

The competition possibility between renewable energy and fossil energy in Vietnam in the future

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ABSTRACT

With high economic growth, Vietnam is now witnessing an increasing energy demand, having much potential for renewable sources such as wind energy, solar energy or biomass energy. The nation is heavily dependent on fossil energy sources such as coal and oil. This situation raises concerns about both energy security and the environment. Therefore, a question arises if Vietnam can develop renewable energy to solve energy demand, energy security and reduce climate change impacts as committed. This article analyses a considerable potential for renewable energy sources (especially wind and solar energy). The analysis also indicates competitiveness between these renewable energy sources compared to the traditional energy sources that Vietnam is dependent on, especially when there are policies to encourage the development of renewable energy and limit emissions. This article proposes some recommendations to develop renewable energy sources, with an overview of replacing fossil energy in Vietnam.

1. INTRODUCTION TO ENERGY DEMAND IN VIETNAM

Recent situation regarding energy demand

Vietnam is witnessing rapid development in economics, with an average annual growth rate of Gross Domestic Product (GDP) at 6–7 per cent, as evidenced by the impressive growth of many sectors over the past two decades.¹ Consequently, a corresponding rapid increase in the energy demand. Fast

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1 Asian Development Bank, 'Pathways to Low-Carbon Development for Vietnam' (Asian Development Bank 2017) <<https://www.adb.org/publications/pathways-low-carbon-development-viet-nam>> accessed 24 April 2020.

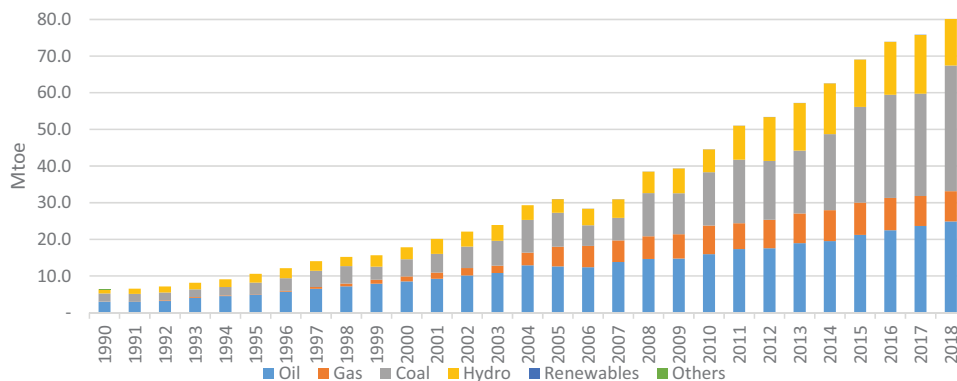


Figure 1. Vietnam's energy consumption

Source: BP, 'BP Statistical Review of World Energy 2019' (2019) <<https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2018-full-report.pdf>> accessed 20 March 2019.

industrialization, urbanization and modernization were driving the energy consumption growth as much as twice of the Vietnamese GDP growth, reaching approximately 12 per cent per year during the past decade.²

According to the International Energy Agency (IEA) and British Petroleum (BP), Vietnam's total primary energy consumption was increasing at a growth rate of 6.1 per cent per year during 1990–2016. The leading energy consumption sectors in Vietnam were industrial, residential, and transport industries.³ In 1990, almost three-quarters of primary energy consumption came from non-fossil fuels, and over 60 per cent of electricity came from hydroelectric generation.⁴ Following BP's data, the consumption of all fossil fuels increased rapidly throughout 1990–2016, and the share of fossil fuel consumption over total energy use in Vietnam, from 27.6 per cent in 1990 to 70 per cent in 2016.⁵

Fossil fuels (like coal, oil, and gas) are the country's dominant sources, are essential for long-term economic growth. Vietnam's total primary energy supply was 85.8 million tons of oil equivalent (Mtoe) in 2018. Coal represented the largest share of the nation's total primary energy supply (at 39.9 per cent); oil was the second at 29 per cent, followed by hydropower (21.3 per cent), natural gas (9.7 per cent), and others (0.1 per cent). In its history, Vietnam was a net exporter of crude oil and coal. Still, now the national supply of these energy sources is projected to grow at a nominal rate than the increase in energy demand. As a result, the growing dependence on imported fuels is rapidly increasing in the cost of energy production.⁶ The chart below shows the rise in Vietnam's energy consumption over the past decades (see Figure 1).

Besides, electricity demand is also constantly increasing in the recent period. Vietnam is one of the most efficient power markets in Southeast Asia. Most of Vietnam's electricity output is driven by low-cost resources. According to a BP's report in 2019, the increase in electricity demand in the 2007–17 period was 11.6 per cent, higher than the economic growth rate (GDP) of 6–7 per cent during the same period. Vietnam's

2 Pham Khanh Toan, Nguyen Minh Bao and Nguyen Ha Dieu, 'Energy Supply, Demand, and Policy in Vietnam, with Future Projections' (2011) 39 *Energy Policy* 6814.

3 BP, 'BP Statistical Review of World Energy 2018' (2018) <<https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2018-full-report.pdf>> accessed 20 March 2019; IEA, '20 Renewable Energy Policy Recommendations' (2018) <<https://webstore.iea.org/20-renewable-energy-policy-recommendations>> accessed 6 November 2019.

4 Asian Development Bank (n 1).

5 Quang Minh Tran, 'Projection of Fossil Fuel Demands in Vietnam to 2050 and Climate Change Implications' (2019) 6 *Asia & the Pacific Policy Studies* 208.

6 Asian Development Bank (n 1).

Table 1. Total electricity consumption in Vietnam during 2008–18

Year	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Electricity consumption (TWh)	71	80.6	91.7	101.5	115.1	124.5	141.3	157.9	175.7	192.5	212.9

Source: BP, 'BP Statistical Review of World Energy 2019' (2019) <<https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2018-full-report.pdf>> accessed 20 March 2019.

total electricity consumption in 2018 reached 212.9 TWh (see Table 1). Most of its electricity generation comes from thermal sources (coal, natural gas and oil), accounting for 60.2 per cent of the total generation; the rest is hydropower (39.5 per cent) and other minor sources (around 0.3 per cent).⁷

Energy sources are diverse in Vietnam, ranging from coal, oil, natural gas, hydropower and renewable energy. At present, Vietnam's electricity output still depends mainly on traditional electricity sources such as hydropower, coal power and gas power. Although the Government has different policies to encourage renewable energy development, these sources only account for the smallest share for the time being.⁸ According to the report of Vietnam Electricity (EVN), the total installed capacity as of the end of 2019 was about 55,000 MW. Among the current energy sources, hydropower represents the largest share (more than 38 per cent) in the total installed capacity, followed by coal-fired power (near 38 per cent), and gas firepower (18 per cent); renewable energy (include small hydropower) accounted for around 6 per cent of the total power generated in the country.

Coal-fired thermal power plants will be the primary source of power generation in Vietnam up to 2040. Coal-fired power generation is projected to have a dominant share in the future, which will result in the country's reliance on coal imports for power generation. However, the heavy reliance on fossil fuels such as coal is a significant cause of environmental pollution and greenhouse gas emissions. The rapid growth of fossil fuels has been associated with a considerable increase in emissions.⁹ This means that Vietnam's greenhouse gas (GHG) emissions are rising rapidly. Vietnam exhibited the fastest growth in carbon dioxide equivalent (CO₂e) emissions intensity in the Association of South East Asian Nations (ASEAN) because of a growing coal dominance in the energy mix. According to a study by the World Bank (WB), Vietnam's total emissions increased seven times, and its per capita emissions is more than tripled.¹⁰ This increasing growth is attributed to emissions from energy, particularly in the power sector. Unless the country takes action towards low-carbon development, it may become a more significant contributor to climate change in the future. Undoubtedly, a relevant fuel-mix strategy is essential for climate change mitigation.¹¹ The development of renewable energy technologies to replace coal for power generation is an essential factor for energy independence, energy security and GHG reduction.

Energy demand in the future

The energy demand in Vietnam is expected to grow significantly, driven by robust economic growth, industrialization, urbanization and population growth. Therefore, many studies estimated that the energy demand in the coming years would keep increasing at the significant rate of 10 per cent annually during 2016–20 and by 8 per cent per annum during 2021–30.¹² According to the Vietnam Energy Outlook (2019) of the

7 Shigeru Kimura and Han Phoumin, *Energy Outlook and Energy Saving Potential in East Asia 2019* (2019) <<http://www.eria.org/publications/energy-outlook-and-energy-saving-potential-in-east-asia-2019/>> accessed 24 April 2020.

8 Duc Luong Nguyen, 'A Brief Overview on Assessments of Wind Energy Resource Potential in Vietnam' [2014] *J Fundam Renewable Energy Appl.*

9 Tran (n 5).

10 Asian Development Bank (n 1).

11 Tran (n 5); Shigeru Kimura and Han Phoumin (n 7).

12 *ibid.*

Vietnamese Ministry of Industry and Trade in collaboration with the Danish Energy Agency, the total primary energy supply would increase about four–five times from 2017 to 2050, depending on the scenarios.¹³

According to the Ministry of Industry and Trade report in 2017, Vietnam's total energy demand in 2020 is about 71 Mtoe, increasing to 138 Mtoe by 2035. In the Vietnam Energy Outlook (2017), the total final energy demand could rise from 54 Mtoe in 2015 to 81.9 Mtoe, 89 Mtoe, and 93.3 Mtoe in 2025 in the low, baseline, and high scenarios, respectively. The final energy demand in 2035 could reach 112 Mtoe, 134.5 Mtoe and 156.5 Mtoe, respectively, in these three scenarios.¹⁴ Throughout 2016–35, the final energy demand increases by 4.7 per cent/year in the baseline scenario (in the Low scenario and High scenario, the growth is 3.7 per cent/year and 5.5 per cent/year, respectively).¹⁵

According to the Ministry of Industry and Trade, Vietnam's rapid economic growth, the national electricity demand is also increasing enormously, at around 10 per cent a year, causing tremendous pressure on the energy sector. According to the revised National Master Plan, the demand will increase from 86 Terawatt hours (TWh) in 2010 to 265–278 TWh in 2020 and 572–632 TWh in 2030. The electricity consumption in 2020 will be 233,558 GWh, and by 2035, the power consumption in Vietnam may be up to 686.567 GWh.¹⁶ To meet the growing demand, Vietnam needs 60,000 MW of electricity by 2020, 96,500 MW by 2025, and 129,500 MW by 2030. The country needs to increase its installed capacity by 6000–7000 MW annually and spends close to US\$148 billion by 2030. The total installed capacity of power plants in the system will reach 103.7 GW in 2025, 133.1 GW in 2030, and 168.5 GW in 2035. The base case's power production will increase by 338 TWh, 551 TWh, and 741.6 TWh in 2025, 2030 and 2035, respectively.¹⁷

2. THE ENERGY RESOURCES IN VIETNAM

Traditional fossil energy sources

Vietnam possesses considerable indigenous energy resources. The most crucial energy until now in Vietnam is coal. According to BP's data, Vietnam has about 3360 million tons of proven recoverable coal reserves, including 3116 million tons of hard coal and 244 million tons of lignite (BP, 2018). To meet the rapid national demand for domestic production, coal production has surged by almost 10-fold during 1990–2016, from 5.1 million tons in 1990 to 46.5 million tons in 2011. Due to challenges in exploitation conditions, coal production has slowed down since 2012 and was recorded at 41.6 million tons in 2018.¹⁸ Historically, the industrial sector has been the largest coal consumer, although the power sector generally requires much more coal supply. The Government has recently promoted coal use to fuel the power sector as a low fuel cost for meeting power shortages and volatility and the use of substantial hydroelectric capacity. According to Vietnam's power sector development plan, the amount of coal for electricity generation will increase from 14 million tons in 2012 to 180 million tons in 2030.¹⁹ Therefore, the domestic coal production cannot meet the demand, and Vietnam became a net coal importer in 2015. In 2018, coal production and consumption were 23.3 and 34.3 million tons of oil equivalent.²⁰

Oil has been considered an essential source of energy to fuel Vietnam's economic development for decades. At present, Vietnam has about 460 million cubic meters of crude oil reserves.²¹ The proven oil reserves are considered high compared to those of other countries in the region and had a high growth rate in the

13 EREA & DEA, 'Vietnam Energy Outlook Report 2019' (2019).

14 Danish Energy Agency, 'Vietnam Energy Outlook Report 2017' (2017).

15 *ibid.*

16 N 428/QĐ-TTg, 'National Power Development Planning Adjusted'.

17 *ibid.*

18 BP (n 3).

19 QĐ 1208/QĐ-TTg, 'The National Master Plan for Power Development for the 2011–2020 Period with the Vision to 2030'.

20 BP (n 3); Kimura and Phoumin (n 7).

21 *ibid.*

Table 2. The installed capacity of renewable energy in Vietnam until 2018

Renewable Energy Source	Installed capacity (MW)	Potential (MW)
Small hydropower	1648	7000 (technical)
Wind	189.2	26,763 (technical)
Biomass	270	318,630 (theoretical)
Solar	8	7140 (commercial)

Source: S Teske and others, 'Renewable Energy for Vietnam – A Proposal for an Economically and Environmentally Sustainable 8th Power Development Plan of the Government of Vietnam'.

recent period. According to BP, Vietnam's proven oil reserves increased significantly from 0.2 billion barrels in 1990 to around 4.4 billion barrels in 2018. Vietnam's oil production increased rapidly over the past two decades from 55,000 barrels per day (bbl/d) in 1990 to 424,000bbl/d at the peak in 2004. Since 2004, oil production has slowed down to 322 bbl/d in 2010, and back to 373 bbl/d in 2014. Since 2014, however, oil production has decreased, and in 2018 Vietnam's oil production is only 275 bbl/d.²² With further efforts to intensify offshore fields' exploration and development, oil production could increase shortly.²³

Vietnam's proven gas reserves have increased steadily from 100 billion cubic meters (Bcm) in 1992 to around 600 Bcm in the past decade.²⁴ Natural gas production has been growing rapidly over the past decade, from 7.7 in 2009 to 9.9 Bcm in 2019.²⁵ According to EIA (2017), half of the gas reserves are located in the Song Hong Basin's northern deep-water areas, occupied high carbon dioxide contents, and costly to extract. Major potential projects are from ExxonMobil's Ca Voi Xanh field, PetroVietnam's Block B project, and Malaysia's overlapping basin. However, according to the IEA (2018), low natural gas prices and the lack of gas infrastructure outside the country's southern part are impediments to upstream investment. At present, gas production and consumption are at a balance. In 2018, gas production and consumption was 9.6 Mtoe.²⁶

Potential of renewable energy in Vietnam

Vietnam has a high potential for renewable energy, including hydro, solar, wind, biomass and waste. Vietnam's available renewable energy sources could potentially contribute to satisfying the soaring electricity demand, mitigate polluting emissions, and enhance energy independence and security.²⁷ In 2007, the proportion of renewable energy in the total primary energy supply was 37 per cent. However, this rate was gradually reduced to 22 per cent in 2017. Hydropower has been the primary type of renewable energy in Vietnam up to now. However, the medium and large hydropower sources (about 20 GW of capacity potential) have been almost fully utilized. The small hydropower resource has a total potential of about 6.7 GW, with more than 3 GW already in operation. Although solar power and wind power have great potential, they accounted for a tiny portion of the total primary energy supply. The current scenario, therefore, leaves so much room for further development.²⁸ The table below presents the installed capacity of renewable energy to compare with its potential, according to the Vietnam Renewable Energy Report in 2018 (see Table 2).

22 BP (n 3).

23 Tran (n 5).

24 BP (n 3).

25 Statista, 'Vietnam: Natural Gas Production 2019' (Statista, 2019) <<https://www.statista.com/statistics/610252/natural-gas-production-in-vietnam/>> accessed 24 February 2020.

26 BP (n 3).

27 Nhan T Nguyen and Minh Ha-Duong, 'Economic Potential of Renewable Energy in Vietnam's Power Sector' (2009) 37 Energy Policy 1601.

28 EREA & DEA (n 13).

Table 3. Data on solar radiation in Vietnam

Zone	Sunshine hours in year	Solar radiation intensity (kWh/m ² , daily)	Rating
Northeast	1600–1750	3.3–4.1	Mean
Northwest	1750–1800	4.1–4.9	Mean
North Central	1700–2000	4.6–5.2	Good
Central Highlands and South Central	2000–2600	4.9–5.7	Very good
Southern	2200–2500	4.3–4.9	Very good
National average	1700–2500	4.6	Good

Source: AECID and MOIT, 'Maps of Solar Resource and Potential in Vietnam' (2014). Nguyen Anh Tuan, 'Assessment of Solar Energy Potential for Electricity Generation in Vietnam'.

Potential of solar energy

Although limited by the demand for land use, solar energy has the most significant potential for development in Vietnam. Most of the country is situated in the tropical zone with up to 5000 hours of sunshine per year. The average number of sunshine hours each year in the north is from 1500 to 1700. The central and southern regions have higher average annual hours of sunshine, from 2000 to 2600. The average normal direct irradiance of Vietnam is 4–5 kWh/m², in the north is 3.69 kWh/m², in the south is 5.9 kWh/m² (see Table 3). As a result, the country has solar power potential.

According to a study on Vietnam's solar energy in 2018, the Vietnam Institute of Energy predicted the solar potential in Vietnam could be up to 380 GW. Still, the distribution is not uniform across regions. The potential is concentrated in the south, south-central and highland regions. Following the study of Polo et al. (2015), the theoretical possibility according to the selected technology, as well as the solar resource estimated across the country, is placed in the range of 60–100 GWh per year for Concentrated solar power (CSP) systems, and 0.8–1.2 GWh per years in the case of Photovoltaic (PV) systems. The areas available for CSP systems are limited to the Central Highlands and Southeast regions. In the case of PV, the available areas are limited to Southeast, Central Highlands, Mekong River Delta, coastal areas, and the Northeast regions.²⁹ Follow the research, the theoretical potential of solar energy in Vietnam is about 360,000 GW, which technical and economic potential, in turn, are 1677.5 GW and 385.8 GW. Despite the great potential, solar energy has grown slowly and inadequately until now, accounting for only a small part of Vietnam's total energy supply. Thanks to a solar promotion mechanism of the Government of Vietnam before June 2019, projects of solar has been booming. By August 2019, the total size of registered investment projects reached about 32 GW, of which 10.3 GW is approved for additional planning up until 2025. However, not all may come to fruition.

Potential of wind energy

With a coastline of more than 3000 km, North and Central Vietnam's hills and highlands have great potential for wind power development. To assess wind energy potential, several preliminary studies have been conducted during the last years. The World Bank (WB) carried out a survey to prepare a Wind Energy Resource Atlas for four Southeast Asian countries, including Cambodia, Laos, Thailand and Vietnam, to support wind energy development for the region.³⁰ According to the study results, more than 39 per cent of Vietnam's total

29 J Polo and others, 'Solar Resources and Power Potential Mapping in Vietnam Using Satellite-Derived and GIS-Based Information' (2015) 98 Energy Conversion and Management 348.

30 Nguyen (n 8); World Bank, 'Wind Energy Resource Atlas of Southeast Asia' (The World Bank 2001) 31870 <<http://documents.worldbank.org/curated/en/252541468770659342/Wind-energy-resource-atlas-of-Southeast-Asia>> accessed 4 May 2020.

Table 4. Vietnam's wind potential at an altitude of 65 m

Wind speed	Short < 6 m/s	Medium 6–7 m/s	Pretty high 7–8 m/s	High 8–9 m/s	Very high > 9 m/s
Area (km ²)	197,242	100,367	25,679	2178	111
Rate of area (%)	60.6	30.8	7.9	0.7	>0
Potential (MW)	–	401,444	102,716	8748	482

Source: World Bank, 'Wind Energy Resource Atlas of Southeast Asia' (The World Bank 2001) 31870 <<http://documents.worldbank.org/curated/en/252541468770659342/Wind-energy-resource-atlas-of-Southeast-Asia>> accessed 4 May 2020.

land area was estimated to have annual average wind speeds greater than 6 m/s at the height of 65 m above the ground level, which is considered suitable for large wind turbines' operation (see Table 4). This developable land area is equivalent to a theoretical wind power potential capacity of 513,360 MW. Besides, about 8 per cent of the land area has an average annual wind speed of more than 7 m/s, equivalent to a total capacity of 110 GW (see Table 4).³¹ These areas are very favourable to develop large wind power stations.

Vietnam is also located in the monsoon wind zone, which the wind density is estimated at 800–1400 kWh/m² per year on islands and 500–1000 kWh/m² per year in the Central Highlands, coastal areas of Central Vietnam, and the Mekong River Delta. The density distribution of wind energy is lower than 500 kWh/m² per year in other areas. Besides, Vietnam has a long coastline and great potential for offshore wind, especially in the South and South-Central regions, which have a relatively shallow seabed convenient for offshore wind construction.³² The total potential of wind energy in Vietnam is estimated at 713,000 MW, of which 510,000 MW is on land, and 200,000 MW is on islands. The south-central coast, especially the Ninh Thuan and Binh Thuan provinces, has the highest potential of wind resource, mainly due to the monsoon winds' deflection, especially in summer. Other areas with good potential are situated along the coast near Can Tho Province, the highlands west of Binh Dinh along the Dak Lak and Gia Lai provincial border.³³ However, the information on wind potential in Vietnam is still insufficient; hence, it is necessary to have more studies in the coming period.³⁴

3. SITUATION AND CHALLENGES FOR THE DEVELOPMENT OF RENEWABLE ENERGY IN VIETNAM

Fossil energy consumption is a significant cause of environmental pollution and greenhouse gas emissions. This energy source is tending to decrease while energy demand is increasing. While Vietnam is assessed as a country with great potential for renewable energy development, the exploitation of renewable energy sources is fundamental to the national economy, society, energy security and sustainable development. The effect of these sources will reduce fossil energy consumption while reducing greenhouse gas emissions, which help diversify energy sources and ensure national energy security. However, renewable power remains relatively new to Vietnam. In recent years, high establishment costs and low power prices have deterred foreign investors from seriously considering Vietnam as a destination.

Over the past decade, to meet the rapidly increasing energy demand, the Government of Vietnam has decided to expand its reliance on renewable energy sources. The Government has issued many documents to encourage renewable energy development to ensure energy security and address the growing power demand.

31 EREA and others, 'Vietnam Technology Catalogue - Technology Data Input for Power System Modelling in Vietnam' <<https://zenodo.org/record/2859959>> accessed 26 April 2020.

32 EREA & DEA (n 13).

33 Nguyen Duc Luong, 'A Critical Review on Potential and Current Status of Wind Energy in Vietnam' (2015) 43 *Renewable and Sustainable Energy Reviews* 440.

34 EREA & DEA (n 13).

Table 5. The targets set in the revised PDP VII for renewable energy

Type	Capacity/Production	2020	2025	2030
Wind	Total Capacity (MW)	800	2000	6000
	Electricity prod. (%)	0.8%	1%	2.1%
Hydro Power	Total Capacity (MW)	21,600	24,600	27,800
	Electricity prod. (%)	29.5%	20.5%	15.5%
Solar	Total Capacity (MW)	850	4,000	12,000
	Electricity prod. (%)	0.5%	1.6%	3.3%

Source: N 428/QĐ-TTg, 'National Power Development Planning Adjusted'.

Among them is the Prime Minister's Decision No. 1855/QĐ-TTg (27 December 2007), which approves the 'National energy development strategy up to 2020, outlook to 2050'. According to this document, the specific target of increasing renewable energy proportion has been set at 5 per cent and 11 per cent of the total primary energy consumption by 2020 and 2050, respectively.³⁵

The Prime Minister approved the National Master Plan for power development for the 2011–2020 period, outlook to 2030 in the Decision No 1208/QĐ-TTg (21 July 2011). In 2016, the Government approved the revised National Power Development Master Plan (the revised PDP VII). According to this plan, the development of renewable energy sources (wind energy, solar energy, biomass energy, etc.) for electricity production would be prioritized with the gradual increase in the percentage of electricity produced from these energy sources from 3.5 per cent of total electricity production in 2010 up to 4.5 per cent and 6.0 per cent in 2020 and 2030, respectively. Notably, the total wind power capacity is expected to increase from the current negligible levels to around 1000 MW and 6200 MW, corresponding to 0.7 per cent and 2.4 per cent of the total power capacity in 2020 and 2030, respectively. It is expected that renewable sources (including small hydropower, wind, solar power and biomass) will account for 21 per cent of the national power generation capacity by 2030 (see Table 5).³⁶ However, wind power and solar power rates only account for a small proportion of the total renewable energy.³⁷

Vietnam renewable energy development strategy (REDS) until 2050 was approved by the Prime Minister in Decision No. 2068/QĐ-TTg (25 November 2015). This Decisions aims are accelerating the expansion and the use of renewable energy sources; gradual increasing renewable energy share in national energy production and consumption; ensuring less dependence on fossil sources; and contributing to better energy security, mitigating climate change, environmental protection, and sustainable socio-economic development.³⁸ The strategy is the contribution of renewable energy (including both small and large hydropower) in the total national electricity production accounting for 38 per cent by 2020, 32 per cent in 2030, and about 43 per cent in 2050.

In 2017, the Government issued Decree No.11/2017/QĐ-TTg on mechanisms for encouraging solar power development in the country. This decree proposed the feed-in-tariffs (FIT) for utility solar power plants at 9.35 US cents/kWh for 20 years. Also, solar power projects and related constructions are exempted or reduced land-use fees, land rents and water surface rents according to the current law applicable to projects in the domains eligible for investment incentives.³⁹

35 Nguyen (n 8).

36 N 428/QĐ-TTg (n 16).

37 Minh Thong Le, 'Unconventional Gas Development in Vietnam: Opportunities and Challenges' (2017) 10 *The Journal of World Energy Law & Business* 14.

38 Kimura and Phoumin (n 7).

39 QĐ 11/2017/QĐ-TTg, 'Mechanisms for Encouraging the Development of Solar Power in the Country'.

The Decision No. 39/2018/QĐ-TTg issued on 10 September 2018, the FIT for wind energy projects has been increased from 7.8 US cents/kWh to 8.5 US cents per kWh for onshore wind power projects and 9.8 US cents per kWh for offshore wind power projects. In addition, wind power projects also benefit from preferential credit, import tax exemption for imported goods, and a corporate income tax reduction. There are also incentives for infrastructure and land and government subsidies to encourage investment.

However, renewable power, including wind power and solar power, only represents a minor part of power generation. Today, hydropower holds the largest share amongst all renewable energy sources, followed by biomass, wind power, and solar power. Large hydropower is almost fully utilized. While only 50 per cent of small hydropower potential has been exploited, the remaining sources are in remote areas, unfavourable areas, and high exploitation prices. However, using other renewable energy sources, especially wind resource, as alternatives to conventional energy sources has not yet been well promoted domestically.⁴⁰ Solar energy and wind energy are slowly improved. By the end of June 2019, nine wind power projects with a total capacity of 304.6 MW launched their operation; 82 solar power projects with a capacity of 4464 MW were connected to the national grid.⁴¹ The installed capacity of wind energy and solar energy in Vietnam was also much lower than those in some Asian countries. However, the wind and solar energy potential in Vietnam is higher.⁴² Hence, to effectively exploit and utilize the given wind energy potential, Vietnam needs to put much more effort in the coming years.

Although there is good potential for wind and solar energy resources, a system of policy documents to support, the development of these energy projects in Vietnam is currently facing numerous obstacles. Firstly, prospective investors may be deprived of reliable and useful information about the overall picture of the nation's wind and solar potential when seeking investment opportunities.⁴³ Secondly, there is a lack of qualified human resources for carrying out complete renewable power projects, essential technical maintenance services, operation and management after installing wind turbines or solar power plants.⁴⁴ Besides, inadequate grid capacity, complicated regulatory frameworks, and the mechanism for electricity prices for renewable energy (which is unclear in the future) are causing many large projects to be delayed and creating anxiety in investors in this field.

4. ASSESSING THE CAPACITY OF RENEWABLE ENERGY DEVELOPMENT

Great potential to reduce emissions and combat climate change

Vietnam's energy demand is predicted to increase by over 10 per cent by 2020, while energy consumption is projected to increase four-fold by 2030 compared to 2014. To meet the growing demand of energy that coal and hydropower cannot fulfil, the Government promotes other renewable sources such as biomass, solar power and wind, reducing the gap between the demand and supply. Carbon emissions (dominated by fossil fuel use) in Vietnam have increased rapidly by 10.1 per cent a year during 1990–2014.⁴⁵ Energy and industries are indeed the key drivers of emissions in the country. The CO₂ equivalent growth rate for power and industries was 8.7 per cent and 15.3 per cent a year, respectively. Vietnam's GHG emissions are growing at a very high rate. In its Nationally Determined Contribution (NDC) to the UNFCCC, Vietnam has committed to reducing annual emissions with domestic means by 8 per cent in 2030 compared to the BAU scenario, or

40 Nguyen (n 8).

41 Minh Ha-Duong and others, 'Options for Wind Power in Vietnam by 2030' (HAL 2020) hal-02329698 <<https://ideas.repec.org/p/hal/ciredw/hal-02329698.html>> accessed 24 April 2020.

42 Luong (n 33).

43 *ibid*; Van Q Doan and others, 'Usability and Challenges of Offshore Wind Energy in Vietnam Revealed by the Regional Climate Model Simulation' (2019) 15 SOLA 113.

44 Luong (n 33); Doan and others, *ibid*.

45 CAIT, 'Historical GHG Emissions' (2017) <https://www.climatewatchdata.org/ghg-emissions?end_year=2016&start_year=1990> accessed 24 February 2020.

25 per cent on condition country receives international support.⁴⁶ However, according to the UNDP—Vietnam, if Vietnam does not take deliberate action to mitigate emissions, the total annual emissions would almost quadruple from 2010 to 2030. With the domestically supported target of 8 per cent in reduction compared to BAU, it would still more than triple the annual emissions, from 226 to 725 million tons of carbon dioxide equivalent (MtCO₂e). If the conditional target of 25 per cent reduction compared to BAU is achieved, the increase in total annual emissions between 2010 and 2030 is still more than 2.5 times.⁴⁷ Therefore, to achieve the targets that Vietnam's INDC has committed to, Vietnam must implement efficient energy use, focusing on the development of renewable energy to gradually replace fossil energy. Therefore, the role of renewable sources is vital for the future of the country.⁴⁸ To achieve the target concerning low carbon economic growth, the Vietnamese Government has focused on exploiting and investing in renewable sources, mostly wind energy and solar energy.⁴⁹

As mentioned above, Vietnam is a country with great potential for renewable energy, especially wind energy and solar energy. Compared to other fossil energy sources, renewable energy has almost no greenhouse gas emissions. It creates enormous opportunities for Vietnam to develop renewable energies to meet the country's increasing need and help reduce greenhouse gas emissions to protect the environment and fight against climate change. Offshore wind has immense potential; it can contribute a significant share to the Vietnamese electricity mix in the coming decades. With great potential, a very high-capacity factor, and technology that has become affordable, offshore wind contribution will increase rapidly in the coming years. According to different analysts, wind power installed capacity in 2030 could be 12–15 GW onshore, 10–12 GW offshore.⁵⁰

According to the Institute of Energy of Vietnam, solar energy is the most tremendous potential, which the average land use rate is about 1.1–1.2 ha/MW, depending on efficiency. In 2014, a report of the Ministry of Industry and Trade under the support of Spanish Agency for International Development Cooperation showed that the technical potential for solar energy could be estimated at around 85 GW.⁵¹ However, according to ADB (2017) and GreenID (2017), the estimation of solar energy potential in Vietnam was biased, as such estimates are strongly dependent on assumptions about areas that can technically be developed.⁵² In 2019, the economic potential of solar energy was up to 380 GW, according to the Danish Energy Agency.⁵³ Vietnam has a lot of ability to develop wind power and solar power in the future.

Increasing competitiveness compared to other energy sources

The increase of tariff

Thanks to the huge wind and solar resources, the cost of producing electricity from such sources has decreased continuously over the past decade.⁵⁴ Since 2011, the FIT was 7.8 USD/kWh, which was not commercially viable for developers. Since November 2018, the FIT for wind power projects in Vietnam amended

46 Vietnam's INDC, 'Intended Nationally Determined Contribution of Vietnam' (2015) <<https://www4.unfccc.int/sites/ndcstaging/Pages/Party.aspx?party=VNM&prototype=1>> accessed 24 April 2020.

47 UNDP in Vietnam, 'Long-Term Greenhouse Gas Emission Mitigation Opportunities and Drivers in Vietnam' (2018) <https://www.vn.undp.org/content/vietnam/en/home/library/environment_climate/long-term-greenhouse-gas-emission-mitigation-opportunities-and-d.html> accessed 24 April 2020.

48 Anne Zimmer, Michael Jakob and Jan Christoph Steckel, 'What Motivates Vietnam to Strive for a Low-Carbon Economy? — On the Drivers of Climate Policy in a Developing Country' (2015) 24 *Energy for Sustainable Development* 19.

49 Tran (n 5).

50 Ha-Duong and others (n 41); GreenID, 'Analysis of Future Generation Capacity Scenarios for Vietnam' (2017); Jake Badger and others, 'Wind Resource Mapping in Vietnam: Mesoscale Modelling Report' (The World Bank 2015) 95802 <<http://documents.worldbank.org/curated/en/264301468115480511/Wind-resource-mapping-in-vietnam-mesoscale-modelling-report>> accessed 29 April 2020.

51 AECID and MOIT, 'Maps of Solar Resource and Potential in Vietnam' (2014)..

52 Asian Development Bank (n 1); GreenID (n 50).

53 EREA & DEA (n 13).

54 Ha-Duong and others (n 41).

to 8.5 USD/kWh for onshore wind power projects and 9.8 USD/kWh offshore. The price of solar power also increased, reaching 9.35 USD/kWh in 2019. These trends will continue in the next years. The increase in the tariff explains the success in capturing developers' interest and the takeoff of field wind and solar power at the end of 2019.

Cost reduction

Many recent studies show that wind power and solar power will play an essential role in the future due to the rapid decline in the costs of renewable energy. This global trend has been observed over the past years and will remain shortly. Recent studies have shown that wind energy production costs have dropped significantly. According to the report 'Renewable Power Generation Costs in 2018' of IRENA, in most parts of the world today, renewables have become the lowest-cost new power generation source. As the costs for solar technologies and wind technologies continue to fall, the scenario mentioned above will become a reality in a growing number of countries.⁵⁵

The global weighted-average Levelized Cost of Electricity (LCOE) from onshore wind power in 2018 was 0.056 USD/kWh, which was 13 per cent lower than the value for 2017 and 35 per cent lower than that in 2010.⁵⁶ The LCOE for offshore wind power in 2018 was 0.127 USD/kWh, denoting a decline of 1 per cent compared to that of 2017 and 20 per cent compared to the value of 2010. Besides, the average total installed cost of wind power has also declined rapidly in recent years. According to the IRENA, the average total installed cost of onshore wind farms fell by 6 per cent in 2018, while the total installed fees of offshore wind farms have reduced modestly since 2010, by 5 per cent between 2010 and 2018.⁵⁷

Regarding solar energy, in particular solar photovoltaics, its LCOE is falling faster than that of wind energy. In 2018, the global weighted-average LCOE of solar PV was reduced to 0.085 USD/kWh, corresponding to a reduction of 13 per cent compared to the value of 2017 and 77% compared to that of 2010. The global weighted-average LCOE for concentrating solar power in 2018 was 0.185 USD/kWh, which is 26 per cent lower than the value in 2017 and 46 per cent lower than that in 2010. The global weighted-average total installed cost of solar energy also declined year on year. According to IRENA, the total installed CSP cost was falling from around 7200 USD/kW in 2017 to 5200 USD/kW in 2018, corresponding to a decrease of 28 per cent. Meanwhile, the total installed cost of solar PV declined by 13 per cent in 2018.⁵⁸

The study results show that renewable energy costs are rapidly decreasing. According to many short and middle term forecasts, the cost of producing this energy source may be equal to or lower than that of fossil energy, causing a positive impact on the development of renewable energy globally, including Vietnam. However, wind power cost went down rapidly in recent years in this nation. The investment cost for wind projects is 1.8 million USD per MW regarding the average installed capacity.⁵⁹ The Technology Catalogue considers that nominal investment in onshore wind will decrease to 1.31 million USD/MW in 2030 and decrease further to 1.11 million USD/MW in 2050 (EREA, 2019). Solar PV has become much cheaper for three years since the formulation of the NDC.⁶⁰

In 2018, Green Innovation and Development Centre (GreenID) analysed the LCOE of all sorts of power technologies under Vietnamese conditions in different years, based on technology and price assumptions as deemed applicable in Vietnam.⁶¹ Table 6 below presents a comparison of the LCOE production from selected key technologies in different years. With the conditions in 2017, solar PV LCOE was 8.84 US

55 IRENA, 'Renewable Power Generation Costs in 2018' (2019) </publications/2019/May/Renewable-power-generation-costs-in-2018> accessed 27 April 2020.

56 *ibid.*

57 *ibid.*

58 *ibid.*

59 Ha-Duong and others (n 41).

60 UNDP in Vietnam (n 47).

61 GreenID (n 50).

Table 6. LCOE of key technologies invested in different years in Vietnam (US cents/kWh)

Year Technology	2017	2017 (external costs)	2020	2025	2030
Small hydro	4.92	4.92	4.92	4.92	4.92
Large hydro	4.20	4.20			
Ground mounted solar grade 1	8.84	8.84	8.07	7.30	7.30
Roof top solar PV grade 1	10.56	10.56	9.80	9.03	9.03
Wind grade 1	8.77	8.77	8.46	8.08	8.08
Ultra-supercritical coal-imported coal			8.35	8.53	8.71
Supercritical coal-imported coal			8.09	8.28	8.48
Pulverized coal-imported coal	7.30	7.03 (+5.08)	7.42	7.63	7.85
Pulverized coal-domestic coal	6.71	6.71 (+5.20)	6.81	6.98	7.16
Gas turbine-domestic gas	7.89	7.89 (+1,66)	8.37	9.86	9.86
CCGT—domestic gas	7.10	7.10 (+1.24)	7.47	8.60	8.60

Source: GreenID, 'Analysis of Future Generation Capacity Scenarios for Vietnam' (2017).. Nguyen Quoc Khanh, 'Analysis of Future Generation Capacity Scenarios for Vietnam' (2018).

cents/kWh, and wind power LCOE was 8.77 US cents/kWh. The highest cost is that of rooftop solar photovoltaic (10.56 US cents/kWh). These LCOEs were higher than that of energy fossil, like coal or gas (around 6.7–8.18 US cents/kWh).

However, in the future, the competitiveness indexes of renewable energy technologies could change as their investment costs keep improving, while fossil fuel cost tends to continue to increase. The results for 2020 show that the ground-mounted solar PV grade 1 now becomes more cost-effective than Ultra-supercritical coal and gas turbines. By 2025, wind grade 1 can compete with supercritical coal and become more cost-effective than coal and gas. By 2030, except for solar PV (which is still not yet competitive with coal), other renewable energy sources can compete with fossil energy.

In Vietnam, coal power is still considered cheaper than renewable energy because external costs (costs on environmental, social and health impacts) are not fully counted. These are costs that citizens and the Government are bearing, while investors are not paying. Hence, if external costs are taken into account, all renewable energy technologies can compete with coal power today.⁶² According to GreenID, when externalities are considered, the picture on the economic level of technology changes, even at the present cost levels. All renewable energy technologies become more competitive than coal power, even rooftop solar and low-grade wind (see table 6).

Thus, the results show that solar and wind power will be competitive by 2025 or sooner without internalizing external costs. However, the internalization of external costs of energy production will make renewable energy more competitive. Renewable energy can already compete with coal and also gas power if the environmental, social costs, health and livelihood costs are internalized in the costs.

The competitiveness and choice of energy sources, especially in electricity production, depend very much on production costs. The production cost's sensitivity depends on various factors such as electric power generation, technology, input fuel prices, investment capital, operating and maintenance costs and the cost of CO₂ emissions (due to the different emissions per energy level).⁶³ The price of CO₂ is a critical factor, according to Kahrl. Apart from the price factor, and the cost of investment between power stations,

62 Nguyen Quoc Khanh, 'Analysis of Future Generation Capacity Scenarios for Vietnam' (2018).

63 Jean-Pierre Hansen and others, *Energie économie et politiques* (De Boeck 2010).

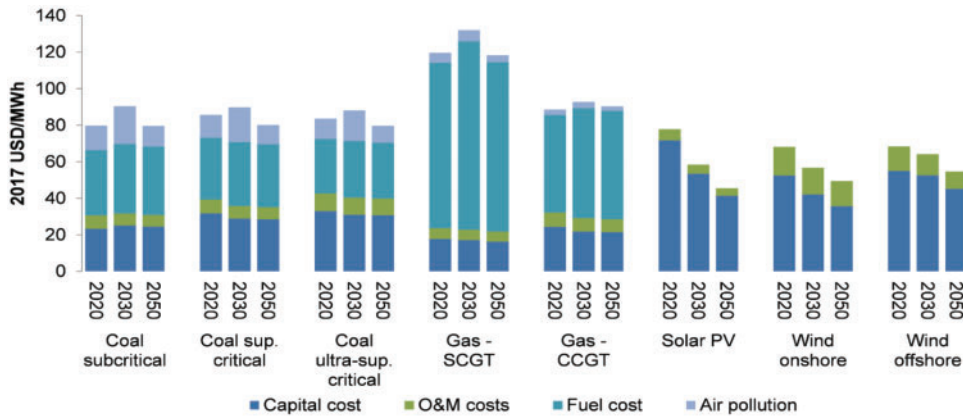


Figure 2. LCOE according to different sources in Vietnam, (Assuming a price of 20 USD/ton of CO₂)

Source: EREA & DEA ‘Vietnam Energy Outlook Report 2019’ (2019).

the competitiveness of electricity production depends on the carbon price.⁶⁴ For example, the cost of carbon represents 35 per cent–40 per cent of the LCOE of coal power plants, while this cost is about 10 per cent in natural gas power plants.⁶⁵ It shows that the price of carbon is crucial and strongly influences the cost of electricity production. While renewable energy has almost no emissions, this will make renewable energy more competitive than fossil energy.

Currently, Vietnam has no carbon market, no taxes, and no carbon fee. Therefore, in calculating the LCOE of energy sources, there are no costs related to carbon emissions. This is also why the LCOE of coal and gas electricity is cheaper than those of solar power or wind power. However, suppose the Vietnamese Government would develop the CO₂ market or promulgates the regulations on taxes and CO₂ fees in the future. In that case, the generation of electricity from renewable energy will undoubtedly be very competitive compared to other traditional power sources.

In a study of the Danish Energy Agency in collaboration with the Vietnamese Ministry of Industry and Trade in 2019, with the assumption that the price of CO₂ in Vietnam is 20 USD/ton, the LCOE of renewable energy (like wind energy and solar energy) is much cheaper than that of fossil energy sources (see Figure 2).

Thus, the forecast results show that with the current cost reduction rate, only until 2020, renewable energy can still compete with traditional energy sources even without external factors. When adding external factors into account, especially the cost of carbon emissions, renewable energy will become the cheapest form of power generation in Vietnam. Therefore, it can be concluded that the potential of RE development (compared to traditional energy) in the future of the country is very high.

CONCLUSION

Vietnam is one of the countries severely affected by climate change and its related disasters. Aware of this, the Government is among the first to ratify the United Nations Framework Convention on Climate Change. However, like other developing countries, the rapid economic development in Vietnam has led to huge national energy demand. The Vietnamese Government has also long displayed a commitment to doing its part to reduce GHG emissions by increasing the share of renewable energy, reducing the use of fossil energy to

64 Fredrich Kahrl and others, ‘Strategies for Expanding Natural Gas-Fired Electricity Generation in China: Economics and Policy’ (2013) 2 Energy Strategy Reviews 182.

65 NEA, IEA, and OECD, *Projected Costs of Generating Electricity 2015* (OECD Publishing; Éditions OCDE 2015).

ensure energy security, mitigating climate change, protecting the environment, and developing sustainably. This is an inevitable future trend for the country.

Compared to other Asian countries, Vietnam has good potential for wind energy and solar energy development. In recent years, the Government has also issued many policy documents related to renewable energy development. However, the state's targets for renewable energy in its policies are very low, not commensurate with the potential of renewable energy, especially wind energy and solar energy. The application of renewable energy in Vietnam is still negligible; renewable energy development is still very slow. To promote the development and application of renewable energy, the Government should continuously improve the existing policies and develop more comprehensive approaches to support the development of renewable energy based on the real on-going development situation and lessons learnt from international experiences.

The above analysis has shown that the cost of generating electricity (LCOE) from renewable energy is declining and that renewable energy is entirely able to compete with traditional fossil energy sources. Even if the external costs are taken into account, especially the cost of carbon emissions, renewable energy is considered the cheapest energy source in Vietnam. In addition, the electricity price mechanism for renewable energy tends to increase. Therefore, renewable energy is highly competitive compared to fossil energy. It is feasible for Vietnam to reduce emissions and ensure energy supply by replacing fossil energy in Vietnam.

To ensure the rapid development of renewable energy in the future in Vietnam, this article propose some recommendations to help investors overcome the existing barriers related to technical and technological, economic and financial and institutional aspects. For example, the Vietnamese Government needs to improve these tariffs to encourage renewable energy projects continuously. In the coming time, it is necessary to consider sharply reducing coal sources and enormously increasing the targets of developing renewable electricity, especially wind power and solar power, to match the potential of these energy sources in Vietnam. It is necessary to reflect on the carbon tax in the current environmental protection tax. Therefore, the Vietnamese Government can develop its carbon tax parallel with the environmental protection tax, like what other countries are currently implementing. In addition, the Government can also set its carbon fee as a kind of environmental protection fee and needs to build a carbon market like other countries in the world. This recommendation is a factor that ensures the rapid development of renewable energy in the future. In addition to renewable energy development policies, the Government should have specific guidelines that prioritize infrastructure developments and power transmission grid systems.