of the 18 industrial zones is from 1.18 to 128.82 MW, which indicates great electricity generation potential and environmental benefits. To better promote large-scale rooftop solar PV systems in the industrial zones, it is suggested that the government integrate large-scale rooftop solar PV into the overall regional development planning, including grid management and industrial zone management, and set the minimum utilization ratio of renewable energy in industrial zones.

8.2 Improve Relevant Regulations

To better promote the development of rooftop solar PV in industrial zones, this report suggests that the Vietnam government enact a renewable energy law, improve the consistency of solar PV policy instruments, and implement policies to promote green industrial zones.

Vietnam has not yet enacted a renewable energy law, but this is critical for renewable energy development. Renewable energy laws have been adopted in multiple developing and emerging countries to set the proper legal framework for renewable energy investment and operation, as it creates a stable, transparent and effective market condition.[25]

To attract private investment, the government should also improve the policy consistency; for example, by extending the validation period of FiT to incentivize solar PV investment.

It is noteworthy that industrial zone developers in Vietnam are interested in partnering with solar companies to build rooftop PV infrastructure for industrial zones. Thus, policies and regulations for developing large-scale rooftop solar PV projects in industrial zones are required. The government can support and encourage rooftop solar PV projects on large industrial buildings by lowering taxes and providing adequate subsidies.

Therefore, we suggest that the local governments launch a series of policies to promote large-scale rooftop solar PV in industrial zones; for example, they could simplify the administrative process of applying for a PPA and electricity licence.

8.3 Expend Financial Resources

Vietnam needs to create a favourable business and investment environment for international investors, in order to take advantage of the growing pool of international sustainable finance, which will facilitate the scale-up of solar PV projects in Vietnam. It is necessary to develop the financial system, accumulate experience in international financial and business cooperation, and promote the expansion of replicable business models. Also, to diversify financial sources, it is necessary to attract and bring in foreign government-aided projects and impact investment, to participate in the large-scale rooftop solar PV pilot projects in Vietnam.

Over the past year, Vietnam has become the Southeast Asian country that investors believe has made the greatest strides in renewable energy adoption. Therefore, Vietnam should take advantage of the growing pool of sustainable finance, to unlock the new sources of capital that it needs to scale-up renewable energy, rather than pushing ahead with an expanded non-renewable power pipeline.

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