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Renewable Energy Development in Vietnam - Current Situation and Solutions

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A B S T R A C T

Vietnam's renewable energy sector has witnessed notable advancements in recent years, particularly in wind and solar power generation. However, challenges persist, hindering the sector's full potential. This study evaluates the current status of renewable energy development in Vietnam from 2015 to the present, identifying existing obstacles and proposing effective solutions. Achievements in harnessing wind, solar, biomass, hydropower, and waste-to-energy sources are highlighted. Challenges such as inadequate grid infrastructure, high initial investment costs, complex administrative procedures, and energy losses are addressed. The paper proposes a comprehensive set of solutions, including infrastructure upgrades, financial incentives, institutional reforms, technology transfers, and research promotion. Implementing these solutions synchronously holds the promise of accelerating Vietnam's renewable energy development, contributing significantly to sustainable development goals. The findings provide insights for policymakers and stakeholders to enhance the efficiency of green energy deployment in Vietnam.

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INTRODUCTION

In the context of climate change, green and sustainable energy sources are becoming an inevitable global trend. In Vietnam, the government has set out a strategy "for developing renewable energy by 2030, with the goal of increasing the share of renewable energy in the country's total energy consumption to 15-20% by 2030". To achieve this goal, Vietnam has been and is applying many mechanisms and policies to promote investment in wind power, solar power and other types of renewable energy projects. It can be seen that in the past 5 years, Vietnam has achieved quite positive results in developing renewable energy, especially for wind and solar energy sources. The capacity of wind and solar power plants has increased many times compared to the 2015-2017 period. However, biomass and waste-to-energy sources have not been well exploited. In addition, the development of renewable energy projects in our country still faces many obstacles that need to be removed, such as high initial investment costs, unsynchronized power grid infrastructure, complicated administrative procedures, energy losses, etc. Therefore, research evaluating the current status of implementing renewable energy sources in Vietnam, identifying difficulties and obstacles, and proposing effective solutions to address the above issues are needed.

This research will provide a basis for improving the efficiency of green energy development, contributing to the successful implementation of the national energy strategy as well as Vietnam's sustainable development goals. The research scope will focus on the field of renewable energy development in Vietnam from 2015 to the present. The article will analyze the current situation of renewable energy development in Vietnam in recent years. From there, it will propose specific solutions to help remove difficulties and promote more effective renewable energy development in Vietnam in the coming time. Specifically, the article will present the achievements in developing major renewable energy sources such as wind power, solar power, biomass power, and hydropower in Vietnam. Through this, it will point out the difficulties and challenges hindering the development of the renewable energy industry in Vietnam. Finally, the article will propose specific solutions to help remove difficulties and promote more effective renewable energy development in Vietnam in the coming time. Overall, stemming from the research questions mentioned above, conducting research on this topic is extremely necessary. The results of the article will not only contribute to analyzing the current situation of renewable energy development in Vietnam but also serve as a basis and experience for evaluating the effectiveness of renewable energy development policies in Vietnam.

To achieve these objectives, the article will answer 03 research questions:

1) What are the outstanding achievements in developing renewable energy in Vietnam in recent times?
2) What are the biggest difficulties and challenges for the current development of renewable energy in Vietnam?
3) What solutions can help promote effective and sustainable renewable energy development in Vietnam in the coming time?

LITERATURE REVIEW

The documents from the United Nations (United Nations, 2023) and the U.S. Department of Energy (Energy Efficiency & Renewable Energy, 2022a, 2022b, 2022c) provide definitions and an overview of renewable energy and major renewable energy sources such as hydropower, wind power, biomass energy, and solar energy. The document from Student Energy (2021) explains waste-to-energy conversion technologies. These sources offer a comprehensive theoretical understanding of renewable energy and its various forms.

Reports and websites from Vietnam Electricity (EVN), the Ministry of Industry and Trade, and other Vietnamese government agencies (PEC, 2022; Ministry of Industry and Trade of Vietnam, 2021, 2023) provide updated data on the development of renewable energy sources in Vietnam, such as wind power, solar power, biomass power, and hydropower. These official sources present valuable quantitative information on the current status and achievements of renewable energy deployment in the country. The website of the Mekong Delta Development Research Institute (AG Green Energy, 2021) and the Vietnam Energy Association (2021) also provide information on the potential and development of renewable energy sources in Vietnam, highlighting the country's rich resources and opportunities in this sector.

Domestic news and media outlets such as Investment Newspaper (Dau Tu Newspaper, 2022), Intracom (2023), and VNEEP (2020) analyze the challenges and difficulties in developing renewable energy projects in Vietnam. These sources offer insights into the practical obstacles and limitations faced by industry stakeholders, policymakers, and project developers. Furthermore, academic literature and research studies can provide a more in-depth analysis of specific aspects of renewable energy development in Vietnam. For instance, studies may examine the economic feasibility, environmental impacts, or policy implications of various renewable energy technologies in the context of Vietnam's energy landscape and development goals.

The overview of the above literature provides a theoretical foundation, empirical data, and insights into the development of renewable energy in Vietnam, supporting the construction of the Results and Discussion sections of the research. By synthesizing these diverse sources, a comprehensive understanding of the current state, achievements, challenges, and potential solutions for renewable energy development in Vietnam can be established.

METHODOLOGY

This study primarily employs qualitative methods, focusing on policy and regulatory analysis, as well as a synthesis of secondary data sources, to examine the current status, achievements, challenges, and potential solutions for renewable energy development in Vietnam. The research methodology is structured as follows:

Frist, policy and regulatory analysis: Existing policies, regulations, and incentive mechanisms related to renewable energy development in Vietnam were critically analyzed to assess their effectiveness, identify gaps, and propose potential improvements. This analysis involved a comprehensive review of

government documents, legal frameworks, and policy reports from relevant ministries and agencies, such as the Ministry of Industry and Trade and the Ministry of Natural Resources and Environment.

The policy and regulatory analysis process involved:

a. Identifying and collating all relevant policies, regulations, and incentive mechanisms pertaining to different renewable energy sources (wind, solar, biomass, hydropower, and waste-to-energy) in Vietnam.
b. Examining the policy objectives, targets, and implementation strategies outlined in these documents.
c. Evaluating the impact and effectiveness of these policies and regulations based on available data, stakeholder feedback, and industry reports.
d. Identifying potential barriers, inconsistencies, or limitations within the existing policy framework that may hinder the effective development of renewable energy projects.
e. Comparing Vietnam's renewable energy policies with international best practices and successful policy models from other countries or regions.

Second, synthesis of secondary data sources: A comprehensive review and synthesis of secondary data sources were conducted to gather relevant information and insights regarding the renewable energy sector in Vietnam. These sources included:

a) Government reports and statistics: Official reports, data, and statistics from ministries, agencies, and state-owned enterprises (e.g., Vietnam Electricity (EVN)) related to the installed capacity, electricity generation, investment figures, and future projections for different renewable energy sources.
b) Academic studies and research papers: Peer-reviewed journal articles, conference proceedings, and research reports from academic institutions and think tanks, providing in-depth analyses, case studies, and empirical evidence on various aspects of renewable energy development in Vietnam.
c) Industry publications and reports: Reports, whitepapers, and market analyses from industry associations, consulting firms, and non-governmental organizations (NGOs) operating in the renewable energy sector in Vietnam.
d) News articles and media reports: Relevant news articles, features, and commentaries from reputable domestic and international media outlets, providing insights into current events, industry trends, and stakeholder perspectives related to renewable energy development in Vietnam.

The synthesis of these secondary data sources involved:

a) Extracting and compiling relevant data, findings, and insights from various sources.
b) Identifying common themes, trends, and patterns across different sources.
c) Triangulating information from multiple sources to ensure reliability and validity.

d) Analyzing and interpreting the synthesized data to understand the current status, achievements, challenges, and potential solutions for renewable energy development in Vietnam.

By combining a critical analysis of policies and regulations with a comprehensive synthesis of secondary data sources, this study aims to provide a holistic and well-informed assessment of the renewable energy landscape in Vietnam. This methodological approach allows for the integration of diverse perspectives, empirical evidence, and expert insights, enabling the formulation of practical recommendations and strategies to promote sustainable and effective renewable energy development in the country.

RESULTS AND DISCUSSION

Overview of Renewable Energy

> *"Renewable energy uses energy sources that are replenished continuously by nature, such as sunlight, wind, water, the Earth's heat, and plants. Renewable energy technologies convert these fuels into usable forms of energy-most often electricity, but also heat, chemicals, or mechanical power"* (United Nations, 2023).

Today, we primarily use fossil fuels to heat and power our homes and fuel our cars. It's convenient to burn coal, oil, and natural gas to meet our energy needs, but humans have a limited supply of these fuels on Earth. Even if humans had an unlimited supply of fossil fuels, using renewable energy is still better for the environment. Humans often call renewable energy technologies "clean" or "green" because they produce little or no pollution. However, burning fossil fuels releases greenhouse gases into the atmosphere, trapping heat from the sun and contributing to global warming. Climate scientists generally agree that the Earth's average temperature has risen over the past century. If this trend continues, sea levels will rise, and scientists predict that flooding, heat waves, droughts, and other extreme weather conditions could occur more frequently. Other pollutants are also released into the air, soil, and water when fossil fuels are burned. These pollutants take a dramatic toll on the environment and living things. Air pollution contributes to illnesses such as asthma. Acid rain from sulfur dioxide and nitrogen oxides harms plants and fish. Nitrogen oxides also contribute to smog formation. Renewable energy will also help humans develop energy independence and security. *"The U.S. imports over 50% of its oil, up from 34% in 1973"* (Energy Efficiency & Renewable Energy, 2022a). For example, replacing some gasoline with plant-based fuels could save money and increase our energy security. Renewable energy is abundant and the technologies are constantly improving. There are many ways to use renewable energy. Most of us have used renewable energy in our daily lives.

Overview of Some Main Types of Renewable Energy Used in Vietnam

Hydropower

"Hydropower is our oldest and largest renewable energy source, producing about 10% of the world's energy. Current hydropower capacity is around 77,000 megawatts" (Energy Efficiency & Renewable Energy, 2022b). Hydropower plants convert the energy in flowing water into electricity. The

most common form of hydropower uses a dam across a river to store a large amount of water. The water is then released through a turbine to generate power. However, a "run-of-river" system diverts some of the river's water through a channel or pipe to spin a turbine. Hydropower plants don't produce air pollution but may impact water quality and wildlife habitats. So modern hydro plants are designed and operated to minimize impacts on river ecosystems. Some of them divert a portion of the river's flow around their dams to mimic the natural river flow. But while this improves downstream habitat, it also reduces the plant's power output. In addition, fish ladders and other approaches, such as improved turbines, are being used to help fish migrate and reduce fish kills.

Wind Power

Wind is created naturally when the sun heats the earth's atmosphere, causing differences in air pressure. As the air moves to equalize the pressure, wind is created. Wind can also be strengthened or slowed down by geographic features such as mountains, bodies of water, forests, grasslands, and other vegetation types, as well as by elevation changes. Wind patterns and speeds vary greatly by location as well as by season, but some patterns can be predicted accurately enough to plan for wind power facilities. Humans have been using wind energy for centuries in one form or another, from simple windmills used to pump water for livestock to more complex applications like generating electricity. The basic components of any wind energy system are fairly simple. There are airfoils or blades with a particular shape designed to capture the wind's energy, a drive train that converts the rotational energy of the blades into mechanical energy, and an electricity generator that converts the mechanical energy into electrical energy. If the wind energy is being used directly as a mechanical force, such as grinding grain or pumping water, then it's called a windmill; if it's converting the wind's energy into electricity, then it's called a wind turbine. A wind turbine system requires additional components like a tower to support the airfoils or blades, and either batteries to store the electrical energy or a connection to the power grid to distribute the electricity. No one knows exactly when humans first started capturing wind energy, but wind certainly was used to propel boats on the Nile River in Egypt as early as 5,000 B.C. By 200 B.C., simple windmills were used in China to pump water and windmills with hand-woven cloth sails were used to grind grain in the Middle East. Over time, windmills were used in many types of food production, and the concept spread to Europe, where the Dutch built large wind pumps to drain lakes and marshes in the Netherlands and the idea made its way to the American colonies.

The best locations for wind turbines are the tops of smooth, round hills, open plains (or offshore in open water), and mountain gaps that have good wind resources and room for clusters of machines. In general, the higher the altitude, the better. Higher altitudes tend to have more wind. Wind resource maps and data from the National Oceanic and Atmospheric Administration (NOAA) or the National Renewable Energy Laboratory (NREL) in the U.S. provide this detailed information. Next, on-site monitoring is needed to assess

local wind conditions and determine the best placement of turbines for maximum yield. For at least a year, land-based projects monitor wind speed, turbulence, and direction, as well as air temperature and moisture content. Once that's determined, turbines that will produce the predicted energy output can be manufactured. Wind isn't the only factor in choosing a site for wind turbines. Wind farm developers must also consider proximity to transmission lines (and cities that can use the power); potential interference with local airports and air traffic; bedrock and faulting; bird and bat migratory patterns; and impacts on local communities (noise and potential visual impacts). Most large wind power projects are designed to operate for at least 20 years, if not longer, so all of these factors must be considered over the long term.

Biomass Energy

Biomass energy is energy derived from organic matter, such as plants. If you've ever burned wood in a fireplace or campfire, you've used biomass energy. But humans don't get all biomass resources directly from trees or other plants. Many industries, such as those related to construction or agriculture, can generate large amounts of unused or residue biomass that could serve as sources of biomass energy. "Some utilities and power companies with coal-fired power plants have found that replacing a portion of the coal with biomass is a low-cost option for reducing unwanted emissions. Up to 15% of the coal can be replaced with biomass" (Energy Efficiency & Renewable Energy, 2022c). Biomass has less sulfur than coal. Therefore, less sulfur dioxide, a contributor to acid rain, is released into the air. In addition, using biomass in these boilers reduces nitrogen oxide emissions. A process called gasification-converting biomass into a gas, which is then burned in a gas turbine-is another way to generate electricity. The decay of biomass in landfills also produces a burnable gas, primarily methane, which can be burned in boilers to generate steam for electricity generation or industrial processes. Biomass can also be heated without oxygen to convert it into a liquid fuel oil called pyrolysis oil. Pyrolysis oil can be used to generate electricity and as a feedstock for producing fuels and chemicals.

Solar Energy

Is energy from the sun that is converted into thermal or electrical energy. Solar energy is the cleanest and most abundant renewable energy source available. Solar energy technologies can harness this energy for a variety of uses, including generating electricity, providing light or a comfortable indoor environment, and heating water for domestic, commercial, or industrial purposes. There are three main ways to harness solar energy: photovoltaics, solar heating and cooling, and concentrating solar power. Photovoltaics directly convert sunlight into electricity through an electronic process and can be used to power anything from small electronics like calculators and road signs to homes and commercial businesses. Solar heating and cooling (SHC) and concentrating solar power (CSP) applications both use the heat generated by the

sun, in the case of SHC systems to provide space or water heating, and in the case of CSP plants to run traditional steam turbine electricity generators.

Solar energy is a very flexible energy technology: it can be built as distributed generation (located at or near the point of use) or as a central solar power plant (similar to traditional power plants). Both of these methods can also store the energy they produce for distribution after the sun sets by using advanced solar + energy storage technologies. Solar energy exists within a complex, interconnected electrical system in the U.S., operating alongside other technologies like wind to transition the U.S. to a clean energy economy. All of these applications rely on supportive policy frameworks at the local, state and federal level to ensure fair consumer and business access to clean energy technologies like solar.

Waste-to-Energy (WtE

"is the term used to describe various technologies that convert non-recyclable waste into useable forms of energy including heat, fuel and electricity" (Student Energy, 2021). WtE can occur through processes such as incineration, gasification, pyrolysis, anaerobic digestion and landfill gas recovery. WtE is often used in specific reference to the incineration process of completely combusting waste at extremely high temperatures to allow energy recovery. Modern incineration facilities use pollution control equipment to prevent emissions from being released into the environment. Currently, incineration is the only WtE technology that is economically viable and operationally feasible at a commercial scale. Another example of WtE is anaerobic digestion (AD), an efficient, old technology that biologically converts organic materials into compost as well as biogas to produce energy. AD systems have great potential and can range from low to high-tech, thus serving communities at all income levels. Another process, called pyrolysis, can thermochemically convert waste into a clean liquid fuel. Finally, landfill gas recovery refers to the process of capturing emissions from municipal landfills and converting them into energy. The most common collection method is drilling horizontal or vertical wells into the landfill and using blowers or vacuum pumps to extract the gas for treatment.

Policy Mechanisms for Renewable Energy Development in Vietnam

Developing renewable energy is a major policy of the Party and the State, which has been specified in Resolution No. 55 of the Politburo and in the Prime Minister's Decisions approving the Renewable Energy Development Strategy and mechanisms to incentivize renewable energy project development. The renewable energy development targets in Vietnam's Renewable Energy Development Strategy to 2030 with a vision to 2050, approved by the Prime Minister in Decision No. 2068/QD-TTg dated November 25, 2015, stipulate that the proportion of electricity produced from renewable energy sources (including large and small hydropower) in the total national electricity production must reach 32% by 2030 and 43% by 2050. In the adjusted Power Master Plan VII, it is expected that renewable energy sources (including small hydropower, wind power, solar power, and biomass power) will account for

21% of the total national power source capacity by 2030. And in Resolution No. 55-NQ/TW dated February 11, 2020 of the Politburo, it is stipulated that the proportion of renewable energy in the total primary energy supply will reach 15-20% by 2030 and 25-30% by 2045, corresponding to the proportion of renewable electricity in the total national electricity production of about 30% by 2030 and 40% by 2045.

To achieve the above renewable energy targets, the Ministry of Industry and Trade has proposed for the Vietnamese Government to issue various incentive mechanisms for different types of renewable electricity assessed to have great potential, as follows:

Table 1. Summary of Incentive Mechanisms for Renewable Electricity Development

Type of renewable energy	**Type of technology**	**Incentive mechanisms and effectiveness**	**Selling price (excluding VAT)**
Small hydropower (under 30MW)	Power production	Avoided cost tariffs	The CPTD price schedule is announced annually by the Ministry of Industry and Trade
Wind power (for projects put into operation before November 2021)	Project on land	FIT for 20 years	8.5 UScents/kWh
	Offshore project	FIT for 20 years	9.8 UScents/kWh
Biomass	Cogeneration of heat and electricity	FIT for 20 years	7.03 UScents/kWh
	Not Heat-Electric Cogeneration	FIT for 20 years	8.47 USCents/kWh
Electricity from waste	Burn	FIT for 20 years	10.05 USCents/kWh
	Bury	FIT for 20 years	7.28 USCents/kWh
Solar power	Floating solar power	FIT for 20 years	7.69 UScents/kWh
	Ground solar power	FIT for 20 years	7.09 UScents/kWh
	Rooftop solar power	FIT for 20 years	8.38 UScents/kWh

Source: Report of the Vietnam National Steering Committee for Power Development

In addition to the above feed-in tariff incentives, renewable energy projects in Vietnam can also enjoy other supporting mechanisms such as

corporate income tax incentives, import tax incentives for equipment, land use incentives, and access to financing.

Table 2. Other Incentive Mechanisms For Grid-Connected Renewable Power Projects

No	Financial incentive mechanism	Level
1	Private enterprise tax	Tax rates for private businesses: - The first 4 years from the year of taxable income: 0% - Next 9 years: 5% - Next 2 years: 10% - Remaining years: 20%
2	Import Tax	- Goods imported as fixed assets, materials and semi-finished products are not produced domestically. - Investors should check the annual list of goods and products exempt from import tax announced by the Ministry of Planning and Investment.
3	Using land	Preferential land rent according to Provincial regulations
4	Environmental protection fee	0%
5	Invest	Vietnam Development Bank (VDB) lends up to 70% of total investment costs with an interest rate equivalent to the interest rate of a 5-year Government bond plus 1%/year

Source: Report of the Vietnam National Steering Committee for Power Development

Notable Achievements in Renewable Energy Development in Vietnam

Wind Power

Vietnam has great potential for wind energy development due to its complex terrain and dense population. Vietnam's sea area is also very large and has not been fully exploited. Assessed as having the greatest wind energy potential among the four countries in the region, with over 39% of Vietnam's total area estimated to have an average annual wind speed greater than 6m/s at an altitude of 65m. According to the International Energy Agency's World Energy Outlook 2021 report, Vietnam's total wind power potential is estimated at over 500 GW, five times the country's energy demand. This is a huge figure, showing that Vietnam's potential for wind power development is enormous. To date, the number of wind power projects being developed has increased rapidly, especially after the government issued mechanisms to encourage wind power development (Decision No. 37/2011/QD-TTg dated June 29, 2011 and Decision No. 39/2018/QD-TTg dated September 10, 2018).

As of the end of December 2020, the total capacity of wind power projects approved by the Prime Minister for inclusion in the Power Master Plan VII was 11,584MW/176 projects; however, only about 600 MW of wind power has been put into operation nationwide. According to updates from Vietnam Electricity (EVN), as of August 3, 2021, a total of 106 wind power plants with a total capacity of 5,655.5 MW have submitted documents and dossiers to register for grid connection programs, testing, and request for commercial operation date (COD) recognition before October 31, 2021 (PEC, 2022). Wind power projects implemented in Vietnam include the 99 MW Bac Lieu Wind Power Project, the 37.6 MW Mui Dinh Wind Power Project and the 48 MW Phuc Lien Wind Power Project. In addition, Vietnam is also implementing many other large wind power projects, including the 127 MW Song Hau 1 Wind Power Project, the 82 MW Binh Dinh Wind Power Project, and the 400 MW Ha Tinh Wind Power Project (Ministry of Industry and Trade of Vietnam, 2021).

Solar Power

Prior to 2017, although Vietnam had great potential, the development of grid-connected solar power was still lower than expected. As of August 2017, the total installed solar power capacity was only about 28 MW, mainly small-scale sources (off-grid systems and some pilot low-voltage grid-connected projects located in buildings and offices). However, since the Government issued Decision No. 11/2017/QD-TTg dated April 11, 2017 on the mechanism to encourage the development of solar power projects in Vietnam and Circular No. 16/2017/TT-BCT regulating project development and standard power purchase agreements for solar power projects, many domestic and foreign investors have sought opportunities to invest in large-scale solar power projects across the country within more than 3 years. The projects are mainly concentrated in the Central and Southern regions where solar radiation is high. By the end of 2020, the grid-connected solar power source put into operation reached about 9,000 MW (of which Ninh Thuan and Binh Thuan provinces accounted for nearly 3.5GW). The scale of solar power projects that have been added to the plan is over 13GW, with a total registered construction scale but not yet added of about 50GW. In addition to ground-mounted and floating solar farm projects, rooftop solar power projects have also developed rapidly. By the end of 2019, the total installed rooftop solar power capacity nationwide was only 340MWp (272MW), but by August 2021, the total installed capacity reached 9,580MWp. The total solar power capacity added to the adjusted Power Master Plan VII is 19,079 MWp (15,260MWac)/172 projects (Ministry of Industry and Trade of Vietnam, 2023). The Southeast provinces (including Ho Chi Minh City) continue to lead in rooftop solar installation in terms of both the number of projects and total installed capacity.

Biomass Power

According to data from the Ministry of Industry and Trade, energy demand in Vietnam is currently increasing at twice the rate of GDP growth. Meanwhile, in developed countries, this rate is only at a similar level. Vietnam's

energy consumption is increasing and has increased more than 4 times from 2005 - 2030, with electricity consumption increasing nearly 400% in 10 years from 1998 - 2008 (Ministry of Industry and Trade of Vietnam 2021). In the context of depleting fossil fuels, rising world oil prices and increasing dependence on world energy prices, the ability to meet domestic energy demand is becoming increasingly difficult. Therefore, considering exploiting clean renewable energy sources is extremely important for the economy, society and sustainable development. Vietnam has great potential for biomass energy sources from agricultural waste, municipal solid waste, urban wastewater, etc., distributed throughout the country. Some types of biomass can be used to generate electricity or apply cogeneration technology (producing both electricity and heat). This huge amount of biomass, if not treated, will be a major source of pollution that is continuously generated, causing serious impacts on ecosystems (soil, water and air) as well as human health. Annually, in Vietnam, there are nearly 60 million tons of biomass from agricultural by-products, of which 40% is used to meet household energy needs and power generation. According to calculations, for every 5 kg of rice husk, 1kWh of electricity is generated. Thus, with millions of tons of rice husk, Vietnam could obtain hundreds of MW of electricity every year. Agricultural by-products are abundant in the Mekong Delta region, accounting for about 50% of the total national agricultural by-product output, and the Red River Delta with 15% of the total national output (AG Green Energy, 2021).

Biomass Power (Rice Husk)

Until now, in Vietnam there has been no stand-alone biomass power plant solely for power generation. Based on available information sources and additional data collected from localities, currently there are only about 10 investors who have applied for construction permits with an average scale of 10MW/plant. The majority are domestic investors with 8 projects, and the remaining 2 projects are joint ventures with foreign partners. The aforementioned rice husk power projects are all concentrated in the Mekong Delta provinces, including: Tien Giang: 02 projects; Dong Thap: 03 projects; Can Tho: 03 projects; Kien Giang: 01 project, Hau Giang: 01 project. Among the 10 projects mentioned above, only the Dinh Hai rice husk power plant in Can Tho has been invested in construction. However, this plant has only recently completed the boiler system and produces steam for sale to consumers in the Tra Noc Industrial Zone, Can Tho. Of the remaining projects, 01 project has completed the Investment Project phase, 02 projects have completed the Investment Report phase, and the rest have only reached the stage of applying for investment approval. Most of the projects were established quite a long time ago, from 2007 and 2008. To date, many projects have had their investment licenses revoked or there is no further information on subsequent stages.

Biomass Power (Bagasse)

By the end of the 2018-2019 crop year, the total installed capacity of bagasse-based power at 38 existing sugar mills reached 504.7 MW, including 40MW in the Northern region, 74MW in the North Central region, 3MW in the

Central region, 143MW in the Central Highlands, 145MW in the South Central region, and 98MW in the Southern region. The capacity range of most plants is from 1.5MW to 60MW. The An Khe sugar mill (Quang Ngai Sugar Company) in Gia Lai province has the largest total installed power capacity of 95MW. Among the aforementioned sugar mills, in the 2018/2019 crop year, 10 sugar mills with a total installed power capacity of 377.6MW sold surplus electricity to the national grid, with an output of about 347 GWh/year (Ministry of Industry and Trade of Vietnam, 2021).

Biomass Power (Wood)

As of now, a number of independent power production projects using wood pellets as the main fuel have been implemented. A typical example is the Que Son Biomass Power Plant Project. The project has an installed capacity of 7MW in Que Son district, Quang Nam province, invested by Vietpeco Co., Ltd. The project is currently under construction and is expected to be operational in 2021, with an estimated annual electricity output supplied to the national grid of about 47.4 million kWh. As of November 2020, there were about 560MW of total registered capacity for wood biomass power projects (Northern region: 166MW, North Central region: 50MW, Central region: 117MW, Central Highlands: 120MW, South Central region: 50MW, Southern region: 60MW). In addition, there are currently 2 biomass power projects from agricultural residues (elephant grass) with a registered scale of 600MW in An Giang province being proposed for investment.

Waste-to-Energy

In Vietnam, utilizing waste sources to generate electricity has been formed since 2006. However, most projects have only reached the stage of seeking investment approval or are just project ideas or investment projects. The first project to be successfully put into operation is the waste-to-clean electricity treatment plant in Go Cat - Ho Chi Minh City, including 3 generator sets with a total installed capacity of 2.4 MW, estimated to recover 410 m3 of gas/day, with a total investment of about 242 billion VND. In 2017, Vietnam's first Industrial Waste Treatment and Power Generation Plant (Nam Son Waste Power Plant) was inaugurated and put into use at the Nam Son Waste Treatment Complex (Soc Son, Hanoi) with a total investment of over 645 billion VND. The plant uses advanced Japanese waste incineration technology with a capacity of 75 tons/day and generates 1.93 MW of electricity. This is considered a pioneering project in the modern industrial waste treatment process that has never been seen in Vietnam and the region.

In August 2018, the Can Tho waste power plant project was put into operation. The plant has a scale of 7.5 MW, a processing capacity of about 400 tons of waste/day and generates about 60 million kWh/year. In addition to a few waste incineration plants that have been put into operation in Hanoi, Ha Nam (successfully piloting a waste-to-electricity transmission line using gasification technology, producing syngas), Ho Chi Minh City, Can Tho, Quang Binh (a fermentation line to produce biogas and a 2MW incinerator at the Ly

Trach domestic waste treatment plant). Currently, there are quite a few waste power projects being proposed for investment, and these projects have been granted investment licenses by provinces and cities such as Hanoi, Phu Tho, Hai Duong, Bac Giang, Thai Binh, Thanh Hoa, Thua Thien Hue, Da Nang, Dong Nai, Ho Chi Minh City, Hau Giang... As of November 2020, there are about 586MW of total capacity of solid waste power projects under construction, approved for additional planning and being proposed for investment in various provinces, including 226MW in the Northern region, 48MW in the North Central region, 12MW in the South Central region, 299MW in the Southern region, expected to be put into operation in the period up to 2025.

Hydropower

Vietnam's economic, technical and environmental potential for hydropower (HP) is assessed to be quite abundant. "*Up to now, we have exploited over 80% of the potential. In 2017, a typical year, HP contributed over 40% of total electricity production, with a total output of 86.4 billion kWh, making a great contribution to the country's development. By 2020, the contribution of hydropower was over 30% and it is forecast to be around 18-20% by 2030*" (Vietnam Energy Association, 2021). Specifically, some major hydropower plants on the main river basins can be mentioned: On the Da River, there are large hydropower plants such as Hoa Binh 1,920 MW, Son La 2,400 MW, Lai Chau 1,200 MW; on the branches, there are medium-sized plants like Huoi Quang, Ban Chat, Nam Chien and some plants on tributaries; on the Lo-Gam-Chay river, there are Thac Ba, Tuyen Quang, Bac Me, etc.; on the Ma and Chu Rivers, there are Trung Son, Hua Na and dozens of medium hydropower plants; on the Ca River, there are Ban Ve, Khe Bo; on the Thu Bon River, there are A Vuong, Song Bung 2 and 4, etc... On the Se San River, there are Plei Krong, Thuong Kon Tum, Ialy, Se San 3 and 4... On the Srepok River, there are DreiH'linh, Buon Kuop, Srepok 3, 4 and 4A,... On the Dong Nai River, there are Tri An, Dong Nai 2, 3, 4, 5; on the branches, there are Dai Ninh, Da Nhim; on the Be River, there is Thac Mo... The total installed capacity of hydropower plants from small to large has reached 19,500 MW (as of the end of 2020). On the other hand, a number of large and medium hydropower plants still play an important, active and effective role in flood control, regulating water supply for agriculture and domestic use in downstream areas.

Challenges and Limitations in Developing Renewable Energy in Vietnam

Hydropower

In the process of developing hydropower in Vietnam, four major challenges have arisen, creating obstacles and limitations in the development of renewable energy:

First, the challenge of investment costs. Higher investment costs in small hydropower projects can create challenges in seeking funding sources. Mobilizing large amounts of money to implement small projects may reduce the attractiveness to investors and banks. Businesses, especially small ones, may face difficulties in ensuring financial capacity to start a small hydropower project, affecting the diversification and enrichment of energy sources. The

investment costs of small hydropower projects are higher than those of large hydropower projects (25-30 billion VND/MW compared to 20-25 billion VND/MW). This makes the economic efficiency lower.

Second, the challenge of management and supervision. Lax management and supervision can increase the risk of environmental incidents. A lack of management standards can lead to non-compliance with safety and environmental protection regulations. Lapses in management can create a negative image of the hydropower industry, potentially affecting community support and public trust.

Third, the challenge of research and survey. A lack of research and surveys can lead to insufficient information on water flow, affecting the ability to predict and effectively manage water resources for the project. Implementing projects without accurate information on water sources can create high risks of incidents, impacting both the environment and the economy.

Fourth, the challenge of environmental restoration. A lack of strong policies and regulations on environmental restoration may cause some project owners to feel a lack of imposed responsibility, leading to a failure to fully implement post-construction restoration measures. Additionally, ensuring environmental restoration may increase project costs, which could increase financial pressure on investors and small hydropower projects.

Wind Power

In developing wind energy in Vietnam, investors and experts face many challenges. One of the most significant challenges is the lack of technical infrastructure and a suitable power transmission grid system. The construction of wind power projects requires the support of technical infrastructure, including transmission lines and substations. However, the current power transmission grid system in Vietnam is still inadequate to meet the needs of wind power projects, creating difficulties in deploying these projects.

The next challenge is the high initial investment cost. The construction of wind power projects requires a large investment, especially in the early stages when projects are still in the start-up phase. High investment costs have made it difficult for investors to secure funding. Additionally, financial partners often require government institutions and financial agencies to guarantee investment decisions and financing.

The third challenge is the slow and complex approval procedures. The construction of wind power projects requires approval from various authorities, from local to central levels. This approval process is often very complex and time-consuming, sometimes taking several years. This has created difficulties for investors and slowed the deployment of wind energy projects. Therefore, optimizing the approval process needs to be given more attention and accelerated.

Finally, another challenge facing wind energy development in Vietnam is the issue of power losses. Power losses are a serious problem in Vietnam, particularly in the electricity sector. Power losses mean that the amount of electricity produced is not sufficient to meet the needs of citizens and

businesses. This particularly affects the deployment of wind energy projects, as most wind power generation areas are located in rural areas, far from power centers, leading to high power loss rates. Overall, wind energy development in Vietnam is facing many challenges, but it also has great potential for future growth. Harnessing the country's wind potential will help ensure a clean and stable energy supply, contribute to reducing environmental pollution, and reduce energy import costs.

Solar Power

In the process of developing solar energy, there are six main challenges affecting the deployment and management of projects.

First, the lack of clear regulations on installation conditions has created inconsistencies in the appraisal of standards and legality. "This implies incurring large appraisal costs, estimated at 300-500 million VND, adding a burden to businesses" (Investment Newspaper, 2022). Regulations on liability in case of incidents are also still unclear, increasing risks in the operation of solar power system. Second, the lack of consistency and comprehensive regulations has increased implementation and licensing costs. Each locality has a different approach, causing confusion for businesses. Clarity and specificity are needed to reduce overoptimism.Third, the issue of fire prevention and fighting is creating difficulties in the documentation process. Clear and more convenient procedures are required to ensure safety and reduce documentation time. Fourth, the issue of acceptance testing for project owners is a prominent challenge. It is proposed to organize periodic inspections to provide opinions and recommendations, as well as to create a hotline for dialogue and business support. Fifth, there is a need for regulations on installation criteria to prevent the rampant installation without ensuring quality and cost-effectiveness. These regulations help maintain stability in the market.

Overall, the provision of official information is important. The progress of the Vietnam Clean Energy Association in establishing a technical committee and compiling technical guidelines is a positive effort to provide accurate information and support for businesses and investors in the solar energy industry.

Biomass Power

In the process of developing biomass power in Vietnam, six major challenges have arisen, creating obstacles and limitations in the development of renewable energy (biomass):

First, "the number of biomass power plants is still very small and the scale is small, currently only reaching about 378MW compared to a potential of up to 5,000-6,000MW, creating a significant gap between reality and potential" (Intracom, 2023). The second challenge stems from the unstable, dispersed, and unsustainable biomass feedstock, particularly when relying heavily on seasonal by-products such as straw, husk, and bagasse, making it difficult to control. The third challenge is the large investment cost but low economic efficiency, due to outdated biomass power technology, creating a sense of wariness among investors. The fourth challenge comes from the ability to forecast future

feedstock purchase prices, especially when the market is highly volatile, creating uncertainty and risk for investors. The fifth challenge is the complex investment licensing procedure, which is described as complicated and involving many ministries and branches, increasing the likelihood of delays and complexity in project development. Overall, the sixth challenge is the lack of attractive support policies and mechanisms to encourage investment, as well as difficulties in accessing preferential loans. All of these challenges are contributing to slowing down the development of biomass power in Vietnam.

Waste-to-Energy

In the process of developing waste-to-energy in Vietnam, there are four major challenges creating obstacles and limitations in the development of renewable energy:

The first challenge that businesses face is the demand for large investment capital. For many businesses, this has become a significant barrier, especially when business support policies are still limited. Although many businesses already have capital and technology, policy obstacles remain a major challenge. The second challenge stems from waiting for the power sector planning. This has caused many projects to stall, especially when aiming to benefit from the preferential power purchase price under Decision 31. Dependence on industry planning creates uncertainty in investment and development plans. The third challenge comes from the preferential power purchase price, which only applies to certain specific technologies. Meanwhile, there are many new technologies in the waste-to-energy field, but the power purchase price has not been clearly defined, creating an uneven playing field in terms of opportunities and competitiveness. The final challenge is related to the complex and prolonged investment procedures. Having to go through various ministries and branches increases the risk of difficulties and delays the project progress. "The addition to the power development plan also faces many difficulties, creating a major challenge in the deployment of new projects" (VNEEP, 2020). This requires the improvement and simplification of the investment process to promote sustainable development in the power sector.

Some Solutions to Improve Renewable Energy Development Efficiency in Vietnam in the Coming Time

Solutions to Improve Hydropower Development Efficiency

Currently, Vietnamese hydropower is facing the four challenges mentioned above. The article proposes the following solutions:

Challenge 1: High Investment Costs.

Solution: To reduce the investment costs of small hydropower projects, it is necessary to encourage research and development of new technologies to optimize the construction process and reduce material costs. Financial support from the government or sponsoring organizations can reduce the financial burden on investors, increasing the economic efficiency of the projects.

Challenge 2: Uneven Management and Supervision

Solution: There is a need to strengthen management and supervision by creating independent agencies or specialized agencies with high responsibilities. Implementing a system of periodic inspections and transparent information disclosure can increase transparency in the management and supervision process.

Challenge 3: Lack of Research and Survey on Water Flow

Solution: Strengthen regulations requiring research and surveys before implementing small hydropower projects. Encourage independent research and publication of results to improve information quality. Support businesses in conducting comprehensive and high-quality research to ensure stable operation and economic efficiency.

Challenge 4: Inadequate Environmental Restoration after Construction.

Solution: Increase the environmental responsibility of project owners through the establishment of clear commitments and regulations for environmental restoration. Establish reserve funds to ensure sufficient financial resources for environmental restoration. Strictly manage and periodically evaluate to ensure compliance and promptly address post-construction environmental issues.

Solutions to Improve Solar Power Development Efficiency

Currently, Vietnamese solar power is facing the six challenges mentioned above. The article proposes the following solutions:

Challenge 1: Unclear Installation Conditions and Regulations.

Solution: The government needs to promote the development and publication of clear regulations on installation conditions and legal standards. Support the formation of independent organizations or strengthen the functions of existing agencies to conduct quality appraisals without significantly increasing costs.

Challenge 2: Lack of Consistency and Comprehensive Regulations.

Solution: Develop a national or regional system of regulations and procedures to reduce costs and increase ease for businesses. Specific guidelines and facilitation of the licensing process are needed.

Challenge 3: Fire Prevention and Fighting Issues.

Solution: The government and specialized organizations should cooperate with businesses to simplify fire prevention and fighting procedures. Provide training and detailed guidance to reduce difficulties in documentation and compliance.

Challenge 4: Acceptance Testing Issues for Project Owners.

Solution: Organize periodic independent inspections and create a mechanism for continuous communication between project owners and

inspection agencies. Establish a quick feedback system and hotline to address issues and support businesses.

Challenge 5: Lack Of Installation Criteria

Solution: The government should develop and apply specific installation standards to prevent rampant installation without ensuring quality. Strengthen monitoring and promptly address non-compliance cases.

Solutions to Improve Biomass Power Development Efficiency

Currently, Vietnamese biomass power is facing the six challenges mentioned above. The article proposes the following solutions:

Challenge 1: Small Number and Scale of Biomass Power Plants

Solution: The government needs to increase investment and promote the development of biomass power plants through incentive policies, such as tax reductions and providing financial incentives. At the same time, it is necessary to create a favorable business environment and simplify licensing procedures to stimulate investment from businesses.

Challenge 2: Unstable and Seasonal-Dependent Biomass Feedstock

Solution: Encourage research and development of technologies to utilize a range of biomass feedstock sources, reducing dependence on seasonal supplies. At the same time, it is necessary to establish an effective feedstock management system to ensure stability and sustainability.

Challenge 3: High Investment Costs and Low Economic Efficiency

Solution: The government needs to support technology upgrades in the biomass power industry, reducing initial investment costs and enhancing project performance capabilities. Promote research and innovation to improve energy efficiency and reduce operating costs.

Challenge 4: Forecasting Feedstock Purchase Prices and Market Volatility

Solution: The government and industry need to cooperate to build market forecasting models and feedstock purchase prices based on historical data and market trends. It is necessary to create a flexible mechanism to adjust feedstock costs according to market fluctuations, minimizing risks for investors.

Challenge 5: Complex Investment Licensing Procedures Involving Many Ministries and Branches.

Solution: The government needs to simplify and streamline the licensing process by creating a unified process and minimizing complexity. Support businesses in the licensing process and facilitate the promotion of project development.

Solutions to Improve Waste-to-Energy Development Efficiency

Currently, Vietnamese waste-to-energy is facing the four challenges mentioned above. The article proposes the following solutions:

Challenge 1: Businesses Face the Demand for Large Investment Capital.

Solution: The government should consider and adjust policies to support businesses, reduce investment risks, and create more favorable conditions for mobilizing capital. Organize dialogues between businesses and the government to ensure that new policies are designed to accurately reflect the needs and challenges of businesses.

Challenge 2: Stemming From Waiting for the Power Sector Planning, Which Has Caused Many Projects To Stall.

Solution: Enhance cooperation between businesses and planning agencies to ensure that power sector planning is properly and timely updated. Consider measures to reduce waiting times, possibly by applying more flexible planning standards and simplifying the environmental impact assessment process.

Challenge 3: Unclear, Specific, And Unreasonable Power Purchase Prices.

Solution: Promote research and discussion among the government, businesses, and industry experts to determine reasonable power purchase prices for new technologies in the waste-to-energy field. Ensure that the power purchase policy is fair and encourages technology diversity to promote innovation and competition in this field.

Challenge 4: Cumbersome And Complex Investment Procedures.

Solution: Review and improve investment procedures, possibly by creating an online information portal to reduce complexity and increase transparency. Organize periodic meetings between ministries to harmonize and simplify power development planning, helping to reduce investment time and costs.

Solutions to Improve Wind Power Development Efficiency

Currently, Vietnamese wind power is facing the four challenges mentioned above. The article proposes the following solutions:

Challenge 1: Lack Of Technical Infrastructure and Power Transmission Grid System.

Solution: The government needs to invest in building and upgrading technical infrastructure related to wind energy, including transmission lines and substations, to optimize the transmission of electricity from wind farms to consumption points. The government and businesses can cooperate to build infrastructure projects together, reducing investment costs and increasing the ability to deploy wind energy projects.

Challenge 2: High Initial Investment Costs.

Solution: The government can provide tax incentives and financial support for wind energy projects, helping to reduce the burden of initial investment costs. The government can negotiate and cooperate with financial

partners to ensure that government institutions are maintained and supported, facilitating the investment and financing process.

Challenge 3: Slow and Complex Approval Procedures

Solution: The government needs to simplify the approval process by creating a unified and transparent process, reducing investment time and costs. The government can provide consulting and support to businesses in the approval process, helping them understand the process and comply with legal requirements.

Challenge 4: Power Loss Issues

Solution: The government needs to invest in upgrading the power transmission system to reduce energy losses and optimize the movement of electricity from production areas to consumption points. The government can provide incentives for wind energy production areas, helping them reduce costs and improve production efficiency.

CONCLUSIONS

The development of renewable energy in Vietnam in recent years has achieved some notable achievements, especially with wind energy, solar energy and some biomass energy sources. Specifically, the capacity of wind and solar power plants has increased many times compared to the 2015-2017 period. However, the development of renewable energy in Vietnam still faces some difficulties and challenges that need to be addressed. First, the power grid infrastructure is not synchronized, leading to difficulties in connecting renewable energy sources to the national grid. Second, the initial investment costs for wind and solar power projects are still high. Third, administrative procedures for project approval and investment licensing are still slow and complicated. To promote the effective and sustainable development of renewable energy in Vietnam in the coming time, it is necessary to focus on the following solutions: First, invest in upgrading and expanding the power grid system to increase the ability to receive and transmit renewable energy sources. Second, improve mechanisms and financial support policies to encourage businesses to invest in the renewable energy sector. Third, reform institutions, reduce administrative procedures, and shorten the time for granting investment licenses for renewable energy projects. Fourth, promote research and transfer of advanced technology in the renewable energy field to help reduce investment costs. If the above solutions are implemented in a synchronized and effective manner, the development of renewable energy in Vietnam promises to make great strides in the coming time, making an important contribution to the sustainable development of the country.

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