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Vietnam's Renewable Energy Development: Opportunities, Challenges, and Future Prospects

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Abstract
The global transition to sustainable energy highlights the critical need for renewable energy development, particularly in emerging economies like Vietnam. This study evaluates Vietnam's renewable energy sector by analyzing opportunities, challenges, and policy implications. The findings reveal that despite Vietnam's vast natural potential—such as hydropower, wind, solar, biomass, and geothermal energy—several barriers hinder progress, including regulatory gaps, financial constraints, and technological limitations. The study quantifies renewable energy growth, showing an average annual increase of 10.9% in renewable electricity generation from 2011 to 2019. Additionally, government policies, including tax incentives and feed-in tariffs, have significantly contributed to the expansion of solar and wind power, which reached 9,639 MWp and 419.55 MW, respectively. However, policy inconsistencies and grid limitations continue to pose challenges. To address these, the study proposes targeted policy recommendations to improve investment mechanisms, enhance technological capabilities, and establish a more robust regulatory framework. The results contribute to policy discussions on sustainable energy transitions by providing empirical insights relevant to both national and international energy strategies.

Keywords: Challenges, Energy Policy, Opportunities, Renewable Energy, Sustainable energy, Vietnam.

1. Introduction

Renewable energy has been garnering significant attention and playing an increasingly important and urgent role for Vietnam in global efforts to transition toward sustainable energy systems, particularly in response to climate change, energy security concerns, and the depletion of fossil fuel resources (International Renewable Energy Agency [IRENA], 2023). Many countries have accelerated their renewable energy development strategies to reduce carbon emissions and enhance energy resilience (World Bank, 2023). In emerging economies, including Vietnam, renewable energy plays a crucial role in supporting economic growth while ensuring environmental sustainability (Asian Development Bank [ADB], 2022).

Vietnam has experienced rapid economic expansion, with an average annual GDP growth rate of 6.2% from 2002 to 2022, resulting in a per capita income increase to nearly USD 3,700 (World

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Bank, 2024). This economic growth has driven a significant rise in energy consumption, estimated at an annual increase of 9.5% (Ministry of Industry and Trade of Vietnam, 2023). As the country seeks to meet its growing energy demand, the development of renewable energy sources has become essential in ensuring national energy security and aligning with Vietnam's commitments to sustainable development goals.

The country possesses abundant renewable energy resources, including hydropower, wind, solar, biomass, and geothermal energy. Policies such as tax incentives, financial assistance programs, and feed-in tariff (FiT) schemes have facilitated significant progress in renewable energy adoption, particularly in solar and wind power (Vietnam Energy Association, 2023). However, despite these advancements, several challenges persist, including policy inconsistencies, financial barriers, grid infrastructure limitations, and technological constraints (International Energy Agency [IEA], 2023). Addressing these challenges is critical to ensuring a stable and efficient transition to renewable energy.

In recent years, research on renewable energy development has expanded significantly, driven by the pressing need to combat fossil fuel depletion, mitigate climate change, and support global efforts toward sustainable energy transitions. Numerous studies have explored how renewable energy fosters sustainable development and green growth. For example, (Xuan, 2016), (Viet, 2017), (Xuan, 2022), and (Huang, 2023) have emphasized its crucial role in achieving sustainability objectives. Meanwhile, other research has assessed the socio-economic benefits of renewable energy, including job creation, economic expansion, and enhanced energy accessibility (Tuyet et al., 2022). Furthermore, policy-oriented studies have examined regulatory frameworks that facilitate renewable energy growth in alignment with sustainability goals (Dap, 2022; Truc, 2023).

Both domestic and international literature have analyzed renewable energy policies and strategies across diverse settings. For instance, Cuong (2017) reviewed global renewable energy policies to extract lessons applicable to Vietnam, whereas Dung (2020) focused on Vietnam's legal and policy framework for renewable energy and energy efficiency. Comparative studies, such as Xuan (2016), have drawn insights from countries like Germany to inform Vietnam's green transition. Additionally, researchers have examined obstacles to renewable energy expansion in Vietnam. Studies by Ky (LH, 2022) and Mai (NTT, 2022) have identified key challenges, including financial limitations, regulatory complexities, technological constraints, and market-related barriers.

The research manuscript on Vietnam's renewable energy development highlights significant opportunities and challenges but reveals a critical research gap in policy effectiveness and financial mechanisms. While existing studies discuss policy initiatives and investment trends, there is limited assessment of how these policies impact long-term renewable energy adoption and grid integration. Additionally, financial constraints and technological limitations are mentioned, but a comprehensive analysis of innovative funding solutions, such as green bonds or public-private partnerships, is lacking. Future research should explore dynamic policy

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adjustments and financial innovations to enhance Vietnam's renewable energy transition, ensuring sustainable growth and energy security. To achieve sustainable development goals, increasing the supply of energy from renewable sources is essential. This study will provide an overview of the current state of renewable energy development in Vietnam, analyze the opportunities and challenges associated with its development. Additionally, policy recommendations are provided to enhance investment frameworks, regulatory structures, and technological innovation to accelerate the country's energy transition. By analyzing Vietnam's renewable energy landscape, this research contributes to the broader discourse on sustainable energy strategies in emerging economies.

2. Methodology

The research design and methodology of this study are structured to provide a comprehensive and multi-dimensional analysis of Vietnam's renewable energy sector, primarily relying on secondary data sources. A systematic approach is employed to collect, categorize, and analyze data from a wide range of authoritative sources, ensuring accuracy, reliability, and policy relevance. The study integrates various data streams, including government reports, statistical data, industry publications, legislative documents, and international reports, to form a holistic understanding of Vietnam's renewable energy landscape.

Government reports and statistical data serve as the foundation of this research, offering critical insights into Vietnam's renewable energy development. Official publications from ministries, regulatory agencies, and state-owned enterprises such as Vietnam Electricity (EVN) provide quantitative data on installed capacity, electricity generation, investment figures, and policy frameworks. These data points allow for an assessment of Vietnam's renewable energy performance and highlight key areas requiring further development. Furthermore, legislative documents outline the government's renewable energy policies, tariff structures, and financial incentives, offering an in-depth view of the regulatory landscape. Reports from provincial and municipal authorities contribute localized insights, capturing regional variations in renewable energy adoption, infrastructure readiness, and investment challenges.

To strengthen the analysis, the study incorporates industry reports and market analyses from organizations such as the Vietnam Energy Association (VEA) and consultancy firms specializing in energy sector research. These sources provide up-to-date market intelligence, helping to contextualize Vietnam's renewable energy growth within broader economic and industrial trends. The inclusion of reports from international organizations and non-governmental organizations (NGOs), such as the World Bank, the Asian Development Bank (ADB), and the Global Wind Energy Council (GWEC), further enriches the study by providing comparative insights and policy recommendations. These global perspectives enable a benchmarking of Vietnam's renewable energy strategies against best practices from other countries, facilitating an evaluation of policy effectiveness.

Additionally, projections and scenario analyses from market intelligence firms are incorporated to forecast future trends in Vietnam's renewable energy transition. These forecasts help assess

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potential growth trajectories, investment requirements, and policy adjustments needed to optimize renewable energy deployment. By synthesizing these diverse sources, the study ensures a robust, policy-oriented evaluation that can inform future decision-making.

The methodology employed in this research involves structured content analysis and comparative policy assessment. Content analysis is applied to extract key themes, trends, and policy implications from collected data sources. A policy analysis framework is used to evaluate the effectiveness of existing renewable energy policies, identifying gaps and areas for improvement. Moreover, comparative analysis is conducted to benchmark Vietnam's renewable energy policies against successful models from other countries, offering valuable lessons for policy refinement.

By integrating multiple data sources and applying structured analytical techniques, this study delivers a comprehensive understanding of Vietnam's renewable energy sector. The research design ensures a balanced perspective, capturing both macro-level policy trends and micro-level implementation challenges. Ultimately, the findings contribute to evidence-based policy recommendations aimed at addressing financial constraints, technological barriers, and regulatory gaps, thereby facilitating Vietnam's transition toward a more sustainable and resilient energy system.

3. Results and dicussion

3.1 An overview of renewable energy development in Vietnam

According to Vietnam's Renewable Energy Development Report 2023, Vietnam has made impressive progress in renewable energy transition, particularly in solar and wind power, thanks to numerous policies and initiatives aimed at promoting renewable energy development. Renewable energy is now being used in various sectors, including industrial production, machinery and equipment operation, commercial services, logistics warehouses, wholesale markets, and, notably, by households. This is especially evident in remote areas, mountainous regions, border areas, and islands (Pham Thi Tam, 2023).

During the period 2011–2015, renewable energy development in Vietnam remained relatively limited due to underdeveloped technology, which resulted in high production costs for renewable electricity and made it less attractive to investors. However, from 2016 to 2020, Vietnam experienced a significant boom in renewable energy development (Government of Vietnam, 2011). Renewable energy, with hydropower as its core component, increased its share in Vietnam's total electricity generation mix from 11% in 2010 to 14.7% in 2015 and 18.4% in 2018. However, by 2019, the share of renewable energy decreased to 15.8%, despite that year witnessing substantial growth in solar power. In recent years, there has been notable progress in the development of new types of renewable energy in the power sector, including wind and solar energy. Over the entire period from 2011 to 2019, renewable energy achieved an average annual growth rate of 10.9%, while hydropower grew at a rate of 10.2% per year.

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Regarding Solar Power: Currently, solar power plants in Vietnam have a total capacity of approximately 5,000 MW, including both ground-mounted solar power and rooftop solar power. Specifically:

Ground-mounted Solar Power: The number of ground-mounted solar power projects in Vietnam has increased rapidly, from 2 projects in 2018 to 88 projects in 2019 and 58 projects in 2020. As of now, the total number of ground-mounted solar projects in Vietnam stands at 148, with a combined capacity of 8,647.58 MW.

Rooftop Solar Power: There are currently 104,526 operational rooftop solar power systems, with a total capacity of 9,639 MWp (equivalent to approximately 7,711 MWac).

Table 1: Number of Projects and Capacity of Ground-Mounted Solar Power in Vietnam

Year	2018	2019	2020	Total
Number of projects	2	88	58	148
Capacity (MW)	86	4655	3.906,58	8.647,58

(Source: Power Development Plan 8)

In addition to solar farm projects, rooftop solar power projects in Vietnam have also developed rapidly. Currently, more than 83,000 rooftop solar power systems are connected to the national grid, with a total installed capacity of nearly 4,700 MWp. The cumulative electricity output from rooftop solar systems fed into the grid has reached approximately 1.13 billion kWh, contributing significantly to the national electricity supply. Among these, the installed capacity of rooftop solar systems in industrial zones accounts for the largest proportion, approximately 56% of the total installed capacity; residential areas account for 28%; commercial areas account for 11%; and administrative and public service sectors account for 5%.

Regarding Wind Power: The number of wind power projects in Vietnam has grown significantly, especially after the government introduced policies to encourage wind power development (Decision No. 37/2011/QD-TTg and Decision No. 39/2018/QD-TTg). In 2011, experts from AWS True Power LLC estimated Vietnam's total wind energy potential at around 27 GW. By 2018, the Institute of Energy conducted a detailed assessment using GIS-based wind resource mapping for onshore areas, considering land availability, land use restrictions, grid connectivity, and other factors. Despite its considerable technical potential, Vietnam currently has only 13 operational wind power projects, with a total installed capacity of approximately 419.55 MW.

In addition to the operational projects, several wind power projects are currently under construction. These include the Thuan Nhien Phong Wind Power Project in Ninh Thuan Province, with a capacity of 32 MW; the Tay Nguyen Wind Power Farm – Phase 1 in Dak Lak Province, with a capacity of 28 MW; the BPP Wind Power Project – Phase 1 in Soc Trang Province, with a capacity of 30 MW; and the Trung Nam Wind Power Project – Phase 3 in Ninh Thuan Province, with a capacity of 48 MW.

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Table 2: List of Operational Wind Power Projects in Vietnam

No	Project Name	Location	Installed Capacity (MW)	Investor	Type of Wind Farm
1	Tuy Phong	Bình Thuận	30	Vietnam Renewable Energy JSC	Grid-connected, onshore
2	Phú Quý	Phú Quý Island	6	Vietnam Oil and Gas Renewable Energy Co., Ltd.	Off-grid, island-based
3	Bạc Liêu Phase 1	Bạc Liêu	16	Công Lý Construction - Trade - Tourism Co.	Grid-connected, offshore
4	Bạc Liêu Phase 2	Bạc Liêu	83.2	Công Lý Construction - Trade - Tourism Co.	Grid-connected, offshore
5	Phú Lạc	Bình Thuận	24	Bình Thuận Wind Energy JSC	Grid-connected, onshore
6	Hướng Linh 2	Quảng Trị	30	Tân Hoàng Cầu Group	Grid-connected, onshore
7	Đầm Nại Phase 1	Ninh Thuận	7.8	Blue Circle Co., Ltd. & TSV Investment Co.	Grid-connected, onshore
8	Đầm Nại Phase 2	Ninh Thuận	30	Blue Circle Co., Ltd. & TSV Investment Co.	Grid-connected, onshore
9	Mĩu Dinh	Ninh Thuận	37.6	Mĩu Dinh Wind Power Co., Ltd.	Grid-connected, onshore
10	Trung Nam Phase 1	Ninh Thuận	39.95	Trung Nam Wind Power JSC	Grid-connected, onshore
11	Trung Nam Phase 2	Ninh Thuận	64	Trung Nam Wind Power JSC	Grid-connected, onshore
12	Hướng Linh 1	Quảng Trị	30	Tân Hoàng Cầu Group	Grid-connected, onshore
13	Phương Mai 3 Phase 1	Bình Định	21	Trung Phong Renewable Energy JSC	Grid-connected, onshore

(Source: Pham Thi Tam, 2023)

- ***Small hydropower plants***

The total technical potential of small hydropower in Vietnam is estimated to range from 1,600 MW to 2,000 MW, with a variety of scales.

Regarding 100–10,000 kW capacity stations, there are approximately 500 small hydropower stations within this category, with a combined capacity of 1,400–1,800 MW, accounting for 82%–97% of all small hydropower stations.

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Regarding 5–100 kW capacity stations, this category includes around 2,500 small hydropower stations, with a total capacity of 100–150 MW, representing 5%–7.5% of all small hydropower stations.

Regarding 0.1–5 kW capacity stations (also known as micro-hydropower), these stations have a combined capacity of 50–100 MW, accounting for 2.5%–5% of the total capacity of small hydropower stations.

Currently, many micro-hydropower projects with capacities ranging from 200 to 500 W are being implemented along border areas or by households in remote and rural communities. Small hydropower plants with capacities of 100 to 1,000 W are sufficient to provide electricity for lighting during flood seasons. In Vietnam, small hydropower projects have been constructed since the 1960s. Initially, these projects were funded by the state budget between 1960 and 1985 in the northern and central provinces of Vietnam. Between 1985 and 1990, small hydropower development received investments from ministries, provincial authorities, military units, and various organizations. Following 2003, investment transitioned to the private sector due to the liberalization of the electricity market. Currently, there are 310 small hydropower projects distributed across the country (in over 31 provinces) with a total installed capacity of approximately 3,443 MW.

- ***Biomass power***

Thus far, the development of biomass power projects in Vietnam remains modest and falls short of its potential. Vietnam has only three biomass power plants, with a total generation capacity of 46.2 MW as of 2022. The primary fuels used are wood residues, corn stalks and cobs, wood chips, and pellets.

Table 3: List of Independent Biomass Power Plants

No	Project Name	Location	Main Fuel	Power Generation Capacity (MW)
1	Quế Sơn Biomass Power Plant	Quảng Nam	Wood and timber waste	7
2	Ea Sar Biomass Power Plant	Đắk Lắk	Wood stems and corn cobs	10.2
3	Trường Minh Biomass Power Plant	Yên Bái	Wood chips, pellets	29

(*Source*: *Vietnam Energy Institute, 2020)*

As of now, in Vietnam, only 10 investors have submitted applications for permits to develop rice husk power projects, with an average capacity of 10 MW per plant. The proposed rice husk power projects are designed solely to produce electricity for sale to the grid, using traditional

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condensing thermal power technology with circulating fluidized bed boilers and pure condensing steam turbines.

At sugar mills, the available bagasse from the sugarcane crushing process is used as the primary fuel to supply energy for technological processes. Meanwhile, at paper mills, firewood is one of the fuels used for energy production. As of now, Vietnam has approximately 35 operational sugar mills utilizing bagasse as fuel for energy generation (electricity and steam). The total installed power capacity from bagasse at these mills reaches 499.77 MW, with capacities ranging from 1.5 MW to 55 MW.

- ***Waste-to-energy power***

The use of waste as a source for electricity generation in Vietnam began in 2006, with the successful launch of the first project: the Gò Cát Waste-to-Energy Plant in Ho Chi Minh City, featuring an installed capacity of 2.4 MW. In 2017, Vietnam's first industrial waste-to-energy plant, the Nam Sơn Waste-to-Energy Plant, was established. This plant employs advanced Japanese waste incineration technology, with a processing capacity of 75 tons per day, generating 1.93 MW of electricity. Following this, the Cần Thơ Waste-to-Energy Plant was developed, with a capacity of 7.5 MW, capable of processing approximately 400 tons of waste per day and generating around 60 million kWh of electricity annually. Currently, five additional waste-to-energy projects (with a total capacity of 150 MW) have been approved.

The development of renewable energy in Vietnam in recent years has been clearly reflected in the structure of domestic commercial energy exploitation. The share of renewable energy in the domestic commercial energy mix has increased significantly, from 6.3% in 2010 to 15.1% in 2019. In contrast, the share of coal in the domestic commercial energy mix has declined sharply, from 45.6% in 2010 to 39.6% in 2019

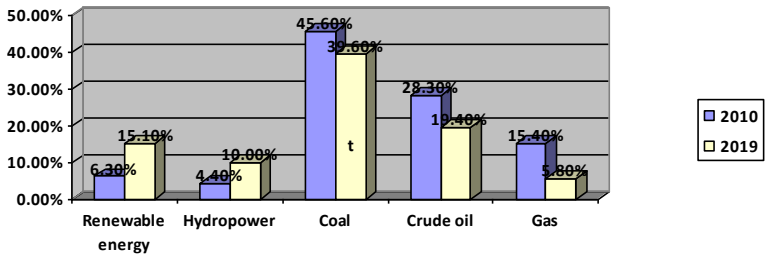

Figure 1: Structure of Commercial Energy Exploitation in Vietnam
(*Source: Power Development Plan 8)*

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In 2019, renewable energy sources in Vietnam supplied approximately 36 billion kWh of electricity. The potential for utilizing renewable energy across various sectors is significant, and the integration of the renewable energy industry has attracted attention from policymakers and market participants. This environment has created opportunities for the development of technologies such as battery storage, heat pumps, and electric vehicles.

However, there remains a lack of effective policies to directly support the integration of power sources, heat production, and transportation. By 2019, renewable energy accounted for nearly 40% of Vietnam's total electricity generation capacity, with hydropower contributing 30.3%, wind power 0.7%, and small hydropower 6.6%. This highlight both the achievements and the need for further policy frameworks to enhance renewable energy deployment.

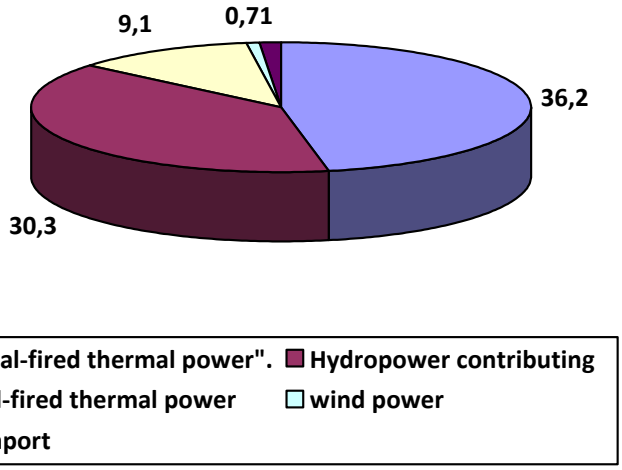

Figure 2: Proportion of Renewable Energy in the Power Generation Mix in 2019
(Source: Power Development Plan 8)

By 2020, the total installed capacity of renewable energy in Vietnam reached 69,300 MW (an increase of 14,000 MW). The proportion of power sources in the energy mix was as follows: hydropower accounted for 30%; coal-fired power 31.1%; renewable energy 25.3%; oil-fired power 2.2%; imports 0.8%; and other sources 0.3%.

The growth of renewable energy has significantly reshaped Vietnam's final energy consumption structure in recent years, with a steady rise in the share of renewable energy and a sharp decline in the use of non-commercial energy. The share of electricity consumption in Vietnam's total final energy consumption (TFEC) has shown a rapid upward trend, reflecting a shift from other types of fuel to electricity during the period from 2010 to 2019. In 2010, electricity consumption accounted for 17.2% of total TFEC; by 2015, this share had increased to 23.2%, and by 2019, it had reached 29.1%.

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Although coal is abundant as a primary energy source, its consumption growth rate in Total Final Energy Consumption (TFEC) has only reached 5.2% per year. The share of coal in TFEC has remained relatively stable, around 23-25%.

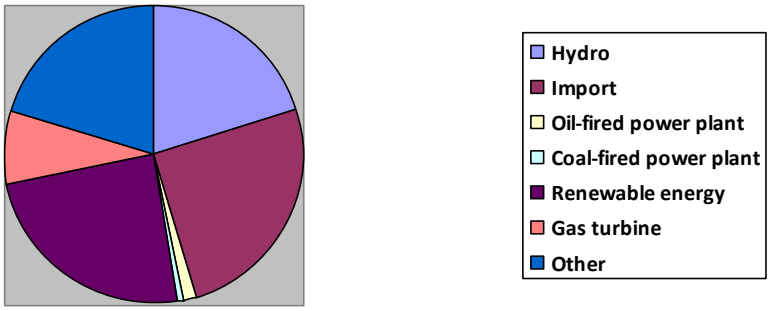
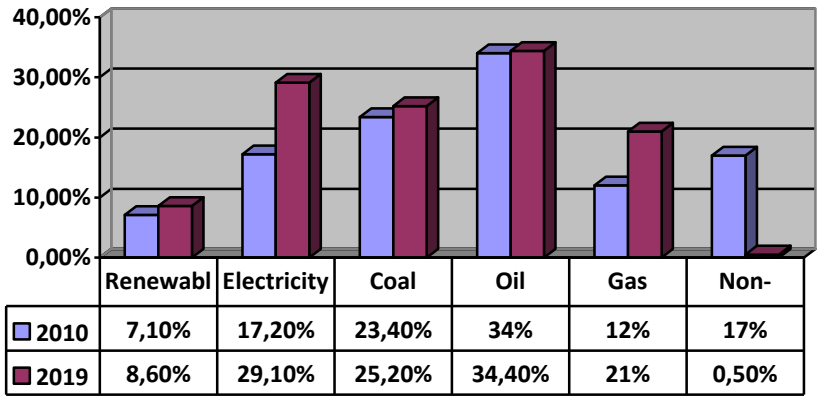


Figure 3: Proportion of Renewable Energy in the Power Generation Mix in 2020
(Source: Institute for African and Middle Eastern Studies)

Meanwhile, renewable energy has experienced a relatively high growth rate, averaging 6.6% per year. Its contribution to the TFEC structure also increased significantly, rising from 7.1% in 2010 to 8.6% in 2019.

Petroleum products accounted for the largest share of TFEC, remaining relatively stable at around 34% in 2019. However, the share of non-commercial energy in TFEC dropped sharply, from 17% in 2010 to just 0.5% in 2019, primarily due to changes in statistical methods.
Unit: %



	Renewabl	Electricity	Coal	Oil	Gas	Non-
2010	7,10%	17,20%	23,40%	34%	12%	17%
2019	8,60%	29,10%	25,20%	34,40%	21%	0,50%

Figure 4: Structure of Final Energy Consumption by Fuel Type (2010-2019)
(*Source: Power Development Plan 8)*

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3.2. Opportunities for Renewable Energy Development in Vietnam

3.2.1. Great Potential for Renewable Energy Development

- ***Water power***

As highlighted in the 2016 Small Hydropower Development Report by the United Nations Industrial Development Organization (UNIDO), the demand for clean and sustainable energy sources has become increasingly critical in both developing and developed countries, particularly in the context of climate change. Moreover, geopolitical and economic uncertainties surrounding fossil fuel markets have further emphasized the need for energy diversification. On a global scale, hydropower remains the most widely utilized form of renewable energy, with a total installed capacity exceeding 1.2 million megawatts (1.2 TW).

Vietnam is home to a dense river network, with around 2,360 rivers spread across the country, 90% of which consist of small streams and rivers. This provides favorable conditions for the development of small hydropower. Vietnam's theoretical hydropower potential is estimated at around 300 billion kWh, with a technical potential of approximately 123 billion kWh. According to the Ministry of Industry and Trade over 1,000 sites with a total capacity of more than 7,000 MW have been identified at present time. Based on the results of a study conducted by the Ministry of Industry and Trade on small hydropower capacity thresholds, Vietnam's small hydropower potential, with capacities ranging from 0.1 MW to 30 MW per station, is estimated at a total installed capacity of approximately 4,015 MW, primarily concentrated in the Northern mountainous regions, the South Central Coast, and the Central Highlands.

Table 4: Technical Potential of Small Hydropower by Capacity Range

Capacity Range (MW)	Total Capacity (MW)
0.1 - < 1	126.8
1 - < 5	1,030.2
5 - < 10	1,048.3
10 - < 15	648.0
15 - < 20	562.8
20 - < 25	309.0
25 - < 30	290.0
Total (≤ 30 MW)	4,015.1

(*Source: Ministry of Industry and Trade, 2006)*

- ***Wind power***

Vietnam is seen as a country with abundant wind energy resources. According to the European energy infrastructure development model, ASEAN estimates the technical potential of this energy source at 22,400 MW. Average annual wind speed in Vietnam is about 5 m/s. The regions most suitable for building wind power plants and with the greatest potential for wind energy development in Vietnam include:

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The Central Coast, especially in Ninh Thuan, Binh Thuan, Phu Yen, Quang Nam, and Quang Ngai provinces. The Southern Coast, especially in Ba Ria-Vung Tau, Binh Phuoc, Kien Giang, and Ca Mau provinces. The Northern Coast, especially in Quang Ninh, Nam Dinh, Thai Binh, and Hai Phong provinces.

According to a report conducted by Power Engineering Consulting Joint Stock Company 3, Vietnam's wind energy potential at an 80-meter height, with an average annual wind speed exceeding 6 m/s, is estimated at approximately 10,637 MW.

Table 5: Technical Potential of Wind Energy in Vietnam

No.	Region	Technical Potential (MW)
1	Northern Region	50
2	Central Region	880
3	Southern Region	855
	Total	1,785

(*Source: IUCN, 2022*)

- ***Solar power***

The potential for harnessing solar energy in Vietnam is based on solar radiation levels. Vietnam benefits from high and stable solar radiation year-round, particularly in the Central Highlands, Central Coast, Southern regions, and the Mekong Delta. On average, solar radiation across the country ranges between 4 to 5 kWh/m² per day. Regions with 1,800 or more sunshine hours annually are considered highly suitable for solar energy development. In Vietnam, this includes many areas, especially in the southern provinces.

Table 6: Average Daily Solar Radiation and Sunshine Hours in Vietnam

No.	Region	Average Solar Radiation (kWh/m²/day)	Average Sunshine Hours (hours/year)
1	Northeast and Red River Delta	3.3 – 4.6	1,100 – 1,600
2	Northwest	4.3 – 5.3	1,500 – 2,100
3	North Central Coast	4.6 – 5.2	1,600 – 1,900
4	South Central Coast and Central Highlands	4.9 – 5.7	2,000 – 2,800
5	Southeast and Mekong Delta	4.8 – 5.5	2,200 – 2,700
	National Average	4.6	2,000

(*Source: Meteorological and Hydrological Data Center. 2020)*

- ***Biomass energy***

Vietnam holds great potential for biomass energy development, with an estimated total potential of 50 million tons of oil equivalent (TOE). Vietnam possesses various types of biomass that can

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be effectively utilized to meet a portion of the market's fuel and electricity demand. Biomass energy can be categorized into two main types: wood fuel and waste from industrial crops.

Wood fuel includes combustible materials derived from natural forests, plantation forests, shrubs on barren hills, scattered trees, fruit trees, perennial industrial crops, and wood processing waste (such as wood chips, bark, and sawdust).

Waste from industrial crops primarily consists of two types: agricultural waste after harvest, such as straw, rice husks, sugarcane tops and leaves, corn stalks, and leaves; and post-processing industrial and agricultural waste, such as rice husks, bagasse, peanut shells, and coffee husks.

In Vietnam, the available potential for biomass energy in electricity production is estimated at around 1,000–2,000 MW. Among biomass sources, wood is the primary resource, accounting for approximately 40% of the total potential, equivalent to 20 million TOE. Wood is utilized for electricity generation, heat production, and biofuel development.

- ***Geothermal energy***

Vietnam has several regions with significant geothermal potential, including the Northwest, Northeast, and especially the Central region, such as Quang Binh, Quang Ngai, Binh Dinh, and Khanh Hoa. These regions are highly suitable for the development of geothermal power projects. According to preliminary studies conducted by the Institute of Geology and Minerals, the total capacity of geothermal power plants in Vietnam could reach over 400 MW.

Table 7: Geothermal Potential by Region

Geothermal Regions	Total number of sources	Subsurface temperature (0C)	The number of geothermal sources with potential for exploitation at various scales		
			Industrial scale	Medium	Small
Northwest	79	103 - 200	10	25	44
Northeast	11	95 – 146	2	6	3
Red River Delta	17	100 – 150	5	3	9
North Central Coast	42	120 – 210	4	10	28
South Central Coast	67	110 - 200	14	18	35
Southern Region, Mekong River Delta	53	150		22	31
Total	269		35	84	150

(*Source: Nguyễn Ánh, 2021*)

3.2.2 Government’s favorable policies for Renewable Energy Development in Vietnam

The Vietnamese government has shown a strong commitment to renewable energy development. For instance, Decision No. 1855/QD-TTg, issued on December 27, 2007, titled "The National Energy Development Strategy of Vietnam to 2020, with a Vision to 2050," outlined key

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objectives. These include ensuring national energy security, supplying adequate and high-quality energy to support socio-economic development, and advancing the development of new and renewable energy sources.

Building on this commitment, in 2011, the government issued Decision No. 1208/QD-TTg, which defined the role and proportion of renewable energy sources in the national energy mix. Furthermore, Article 29 of Law No. 24/2012/QH13 (the Electricity Law) established the legal foundation for developing renewable energy projects.

In a significant step forward, the first National Renewable Energy Development Strategy was introduced under Decision No. 2068/QD-TTg on November 25, 2015. This strategy set specific goals, aiming for the share of electricity generated from renewable energy (including both large and small hydropower) to account for 32% of the total national electricity output by 2030 and 43% by 2050. To support these targets, the government has implemented various policies to encourage and accelerate the development of renewable energy projects. Specifically, these policies include:

Tax and fee incentives: The government implements corporate income tax exemptions and reductions, import tax exemptions and reductions, and investment fee waivers.

Table 8: Tax Incentives to Promote Renewable Energy Development

No.	Financial Incentives	Policy Details
1	Corporate Income Tax	- Preferential tax rate of 10% for 15 years
		- Or, tax exemption for 4 years (50% tax reduction for the following 9 years)
2	Import Tax	- Exempt from annual import taxes as announced by the Ministry of Planning and Investment
3	Land Use	- Exemption or reduction of land use tax and rental fees for investment projects
4	Environmental Protection Fee	0%

(Source: compilled by author)

- ***Financial and credit policy***

This policy includes the use of preferential credit loans. Specifically, the loan-to-value ratio for renewable energy projects has been increased from the usual 70% to 80% compared to other types of projects. Additionally, the government has implemented a Feed-in Tariff (FIT) mechanism to encourage investment in renewable energy, particularly in solar and wind power. Furthermore, various incentive policies have been introduced to adjust electricity trading

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mechanisms for rooftop solar projects, transitioning from a net-metering system to a separate electricity purchase and sale mechanism with distinct energy delivery arrangements.

- ***Price support policies for renewable energy***

Private investors in wind energy are permitted to sell electricity at higher rates. For onshore projects, the rate has increased from 7.8 US cents/kWh to 8.5 US cents/kWh, while offshore projects are officially set at 9.8 US cents/kWh.

For biomass energy, the government requires Vietnam Electricity (EVN) to purchase all electricity generated under non-negotiable contracts. The selling price is fixed for two main types of biomass energy: cogeneration, priced at 5.8 US cents/kWh, and avoided cost pricing, which is based on imported coal-fired power rates (approximately 7.5 US cents/kWh, applicable in the southern region).

For waste-to-energy projects, the government prioritizes and supports waste-to-energy projects using two types of technologies: methane gas recovery from landfills and incineration with environmentally safe practices. The corresponding electricity prices are 7.28 US cents/kWh and 10.05 US cents/kWh, respectively.

Finally, the support price for solar energy is set at 9.35 US cents/kWh.

3.3. Renewable Energy Development in Vietnam: Challenges Ahead

Although Vietnam has favorable natural conditions and significant potential for renewable energy development, renewable energy currently makes up only about 5% of its total power generation capacity (DOC, 2024). The development of renewable energy faces several challenges, including:

Firstly, there are challenges related to policies and legal frameworks. Specifically, Vietnam has not yet developed a comprehensive master plan for renewable energy development and lacks a clear, consistent, and stable legal framework. Current incentives are also insufficient to attract investors. Meanwhile, policies play a crucial role in driving development, and a robust legal framework ensures stability and security for investments in this sector. To accelerate renewable energy development, Vietnam needs to build a solid policy framework, accompanied by specific policies, clear objectives, and necessary support programs to advance the growth of this renewable energy source.

On the other hand, the current Feed-in Tariff (FIT) is applied uniformly across the country, resulting in concentrated development in economically favorable regions, such as areas with high solar radiation or strong wind speeds. This has led to overloading of the electrical grid in certain regions or the need to invest in areas with low electricity demand, requiring long-distance power transmission.

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Currently, the FIT mechanism is applied uniformly to all projects, regardless of differences in scale. This results in larger projects achieving significantly higher efficiency compared to smaller ones, even when natural conditions are similar. Therefore, an appropriate approach would be to apply the FIT only to small projects (around a few MW). For larger projects (tens of MW or more), direct power purchase agreements (PPAs) should be negotiated between Vietnam Electricity (EVN) and investors to ensure capital recovery and reasonable profitability.

For the support mechanism for rooftop solar power projects, some regulations remain unreasonable:

The regulation limiting the capacity of rooftop solar power systems to no more than 1 MW, primarily aimed at households and small businesses, is unreasonable. This restriction prevents organizations and businesses with large rooftops from installing larger solar power systems to meet their own electricity needs. Therefore, this regulation should be divided into two parts: for households, the maximum capacity should be capped at a certain level (around a few dozen kW); for organizations and businesses, there should be no capacity limit, provided it aligns with their electricity consumption needs.

The regulation requiring households to sell all self-produced electricity and repurchase all electricity from the utility company is unreasonable, as it results in households being taxed twice for the same amount of electricity: value-added tax (VAT) on purchased electricity and income tax on sold electricity. To address this issue, it is proposed to implement a net-metering mechanism, as approved in Decision No. 2068/QD-TTg dated November 25, 2015, by the Prime Minister. Additionally, renewable energy projects need clear standards and regulations. It is essential to establish standards and certifications for imported equipment to ensure compliance with technical requirements and current regulations, while also helping businesses operate their plants in accordance with the law. The lack of such standards can cause unnecessary difficulties and complications for manufacturers and investors in the renewable energy sector.

Secondly, financial difficulties remain a major concern. Renewable energy projects often face substantial difficulties due to high initial investment costs, limited participation from financial institutions and investors, and intense competition from fossil fuels. Furthermore, subsidies for renewable energy are less generous compared to traditional energy sources, slowing the development of renewable energy.

In Vietnam, renewable energy projects face challenges in accessing domestic credit as banks consider this sector high-risk, resulting in equity requirements of up to 30-40% and very high interest rates, ranging from 30-40%. On the other hand, loans from international banks offer much lower interest rates (around 4-5%), but domestic enterprises struggle to access them due to the requirement for government guarantees. To ensure the progress and efficiency of projects, many domestic investors are forced to collaborate with foreign partners or transfer part or all of their projects to access international loans with lower interest rates.

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In addition to price support policies, budgetary subsidies for renewable energy projects remain limited. A potential financial solution could involve the government introducing regulations requiring organizations and individuals using fossil fuels to pay environmental fees based on their fuel consumption. A portion of the collected fees could then be allocated to funding renewable energy development and applications through the Sustainable Energy Development Fund.

Thirdly, technological challenges remain a significant barrier to renewable energy development. Advanced technology and substantial investment in skilled human resources are essential for the operation and maintenance of renewable energy projects. However, Vietnam faces limitations in technological expertise, along with inadequate infrastructure and support services for equipment repair, maintenance, and replacement. These constraints have resulted in uneven development across renewable energy projects.

While the construction of an renewable energy project typically takes 6 months to a year, completing the necessary investment procedures and approvals often takes just as long. In contrast, building power lines or transformer stations can take 2 to 3 years, with additional delays of 1 to 2 years in cases of land clearance or compensation issues. This disconnect between the pace of renewable energy development and grid infrastructure upgrades has created significant "bottlenecks" in power transmission, reducing the efficiency and capacity of renewable energy generation.

To resolve these issues, there must be stronger collaboration between government agencies, investors, and power utilities during the planning, approval, and investment phases. Grid infrastructure construction or upgrades should be prioritized and completed before renewable energy sources are connected to the system. Without clear agreements on the responsibilities of each party involved in grid investment and development, projects risk being stalled or abandoned.

Wind and solar power projects have variable electricity generation capacities depending on natural conditions such as wind speed and solar radiation, which can impact the operation of the power grid. As the share of wind and solar power in the energy mix increases, appropriate solutions are needed to ensure the national power system operates reliably and safely.

Fourthly, challenges arise from the heavy reliance on natural conditions (such as water, sunlight, wind, and geographical location). Vietnam's complex terrain, characterized by mountains, rivers, and coastal and island areas, can create difficulties in the construction and installation of renewable energy projects, especially offshore projects. Additionally, Vietnam's tropical monsoon climate, with extreme weather events such as storms, floods, and droughts, poses significant risks and potential damage to renewable energy projects.

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4. Policy implimantations for promoting the development of eenewable energy in Vietnam

To achieve the goal of net-zero emissions by 2050, Vietnam needs to significantly increase the capacity of renewable energy sources, with particular attention to the following solutions:

Firstly, in terms of policy, the development of renewable energy policies must be thoroughly researched and constructed with clarity and consistency across strategies, plans, and implementation frameworks. It is imperative to prioritize the drafting and enactment of a Renewable Energy Law, as Vietnam currently relies solely on the Electricity Law and the Law on Efficient and Economical Use of Energy, which lack specific regulations for the renewable energy sector. The adoption of a Renewable Energy Law would provide a comprehensive legal framework to facilitate and regulate investment activities in this field. Furthermore, it is essential to finalize investment incentive mechanisms, particularly tax incentives for renewable energy equipment and high-efficiency devices in a timely manner to promote the sector's development effectively.

For large-scale renewable energy projects, the bidding mechanism will be adjusted. The selected project developer will be the one offering the lowest electricity selling price for ground-mounted and floating solar power projects. Although implementing this mechanism may take time, it will ensure fairness and transparency for investors while maintaining alignment between the development of renewable energy projects and the transmission grid system.

Secondly, investment in research for renewable energy development. Vietnam should establish fundamental research centers and development hubs focused on renewable energy, new energy, and carbon storage technology. Its aims are to enhance expertise, facilitate technology adoption and transfer, and improve management practices to accelerate and scale up the deployment of renewable energy and the management of clean energy systems.

Vietnam needs to expand international cooperation in scientific research, development, and technology transfer in the field of renewable energy. This aims to access and adopt advanced technologies from developed countries while enhancing domestic research and implementation capabilities.

Moreover, Vietnam needs to develop a highly skilled workforce in fields related to renewable energy and smart grids. Vietnam should implement specialized training programs, practical exercises, and research initiatives to equip workers with the necessary knowledge and skills. Vietnam should also reform training programs and curricula, adopt diverse training methods, and integrate theoretical education with practical production experience. This will ensure that the workforce is qualified and capable of operating large-scale power systems, integrating a high share of renewable energy sources, and applying smart grid technologies effectively.

Thirdly, diversify funding sources and financing mechanisms for renewable energy development. Vietnam should enhance its efforts to attract and mobilize investment from both domestic and international sources for renewable energy development. This includes engaging private

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companies, investment funds, and international financial institutions. Vietnam should effectively utilize international support commitments such as the Just Energy Transition Partnership (JETP), the Asia Zero Emission Community (AZEC), as well as green credit programs, climate credit schemes, and green bonds to secure financial support for renewable energy projects. Vietnam should diversify funding mechanisms by introducing various forms of capital mobilization, such as issuing green bonds, offering green credit, and providing concessional loans to finance renewable energy projects.

The Vietnamese government should create favorable conditions and encourage its citizens and businesses to invest in rooftop solar power and self-produced, self-consumed energy sources. The government should provide tax incentives and other financial support to stimulate community investment. It should also offer financial and technical assistance to households and businesses interested in installing rooftop solar systems, including concessional loans and subsidy programs. Additionally, Vietnam should establish a transparent and favorable investment environment to attract and encourage private sector participation in renewable energy projects. This includes simplifying administrative procedures and ensuring transparency in the project approval and permitting process.

The Vietnamese government should adopt flexible and efficient credit policies to enable businesses to access capital for renewable energy projects. These measures could include concessional loans, green credit programs, and financial support packages provided by banks.

5. Conclusion

The development of renewable energy in Vietnam presents both significant opportunities and persistent challenges. The country has demonstrated remarkable progress, particularly in solar and wind energy, with total installed capacities reaching 9,639 MWp and 419.55 MW, respectively, driven by government incentives such as feed-in tariffs and tax reductions. However, despite an average annual renewable electricity generation growth of 10.9% from 2011 to 2019, Vietnam's renewable energy share remains lower than regional benchmarks such as China and Thailand, where installed capacities have exceeded 100 GW and 13 GW, respectively. These comparisons highlight the need for stronger policy support and infrastructure investments to enhance Vietnam’s competitiveness in the renewable energy sector. The study identifies key challenges, including policy inconsistencies, financial constraints, and grid infrastructure limitations, which hinder large-scale renewable energy integration. Policy gaps, particularly in long-term regulatory frameworks and investment mechanisms, create uncertainty for investors, while limited access to financing and high capital costs slow the deployment of new projects. Moreover, the country’s heavy reliance on hydropower exposes the energy system to seasonal variability, further underscoring the need for diversified energy sources.

To address these issues, targeted policy recommendations have been proposed, emphasizing the need for enhanced financial incentives, improved grid capacity, and clearer regulatory frameworks. Strengthening public-private partnerships and facilitating access to international green financing mechanisms, such as green bonds and climate funds, can accelerate renewable

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energy investments. Additionally, technological advancements, including energy storage solutions and smart grid deployment, are essential to ensure stable integration of variable renewable energy sources into the national power system.

Despite these insights, the study has certain limitations. The research relies primarily on secondary data sources, which may not capture the most recent policy changes or emerging investment trends. Future research should incorporate primary data collection, such as stakeholder interviews or case studies, to provide a more comprehensive assessment of renewable energy development. Moreover, a comparative analysis with other Southeast Asian countries could offer deeper insights into Vietnam's relative performance and policy effectiveness.

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