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VIETNAM'S ENERGY SECURITY IN 2023: GLOBAL COAL AND LNG MARKETS

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Foreword

VIETSE is an independent think-tank with the mission to accelerate the transition of Vietnam towards a carbon-neutral society. We prepared this report entitled "Vietnam's energy security in 2023: Global coal and LNG markets" to illuminate the political choices to be made about the future of energy in Vietnam – and particularly the lawmaking discussions on electricity and prices. As much as everybody else, lawmakers and policymakers are aconflicte that there is a connection between the high costs of fossil fuels in international markets and the Vietnamese household electricity bill. This report explains the technical and economic mechanisms at work in this connection, in order to motivate proposed solutions for the development of the power system in the next few years. Yes, the unbearable costs of importing coal are to blame for the blackouts in Hanoi in early July, 2022. What can we do about it, how to navigate the global energy crisis?

The report's executive summary spells five key propositions: Reduce the electricity demand, Exploit the Block B offshore gas field, Promote renewable power sources, Increase the retail price of electricity, Let state-owned enterprises raise capital for sustainable investments by taking debt on financial markets.

These will be justified in technical details in the report, this foreword would like to situate the present work in Vietnam's more general political context. On May 30th, 2022, the National Assembly's Oversight Delegation on the implementation of policies and laws on planning pointed out that the progress of planning for the 2021-2030 period is slow: 104 out of 111 plans are not yet completed and approved. This affects socio-economic development in many sectors. Many energy investment projects are on hold at the moment. Investors will not wait forever, and there is a risk of loosing opportunities, for example in the offshore wind industry.

In our view, three fundamental tensions hinder the planning process:

- One is the tension between market liberalization vs. state management. For example national security and engineering constraints justifies that the transmission network is centrally managed, while speed and finance availability justifies that decentralized renewable energy projects are left to the market. It is not obvious, at this juncture, how much LNG-to-power infrastructure can and should be left to the private sector.

- There is a tension between the imperative and the indicative nature of the plan. The law defines planning as a rational engineering exercise. A power development plan starts by forecasting the electricity demand, defines a list of power plants to be constructed, and then blueprints the necessary transmission lines and substations to be built. It is an imperative plan: "EVN, build this !" On the other hand, the executive government has to navigate the ever-changing technical, economic and political situation. The military say that no plan ever survives contact with the enemy. The current power development plan (PDP7A), for example, was significantly impacted by a wave of investors proposing to implement billion dollars LNG-to-power projects. At that time it was rational for the Government to accept these proposals and add them to the PDP7A. This part of the plan is only indicative, the investors cannot be forced to build.
- There is still a tension between the urgency of greenhouse gas emissions mitigation and the need to provide more and cheap electricity. The 2050 carbon neutrality goal adopted at COP26 requires a change of mindset from a multiplicity of actors which will take years. It is a radical reorientation of the country's socioeconomic development, alike to a Doi Moi 2.0.

VIETSE believes in a pragmatic approach to policymaking, finding customized, balanced solutions to resolve these tensions. Different segments of the energy system require different modes of organization, with more or less state management. In a market-oriented economy, the plan is not like an architectural blueprint to build the system, but more like a sailing plan: it says what the final destination is, proposes an route and mechanisms to adapt to the weather along the way. And we recognize that while Vietnamese society has deep rooted traditions, it is also capable of dynamic change when it comes to the energy transition. Vietnam has everything it takes to embrace the low-carbon goal and remain a model case of socioeconomic development.

Final words, a single technical report is never going to cover all aspects. As the leading Vietnamese energy transition think-tank, VIETSE conducts many studies on a wide range of topics such as the electricity price, long term low carbon scenarios, power grid management, biomass and waste energy, energy storage, virtual power plants… We invite you to know more about our activities at https://vietse.vn/ and look forward to hear from you at an energy transition dialogue event soon.

Dr. Ha-Duong Minh Xavier, VIETSE's Chairman

Ms. Ngo To Thi Nhien, VIETSE's Executive Director

Executive summary

In 2023, the world confronts high fossil fuels prices on international energy markets. Coal prices have quadrupled from before the Covid crisis, and Liquefied Natural Gas prices have doubled. The present global energy crisis is the fourth after the ones in 1973, 1979 and 2008. This time is different: electricity from solar and wind power generation capacities has become cheaper than from equivalent coal- and gas-fired thermal capacity. Accounting for the social and environmental costs of greenhouse gas emissions further increases this differential.

The world may have entered a new normal situation, where investments in exploration and production do not sustain the continuous expansion of fossil fuels production capacities – leading to supply-contrained markets. If there are less capital expenditures in the fossil fuels sector, the new normal would however require effort in the electricity sector. The variability of solar and wind capacity requires investment in the power system to develop backup capacity and flexible solutions ensuring ensure reliable supply and grid stability. These capital needs extend to critical investment in the transmission and distribution grid.

For Vietnam, we find that peak oil has passed, that the domestic coal production is struggling and failing achieve 100% of the plan, and that the natural gas peak is close but there is still a chance to defer it. Private investment capital is available to drive renewable capacity development. Once a robust legal framework and a balanced regulatory structure are in place, market mechanisms such as auctions, direct power purchase agreements and self consumption will attract private investors into new solar and wind projects.

Regarding the pace of fossil fuels use reduction in Vietnam, net-zero scenarios converge to find that emissions should peak in 2035. They also agree that the main energy strategy is to pursue electrification based on renewable electricity sources.

In light of the fossil fuels scarcity outlined in this report, what could be policy options for the energy transition in Vietnam, in today's context of the energy crisis. Options available to support the energy transition and energy security include:

1. Reduce electricity peak loads by (i) promoting energy efficiency (through application of industry standards, appliance labeling, etc.), (ii) prioritizing decentralized power generation (i.e. solar rooftops with storage), and (iii) stressing demand side management (smart meters, internet of things, etc.).
2. Finalize the development of Block B offshore gas field gas-to-power value chain project. Block B provides significant fiscal revenues to the State. Its production costs are stable and predictable, unlike the spot LNG market. Although the cost of the gas produced from Block B may appear high for base-load power generation, the project provides the flexibility and capacity needed to support the scale-up of renewable electricity sources in the South.
3. Promote renewable power sources. While the government can provide incentives for development, its main focus should be to ensure a legal and regulatory framework that supports an efficient market. To minimize system costs, drive renewable energy projects to the Northern region, where the electricity demand is high and more grid capacity is available. Develop the domestic market for offshore wind power to take a position in the sector's global supply chain. Exploit the financial and technical knowledge of qualified international offshore wind developers. Continue to expand the near-shore wind farms. Promote a strategic reorientation of the national oil and gas companies to the new energy industry landscape.

There is much more to say about Vietnam's options in the global energy crisis context than these few pages allow. We hope that this overview do justice to the complexity of the problem, and raise curiosity about possible actions.

1 Introduction

Buckle up, our century has entered an area of turbulence. The World Health Organization declared Covid-19 a pandemic in March 2020: it had caused an excess mortality of over 21.4 million deaths by May 2022[1]. Lockdowns and other measures in reply to the pandemic caused a global recession: the global economy contracted by 3.5% in 2020, a seven points loss compared to the forecast 3.4% growth rate[2]. The demand drop in the recession depressed the price of fossil fuels to record lows: for example the price of natural gas for Northern Asia (ANEA index) went from a peak of 6.50 USD/mmbtu on 2019/10 to a low of 1.80 USD/mmbtu on 2020/05[3].

Vietnam fared comparatively better than average. By January 2022, its had accumulated 440 confirmed Covid-19 deaths per million people, compared to 842 for the world (Source: Covidtracker world). When the world's economy contracted by 3.5% in 2020, Vietnam's economy grew by 2.9% (Source: Our World in Data).The following year in 2021, the world's economy recovered, expanding by 5.9%, while Vietnam GDP grew at only 2.6% (Source: World Bank). Overall, Vietnam had a less bumpy ride through the Covid-19 crisis.

The global economic recovery in 2021 increased the demand in fossil fuels, which lead rising prices on international fossil fuels markets (see Figure 1 and Figure 3). Vietnam was touched by inflationary pressures, but less critically than many other countries.

Figure 1: Price of LNG in Asia since 2015

Source: Tradingviews, accessed 2023-01-10

[1] Hannah Ritchie et al., "Coronavirus Pandemic (Covid-19)," Our World in Data, May 23, 2022

[2] Eduardo Levy Yeyati and Frederico Filippini, "Social and Economic Impact of Covid-19," Working Paper, Brookings Global (Brookings, June 2021).

[3] Rystad Energy, "Global Gas Report 2022" (International Gas Union / SNAM, May 2022).

What happened in Turkey in 2022 illustrates the consequences of energy insecurity in a middle-income country. Turkey depends on imports for 74% of its energy (2020 figure). Iran, which provided 16% of Turkey's natural gas last year, cut its gas flows for ten days due to a technical failure on January 20th. Turkish gas-fueled power plants had to reduce their use by 40%. On January 24th, the electricity company announced a three-day restriction on electricity distribution to all organized industrial zones in the country. Businesses could only use electricity for heating, lighting and security purposes. Many industrial manufacturers had to pause production.

It could happen here. In spring 2022, the coal shortage seriously threatened Vietnam's electricity supply. Nghi Son 1, Vung Ang 1, Vinh Tan 2, Duyen Hai 1, and Hai Phong thermal power plants are already operating at reduced capacity to save coal. Blackouts occurred in the North on July 4th, due to high cooling demand in the summer. Vietnam's domestic coal production has been too low to fuel our power plants for seven years.

Part of the response plan is to produce electricity using domestic natural gas. Unfortunately, the Ca Voi Xanh and the Lot B offshore gas fields are complicated to develop. The former contains lots of CO_2 and is quite far from shore in the East sea, which raises geopolitical issues. The latter is expensive to produce as the geology requires lots of drilling. The economics are not there yet.

Facing delays in the development of thermal power generation projects, in 2018, the government launched the development of solar and wind power generation. It was not easy, but it worked to meet the electricity demand until last year. But as the economy recovers, the electricity demand increases. We did not abandon the idea of producing electricity from gas. As the two domestic projects cited above remain stalled, we started to build terminals to import liquefied natural gas.

As Vietnam does not import LNG yet, the high prices of 2021-2022 had no consequences. But the cases of Pakistan and Sri Lanka illustrates the extreme risk of fossil fuels dependence. They are now in a vicious circle where the fossil fuels crisis leads to a macroeconomic catastrophe, which leads to further difficulties to import fossil fuels.

Text 1: No country is immune to an energy crisis

According to Vietnam's General Statistical Office, the average consumer price index grew by 1.84 % in 2021, compared to 4.7% in the US for example. The cost-of-living crisis, which is still going on in 2023, prompted central banks to tighten access to credit it order to control inflation – at the cost of slowing GDP growth. The dollar appreciated against other currencies, which is a concern for fossil fuel buyers on international markets where transactions are settled in US dollars.

The Russia-Ukraine conflict starting late February 2022 led to global food and energy crisis which set back the prospects for a return to balanced growth. Acccording to the

IMF World Economic Outlook, in 2022 GDP growth for the global economy was 3.2%. For Vietnam, it was the rebound year from the Covid crisis, with a GDP growth of 8.0%[4]. One of the reasons for Vietnam's economic success is the US-China trade war. In 2018-2019, the tariffs rates towards each other increased to around 20%, compared to a normal rate of 3 – 6.5% towards the rest of the world. They have remained at this level since the 2020. While decreasing international trade generally slowed the global economy, it may have benefited for Vietnam as increased export opportunities to the US.

The conflict accelerated changes in global energy market. It caused energy prices to climb faster: by March 2022, the spot price for natural gas in Asia had reached to a monthly average of 39.30 USD/mmbtu. The NATO allies took economic sanctions against Russia, who eventually cut off its gas supply to Europe. The energy crisis was acute there. Electicity prices in the UK and Germany, which were already among the highest in the world, doubled (see Figure 18). However, Europe managed to avoid energy shortages and rationing. This is due to a combination of factors including warm weather decreasing the need for heating, and policy measures such as gas and electricity price caps and subsidies, diversification and procurement of floating LNG import terminals, demand reduction, energy efficiency and the accelerated development of renewable energy sources[5]. Other countries were not as lucky, see Text 1.

During the energy crisis, various utilities switched to using more coal instead of gas. CO_2 emissions increased by over 2 billion tonnes in 2021, rebounding to their highest level in history[6]. It is now clear that human-induced climate change is widespread, fast and increasing, causing dangerous and widespread disruption in nature and affecting the lives of billions of people: water cycle chaos and high temperature anomalies are observed everywhere, with a record warming of +38.5°C above normal at Dome C on the Antarctic Plateau measured on March 28th, 2022.

To sum up, in 2022 the world moved from a health crisis into an energy/food/inflation crisis, on the background of a climate emergency[7]. This report examines the fundamental drivers of the energy crisis for Vietnam, and exposes the problem of continuing the energy transition and maintaining energy security in spite of unaffordable fossil fuel prices on international markets. The report is organized in four parts. The next part (chapter 2) examines what is happening in global fossil fuels markets. Chapter 3 explains the difficulties to increase domestic fossil fuel production further. Chapter 4 exposes the importance of fossil fuels in Vietnam's carbon emissions, looking both at the past history and future net-zero scenarios. Chapter 5 summarizes that the role of LNG in Vietnam's energy system is now more limited than thought three years ago construction in 2022.

[4] Nguyen Thi Thanh Huyen, "Infographic Social-Economic Situation 4th Quarter and 2022," General Statistics Office of Vietnam, December 2022.

[5] Directorate-General for Communication, "EU Action to Address the Energy Crisis," 2022.

[6] IEA, "Global Energy Review: CO2 Emissions in 2021" (International Energy Agency, March 2022).

[7] Jongrim Ha, Ayhan Kose, and Franziska Ohnsorge, "One-Stop Source: A Global Database of Inflation," Text/HTML, Policy Research Working Paper (Washington, DC: World Bank, 2021).

Figure 2: Thi Vai terminal, the first faclity to import LNG in Vietnam

Source: Google Earth

2 Global market trends of fossil fuels

2.1. Liquefied natural gas (LNG)

Natural gas can be traded internationally in two ways: compressed in a pipeline or liquefied in a ship. There is no pipeline connecting Vietnam to large oil or gas producing country, so the practical option is to import LNG by ship. This requires dedicated portuary facilities (see Figure 2) to dock the ship, re-gasify the LNG and store it. The gas can then be used to make electricity, fertilizers or other products, on site or remotely via a domestic pipeline. The gasification, storage and generation infrastructure can be built as fixed onshore units, or leased as floating units.

Compared to domestic gas, the price of imported gas is higher on average and much more uncertain. Traditionally, LNG was sourced using long term contracts, indexed on the cost of oil. In 2015-2019, a growing share of natural gas trade was contracted on short term, spot markets, but players tend to return towards using long-term contracts since 2020[8].

In spot markets, prices are very sensitive to competition, anticipations, and speculation. In 2022, it was difficult to find long term supply contracts for natural gas at prices comparable to pre-crisis levels for delivery before 2026. On the spot market, the Japan-Korea Marker gas price peaked ten times higher in 2022 than at its lowest point in spring 2020. Electricity made from imported LNG is subject to costs swings driven by international markets. Volatility would be larger if the gas was sourced on the spot market than by long-term contracts.

The war in Europe changed the natural gas market in several ways. As Germany and Europe practically stopped importing Russian gas by pipeline, they turned to the LNG market. The US is the world's largest producer of natural gas, before Russia. To export, the US has to build liquefaction plants. As of August 2022, all of them are located in the East coast, oriented to export towards Europe (Source: IEA). The only liquefaction on the West coast of North America, the Costa Azul LNG terminal in Mexico, is not competitive with Middle East and Indonesia for the Asian markets.

According to EVN's letter 1479/TB-EVN published on March 27th, 2022 on electricity supply capacity until 2025, we have plenty of operational renewable electricity sources in the Southeast region, so domestic gas turbines there will run about ~1500-2500 hours/year in 2022-2023, i.e. only 17% to 28% of the time. Such low capacity factors would make it difficult to convince an investor to build a new gas power plant. That number may climb in 2024-2025 if new renewable energy sources do not meet the new electricity demand. But what will be the price to import natural gas then? The world's gas production cannot

[8] IEA, "Gas Market Report, Q4-2022 Including Global Gas Security Review 2022" (International Energy Agency, October 2022).

expand fast enough. Since the war broke out, Europe has competed with Asia to buy all the gas America can produce. When Germany and Japan bid, middle-income countries at the table find it hard to follow. To ensure sufficient electricity supply in 2025, EVN recommends to add 4000 MW of wind power and 1500 MW of solar power with appropriate storage systems in the Northern region.

Imported natural gas is too pricey to be used as the backbone of an electric system. Economics prescribe using it preferably to supplement renewable energy sources. Gas turbines are suitable for following the electricity load and answering demand peaks. Even there, as energy storage technology develops, the price competitivity of gas is questionable at the 10-years time horizon. Build too many regasification and storage terminals, and some will sit empty when the gas prices are high. The MOIT wisely reduced the dependence on imported natural gas in the latest iterations of the PDP8 drafts. To add more flexibility to the strategy, we can consider Leasing instead of Building. It is time to pay more attention to floating regasification, storage and power generation solutions.

In addition to grey hydrogen production, in the short term, Vietnam will have two more green hydrogen production plants proposed by foreign investors to the government, creating a premise for the green hydrogen industry and reducing dependence on imports.

2.2. Coal prices also increased

Figure 3 shows the history of international coal price. Between 2009 and mid 2020 it evolved in a band between 50 and 130 USD/t. It started to increase post Covid, reaching about 400 USD/t by mid 2022. The consequences are immediate. According to the Vietnam Customs[9], the imports of coal in the first half of 2022 fell down by 15.1% compared to 2021, but the total cost increased by 135.8% to 4.32 billion USD. See Table 1 for the whole year 2022 statistics.

Table 1: Statistics of fossil fuels imports in Vietnam for 2022

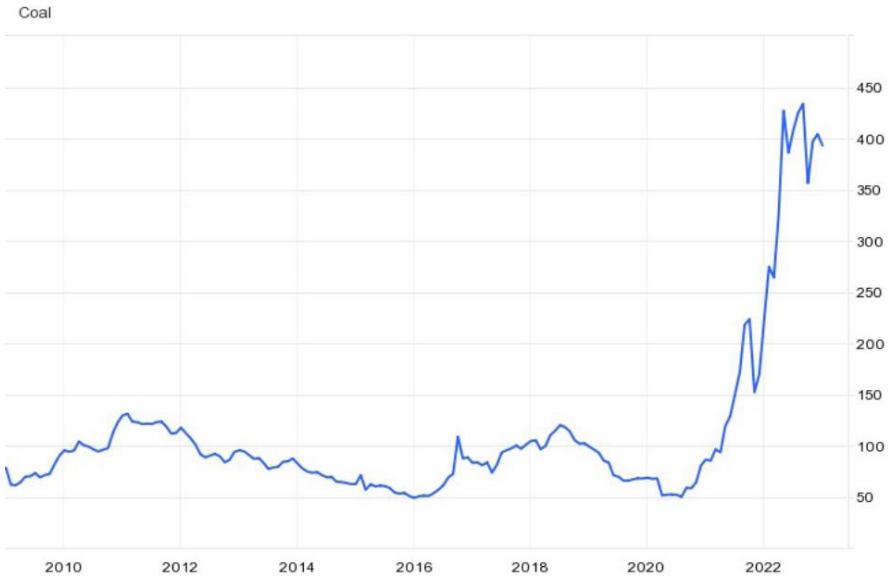
Main import	Volume		Value	
	Ton	change % 2021	USD	change % 2021
Coal	31 973 881	-12.1	7 164 216 794	+60.2
Crude oil	10 202 348	+1.6	7 810 461 648	+50.1
Petroleum products	8 874 959	+27.7	8 968 876 565	+118.5
Liquefied petroleum gases	1 965 257	-0.3	1 538 454 885	+12.2

Source: GSO table 2N/TCHQ Preliminary, accessed 2023-01-13

The cost increase is higher in VND terms, since the US Dollar continuously appreciated against the Vietnamese Dong in the first eleven months of 2022. The dollar year low was at 22,635 VND in late January, peaking at 24,900 VND in late November. As of January 12th, the dollar is down again to 23,600 VND, only up by 3.23% compared to one year ago.

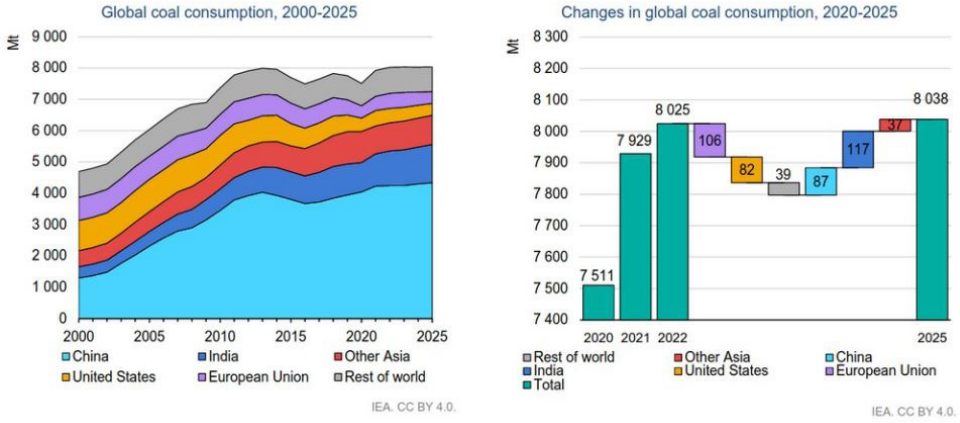
[9] General Department of Customs, "Statistics of Main Imports by Month," July 7, 2022.

Figure 3: Coal prices increased from about $100-per-tonne in 2019 to $400-per-tonne in 2022 (Newcastle coal future benchmark)



Source: Tradingeconomics, accessed 2023-01-10

Figure 4: Global coal consumption by region, 2000-2022 with projected changes to 2025



Source: IEA, Coal 2022 report, p.12

Approximately half of Vietnam's electricity comes from coal-fired power plants, and about half of the coal used in Vietnam is imported. At 400 USD/t of coal, the cost of produced electricity is way above the electricity retail price. Nguyen Duc Ninh, Director of the National Load Dispatch Center (A0), said[10] that the lack of coal for power production in March and April had affected the power system, adding the unmobilised coal-fired power capacity was up to 3,000-4,000 MW. He added that "The average retail price of electricity according to current regulations was 1,864 VND per kWh, but the variable price of power plants was more than 2,000 VND per kWh, even totalling up to nearly 4,000 VND each.".

[10] E. I. N. News, "Losses of More than VND31 Trillion Mean EVN May Increase Electricity Prices," EIN News, December 24, 2022.

Deputy EVN's General Director Nguyen Tai Anh, reviewing 2022[11], noted: "The retail price of electricity has been kept stable for nearly four years, while the price of fuel for electricity production and the exchange rate have both increased sharply." He said it made it difficult for EVN to balance its finances, and that the company suffered heavy losses in 2022. EVN estimates its 2022 losses to 31 trillion VND (out of a total annual revenue of 460 trillion VND), that is approximately 1.3 billion USD.

The global consumption of coal stagnated over the last ten years to about 8000 Mt per year. As Figure 4 shows, it dipped in 2020 with the Covid crisis and then rebounded strongly in 2021. The demand was even stronger in 2022. A cold winter, a hot summer and strong economic recovery led to high electricity demand, and with high prices of natural gas (see Figure 1) many generators ran the coal-fired power plants more. Although the international price of coal increased as much as the price of gas during this energy crisis, see Figure 3, coal was in 2022 a comparably cheaper source of energy than gas if one does not account for the environmental externalities.

However, Figure 4 also shows that the International Energy Agency forecasts that the 2021-2022 bounce in coal consumption will be followed by slow growth. This is based on the market anticipations embodied expressed through forward prices.

In terms of market fundamentals, the future of coal will be driven by China, which accounts for more than half of the world's coal demand, with India being the other important player in the market. In April 2021, President Xi Jinping announced that China would strictly limit the increase of coal consumption in 2021-2025. That year permitting new power plants was essentially frozen. However, in September 2021 China experienced the global energy crisis as coal shortages and power shortages. That led to a policy shift, with 7.3 GW of new coal power plants permitted in the first six weeks of 2022.

In 2021, 45 GW of global coal power capacity was commissioned while 26.8 GW was retired, causing a net increase in the global coal fleet of 18.2 GW[12]. Half of the increase were in China, half of the retirements were in the EU. The coal fleet in Vietnam added two-thirds (14.1 GW) of its current 22.7 GW of operating coal power capacity since 2015, including 2.4 GW at three coal plants in 2021 alone[13]. A further 6.8 GW is under construction. Of the 20.1 GW at the preconstruction stage, only a quarter (5 GW) of the capacity is permitted. No new permits were granted in Vietnam in 2021. Following the November 2021 COP26 announcement of the net-zero by 2050 target, new permits are unlikely to be issued, and the Government asked to explore the conversion of already permitted plants to gas power projects.

2.3. High fossil fuel prices to remain high

The international coal and LNG markets changed deeply in 2022. The prices are still very much correlated since thermal coal and LNG are substitute for electricity generation, but Russia has lost its spot in the top-three exporting countries. In January 2023, prices remained higher than they were before the Covid crisis, see Figure 1 and Figure 3.

[11] E. I. N. News, "Losses of More than VNĐ31 Trillion Mean EVN May Increase Electricity Prices," EIN News, December 24, 2022.

[12] Global Energy Monitor et al., "Boom And Bust Coal 2022," April 25, 2022.

[13] Monitor et al.

Fossil fuels are very much like other commodities or stocks: analysts spend lots of efforts to understand their future prices, but that effort yield little robust predictive knowledge. Deep uncertainty and surprises are the norm. Within these predictability limits, we argue that two forces are pushing the market prices to remain relatively high in the forthcoming three years: geopolitical uncertainty and climate policy.

- Geopolitical uncertainty: After the Covid crisis dip, crude oil prices bounced back to over $100 per barrel during the strong recovery year 2021. The Russia-Ukraine war dashed any expectations for a return to pre-crisis levels. Oil and gas exports from Iran and Russia are facing serious political constraints. The US shale oil industry shows capital discipline, restraining its expansion speed. Thus, the crude oil market remains driven by the OPEC+ cartel, which has interest to keep prices high.
- Climate policy: From a physical perspective, no new fossil fuel infrastructure is admissible. The amount of carbon in fossil fuel reserves already in exploitation exceeds what is compatible with a 1.5°C global warming[14]. The economic perspective is more nuanced: as more severe climate policies bear on the use of fossil fuels, opening new fields and mines becomes less profitable. This is why capital is moving towards other industries, and the oil and gas companies consistently under-performed other economic sectors on the stock market during the last 15 years. Less investment in production capacities means less supply, translating into higher prices.

For coal, the IEA[15] expects the global production to start declining after 2023, against a stable global demand. Fundamentals thus imply a seller's market with prices on the high side. Examining the prices expections revealed by the forward price curve of coal deliveries to Europe, the IEA (idem, p.85) notes that swap prices for coal in 2025 were at 281 USD/t in mid-September, falling to 167 USD/t in mid-November. The Agency concludes that "Coal markets are expected to remain tight for the foreseeable future.".

The LNG market is supply-constrained, and will remain so until 2026 as additional liquefaction facilities only started being build in 2022. For 2023, the AIE[16] expects that "LNG export growth continues at around 4% thanks to the anticipated return to full production of the 20 bcm Freeport LNG terminal in Texas, despite a marked slowdown in new liquefaction capacity additions in 2023.".

Bloomberg[17] expects the global LNG market "to be tight over 2022-26 as Europe's quest to reduce its dependency on Russian gas increases demand for LNG. This will curb gas demand growth in China and emerging Asia as the European market outbids these buyers for the limited amount of flexible LNG supply.".

High fossil fuels prices drive inflation. GSO states that[18] on average, in 2022, the consumer price index (CPI) increased by 3.15% compared to the average in 2021, first because

[14] Kjell Kühne et al., "'Carbon Bombs' - Mapping Key Fossil Fuel Projects," Energy Policy, May 12, 2022, 112950.

[15] IEA, "Coal 2022 – Analysis" (International Energy Agency, December 2022).

[16] IEA, "Gas Market Report, Q4-2022 Including Global Gas Security Review 2022."

[17] Bloomberg, "Global LNG Outlook Overview: Tight Supply Expected until 2026 | Insights," Bloomberg Professional Services, June 29, 2022, sec. Commodities.

[18] Nguyen Thi Thanh Huyen, "Consumer Price Index, Gold and USD Price Indexes in May of 2022" General Statistics Office of Vietnam, May 29, 2022

domestic gasoline prices increased by 28.01% over the previous year (making the overall CPI increase by 1.01% points), gas prices by 11.49% (making the overall CPI increase by 0.17%). The core inflation, which is the CPI increase excluding energy and food, was only 2.59%.

Besides transport, increasing energy prices impact other sectors of Vietnam's economy. Oil and gas are used to make fertilizers – therefore impact food. Chemicals, iron and steel, cement, pulp and paper, and aluminum are energy-intensive industry. Last but not least, if a country relies on imported coal and gas to produce its electricity, high fuel costs can translate into high electricity costs (Figure 18 shows this did happen in many countries in 2022, if not in Vietnam).

This is what Vietnam plans to do – import fuels. According to the current Power Development Plan, 23 GW of gas-to-power generation capacity are authorized to be build between now and 2030. Figure 2 illustrates the first liquefied natural gas import facility being constructed in Thi Vai, to feed the new Nhon Trach 3 & 4 power plants.

In 2019, the Bac Lieu LNG power project was added to the Masterplan after its investors proposed to sell electricity at 7 UScent/kWh. This figure now appears too optimistic. The problem is, for an LNG power plant to sell electricity at the price of 8 - 9 UScent/kWh, the input LNG price must be around 12 USD/mmbtu. If the LNG price is up to 40 - 50 USD/mmbtu, then the electricity selling price cannot be below 20 UScent/kWh. EVN will only buy very limited quantities at that price[19].

The Bac Lieu LNG project was built on a 2 mtpa per year, 20 year Sales and Purchase Agreement between project developer Delta Offshore Energy and LNG supplier Magnolia Energy from Lousiana. In 2020 that company went in financial distress, and Delta announced that it would not be renewing the Memorandum of Understanding.

Even signed and running long term LNG supply agreements can be fragile. The case of Pakistan illustrates this risk. In 2017 the country signed two large LNG supply agreements for around 12 USD/mmbtu: one cargo per month for 5 years with Gunwor and one cargo per month for 15 years with ENI. When the spot price bottomed out in 2020, Pakistan was thinking about canceling the deals to get a better price elsewhere[20]. Tables turned two years later. As the breakup penalty was 30% of the agreed low price and the seller could find clients elsewhere willing to pay a much higher price, ENI and Gunwor started to regularly canceled cargoes to Pakistan in mid 2021. That threw Pakistan in a deep energy and economic crisis.

LNG delivered to Asia costs around 20 USD/mmbtu in the summer of 2022. The economic conditions are the same for all private companies holding LNG to power projects authorized to build in Vietnam. They will not invest unless they get reasonable perspective to make profits. With the high costs of LNG, projects will be delayed.

[19] Nguyễn Huy Hoạch, "Giá LNG tăng cao và vấn đề phát triển nguồn điện khí ở Việt Nam," Năng lượng Việt Nam Online, March 29, 2022.

[20] Stephen Stapczynski and Faseeh Mangi, "Pakistan LNG Mulls Nixing Eni, Gunvor Deals Amid Cheaper Options," BNN Bloomberg News, February 25, 2020.

2.4. Renewable electricity avoids fuel costs, but has system costs

This is not the first time that a generation of thermal power projects get delayed in Vietnam. This was already the case a few years ago[21]. The policy response to avoid power shortage was to install renewable energy sources. Figure 5 illustrates that story. The Vinh Tan power centre was initially planned with four projects. The photo shows that only three out of four projects are build. The second lot from the left is empty (see red marker with a star). This is the Vinh Tan 3 project, a 1,980 MW plant scheduled to connect in 2018. The main investor One Energy (Hong Kong) withdrew, and in February 2021 investor Mitsubishi also quit. Now the site is surrounded by solar farms (see all blue markers with a dot).

In 2017, Decision 11 kickstarted the renewable electricity sector in Vietnam by giving a feed-in tariff of 9.35 UScent/kWh to solar projects. In 2020 Decision 13 reduced this to 7.09 UScent/kWh, still offering a tariff of 8.38 UScent/kWh for rooftop solar power projects. In 2018, Decision 39 promulgated a tariff of 8.5 UScent/kWh for onshore wind power projects, and 9.8 UScent/kWh for offshore. That led to a rush of new capacity installation, mostly by private investors.

These prices are not sustainable for EVN's balance sheet. The average retail electricity price in Vietnam is equivalent to 8.3 UScent/kWh according to Decision 648/QD-BCT from 2019. A company cannot survive long-term if sells retail for less than it buys wholesale! Fortunately, the costs for the next wave of solar and wind farms in Vietnam are likely going to be lower. Even if the price of PV modules and wind turbines are not declining as fast as they used to, due to general inflation in materials and shipping costs, compared to 2017-2018 the sector is mature in Vietnam, and the industry has made five years of technical progress. According to IRENA[22], "the global weightedaverage levelized cost of electricity of onshore wind fell 56% between 2010 and 2020, from USD 0.089/kWh in 2010 to USD 0.039/kWh in 2020" and "the global weighted-average levelized cost of electricity for utilityscale PV projects fell by 85% between 2010 and 2020.".

Moreover, the costs of renewable electricity in Vietnam will be lower than the numbers seen so far because the procurement mechanisms will be market-based: competitive auctions and direct power purchase agreement. The results of recent solar and wind auctions in most other countries are way lower than the FIT given in Vietnam in 2017-2020. For example, PV auctions lowest bids around 1.3 UScent/kWh have been seen in Abu Dhabi, in Portugal and in Chile.

The answer is no. To sum up so far, solar and wind farms can be installed in one-two years and do not have fuel bills, making them cheaper to use in the long run than thermal power plants. They require more upfront capital, but this capital does not have to come from the Government's budget. Most renewable generation capacity in Vietnam was from private capital. Is the energy transition problem solved then?

[21] Hoàng Quốc Vượng, "Report 58/2019/BC-BCT on the Progress of Implementing Some Key Power Source Projects in PDP VII Revised - Tình Hình Thực Hiện Các Dự Án Điện Trong Quy Hoạch Điện VII Điều Chỉnh" (MOIT, EREA, June 4, 2019).

[22] IRENA, "Renewable Technology Innovation Indicators: Mapping Progress in Costs, Patents and Standards" (Abu Dhabi: International Renewable Energy Agency, March 2022).

Mobilizing private capital to install renewable power generation sources solves only half of the problem. Developing a reliable electricity system requires much more than building plenty of renewable-based generation capacities. It requires a) sufficient transmission and distribution networks, b) backup capacities for the times when the renewable power sources are not available, and c) flexibility solutions to compensate for the short-term variability of solar and wind (for more detailed discussion of the constraints on renewable power, see[23, 24]). Up to 2022, the transmission problem was the most urgent: many new solar and wind farms had to reduce production because the grid could not deliver it to customers. The existing hydro and natural gas power plants provided for backup capacity and flexibility. These would not be enough if solar and wind power generation expand much. Before discussing who will pay for these investments, let us see if they can be avoided.

Figure 5: A partially completed coal power center surrounded by new solar farms in Tuy Phong, Binh Thuan, Vietnam

Source: Google Earth

[23] Minh Ha-Duong et al., "Planning, Policy and Integration for Sustainable Development of Offshore Wind Energy in Vietnam 2022 - 2030," in Vietnam Symposium on Advances in Offshore Engineering (VSOE2021), vol. 208, Lecture Notes in Civil Engineering (Springer, 2022), 48–66.

[24] Minh Ha-Duong, "On Technology Transfer and Utility-Scale Power Storage," IAEE Energy Forum 30, no. Fourth quarter (October 1, 2021): 30–31.

3 Vietnam passed peak oil, can defer peak gas

3.1. Reserves and exploration

Before 1975, in the Southern continental shelf, there were search activities by foreign oil and gas companies, the most typical of which was the US oil company Mobil, which held exploration in the Bach Ho area since 1971. In October 1974, Mobil company drilled Bach Ho field, at block 04-TLD, found oil at a depth of over 2.7 km. They also identified potential in Thanh Long and Dai Hung areas. Marathon and Union Texas decided to drill oil wells in late 1974; Esso and Sunningdale companies in April 1975. By the end of 1975, at least 20 rigs were expected to be built.

According to those plans, the preparation for exploitation would take at least a few years and it was expected that the first oil would be produced in 1977. Foreign oil companies proposed to the Government of the Republic of Vietnam two points: first, let the company dig right away without having to go through bidding and administrative procedures; secondly, the revenue from oil extraction will be divided split evenly: half to these companies, half to the Republic of Vietnam[25]. However, the government of the Republic of Vietnam collapsed in mid-1975 and American companies had to leave without any projects being implemented.

After 1981, these oil fields were managed and exploited by the Vietsovpetro Joint Venture of Vietnam and the Soviet Union. After nearly 3 years of preparation, on December 25, 1983, the ship Mikhain Mirchink drilled the first exploration well BH-5 at Bach Ho field. Vietnamese and Soviet experts aboard this ship confirmed the oil field practicability in Spring 1984. On June 26, 1986, the Vietsovpetro Petroleum Joint Venture Enterprise exploited the first ton of oil from the Bach Ho field, marking the beginning of Vietnam's crude oil exploitation in the southern continental shelf.

The more recent history of oil and gas prospection in Vietnam is divided into three periods:

i. From 2000 onwards mainly deployed in 4 sedimentary basins Song Hong, Cuu Long, Nam Con Son and Malay - Tho Chu;

ii. After 2000 this work was extended to the deep-water areas far from the shore such as Phu Khanh, the Southeast of Con Son and Tu Chinh - Vung May;

iii. Since 2010 up to now, exploration activities have been carried out in deep water and offshore areas such as 2D and 3D seismic survey activities in the East of Phu Khanh Basin, East of Nam Con Son Basin and Tu Chinh - Vung May. Especially in this period, for the first time, the oil and gas industry conducted deep water drilling in Blocks 129-132, 04-1, 05-2/10 and 136.

[25] Nguyen Tien Hung. 2005. "When Allies Run," volume 2, p. 49

Up to now, the volume of oil and gas search and exploration in the sea and continental shelf of Vietnam has reached over 600,000 km of 2D seismic routes, about 100,000 km² of 3D geology and nearly 1,000 drilled wells, concentrated mainly in Cuu Long, Nam Con Son, Red River and Malay - Tho Chu areas. In addition, the Oil and Gas Group has coordinated activities in geological survey of Vietnam, the Philippines and China in the Truong Sa area, or bilateral cooperation between Vietnam and China in the agreed area in the North Gulf.

According to the assessment of the Vietnam Oil and Gas Group (PVN)[26] , the total oil and gas reserves discovered on the continental shelf of Vietnam are about over 1.5 billion m³ of oil, including about 734 million m³ of oil and condensate and 798 billion m³ of gas. The reserves being exploited are mainly in the Cuu Long, Nam Con Son, Song Hong and Malay-Tho Chu basins[27], see Figure 6.

Although from 2010 up to now, search and exploration activities have made their initial steps in deep water and offshore areas such as seismic survey activities in the east of Phu Khanh basin, east of Nam Con Son basin and Tu Chinh - Vung May. However, such explorations require high technology, complicated construction conditions and the necessary cooperation with foreign oil and gas companies.

In addition to the areas where oil and gas have been discovered, in the sedimentary basins on the continental shelf and the exclusive economic zone of Vietnam, there are many unexplored structures with the potential to recover from 1.5-2.5 billion m³ of oil, of which the deep, offshore and complex water area accounts for about 50%, which is distributed as follows: Cuu Long basin (9%), Red River (20%), Malay - Tho Chu (3%), Phu Quoc (2%), Nam Con Son (15%), Phu Khanh (16%), Tu Chinh - Vung May (32%), Hoang Sa (5%). Exploiting the potential of these structures is complicated and difficult to actively implement.

In 2017, PVN's oil production output was 25 Mt, but search and exploration increased reserves by only 4 Mt. In the first eight months of 2018, search and exploration activities only added 2 Mt to reserves. As the imbalance between exploration and exploitation continues, the production of the oil and gas industry can only decline in the future[28].

In the short run, the price of fossil fuels is driven by the balance production and demand. In the long run, production is driven by the transformation of geological mineral resources into economically exploitable reserves, a transformation permitted by investment in exploration and production. In theory, high prices lead companies to increase search and exploration, driving down the market price towards the long-run equilibrium. This is not what happened after the pandemics. In spite of high prices, major oil and gas companies are not replacing their reserves in the face of market uncertainty, a looming

[26] Nguyen Hoan. 2021. "Petrovietnam exploration and production activities offshore Vietnam: Situation and solutions", accessed 12/04/2022.

[27] Vietnam Oil and Gas Group. Oil and gas exploration and production: Need for appropriate mechanisms and policies . 2021.

[28] Le Phuong. 2018. "The oil and gas industry faces many challenges", access July 5th, 2022

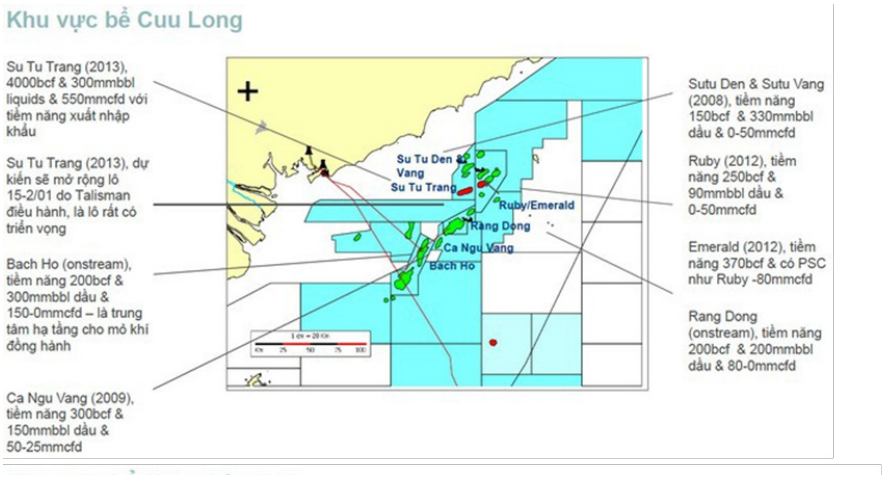
recession[29]. For example, American companies in the shale gas extraction business have been slow to increase investment post pandemic even as the demand increased – the so-called "capital discipline". Some shareholders may anticipate that Europe's appetite for LNG could be short-lived, as the block strives to be the first carbon-neutral continent.

On top of this general background, history shows that offshore oil and gas production Vietnam is a high risk investment for occidental companies. The hundreds of million dollars spend for the Block B and Blue Whale projects have not resulted in profitable returns. Russian oil companies, which have been another traditional partner of PVN, have their own financial and technology trouble with the western embargo and sanctions.

Table 2: Current oil and gas production in Vietnam

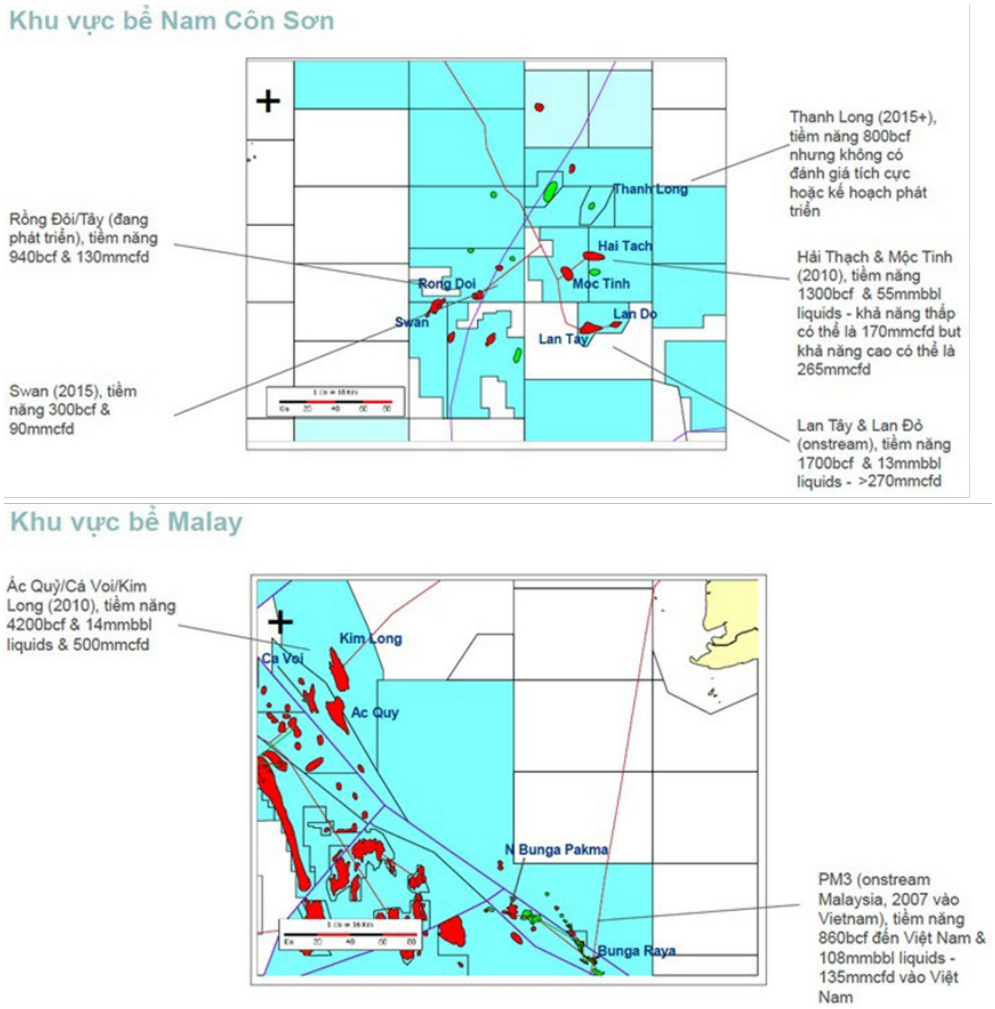
Mine/Main Lot Name	Basin area	Crude oil/gas	Production (temporary)
Bach Ho	Cuu Long	Oil	263,000 barrels/day
Te Giac Trang	Cuu Long	Oil and Gas	100,000 barrels/day 0.3 billion m^3
Su Tu Den	Cuu Long	Oil and Gas	82,000 barrels/day
Lan Tay	Nam Con Son	Gas & Condensate	4.4 billion m^3
Lan Đo	Nam Con Son	Gas & Condensate	1.7 billion m^3
Junin 2	Venezuela	Oilfield	200,000 barrels/day
Dung Quat (BSR)	Quang Ngai	Refined from crude oil	148,000 barrels/day

Figure 6: Vietnam oil and gas production areas



[29] Aatisha Mahajan, "Global Oil and Gas Exploration Shrinks as Companies Shift Focus to Lower-Risk Core Assets and Regions," Rystad Energy, September 7, 2022.

Figure 6: Vietnam oil and gas production areas (continued)



3.2. Crude oil production has peaked

According to statistics of the PVN from 2015 to now, domestic oil production has continuously decreased, from 16.9 Mt in 2015; down to 15.2 Mt in 2016; 13.4 Mt in 2017; 12 Mt in 2018; 11 Mt in 2019; 9.7 Mt 2020. The cause of this situation is that most of the oil and gas fields being exploited in our country have been put into operation in the period from 1986 to 2015 (Table 2). The largest fields, which have the main contribution to the output, have been exploited for 15-35 years. They are in the final stage of mining, the water level is high and continues to increase continuously over time. The average inundation of these fields is now at 50% - 90%, leading to a natural decrease in output of about 15% - 25%/year.

At the aggregate level, data from the General Statistics Office in Figure 7 shows that in the period 1995 - 2020, Vietnam has exploited a total of 395.5 Mt of oil, equivalent to about 67.35% of the discovered reserves. The annual exploitation output decreased continuously in the period 2015- 2020. This is also the period when the number of newly signed oil and gas contracts decreased significantly (only 6 contracts). If calculated according to the average rate of exploitation over the past 25 years, about 15 Mt/year, it will only take about

13 years for Vietnam to fully exploit the discovered oil reserves. With no new developments, the output of crude oil will be 4.1 billion barrels in 2025 and 3.8 billion barrels in 2030.

Figure 7: Crude oil production in Vietnam, 1995-2020

Source: General Statistics Office, 2022

From a trade perspective, crude oil exports peaked in 2004 at 388,600 barrels/month, and by 2016 had decreased to 148,900 barrels/month. Vietnam started being a net crude oil importer from 2018. Currently, Kuwait is the leading crude oil exporter to Vietnam, mainly for the Nghi Son refinery. Other crude oil sources are the US and Russia. Previously, Vietnam imported crude oil for Binh Son Refinery and Petrochemical (Dung Quat) from Azerbaijan, Brunei, Australia, Malaysia & Myanmar (about 5 million barrels in 2020), and from US WTI & Nigeria Bonny Light (10 million barrels in 2020).

The search, exploration and discovery of oil and gas fields in the past 10 years has been mainly small-scale with increasing risks. The problem of small-scale fields here is that low profit margins make contractors reluctant to develop, along with incentive policies and investment policies have not been improved much, so oil and gas is no longer an attractive investment field as in the period before 2010. In the period from the beginning of 2016 to the end of 2020, with the influence of world oil prices continuously moving at a low level, the number of new contracts signed has decreased. Only 6 contracts were signed, of which there was only 1 oil and gas contract with foreign countries, Murphy Oil[30].

As near-shore fields exhaust, exploration has to search for fields to in deep water areas, far from the shore. Deep offshore fields are inherently more difficult and expensive to produce. Moreover, some may raise geopolitical issues, like the Blue Whale field. Historically, the Petrovietnam had joined efforts with foreign companies[31] for search and exploration because of limited financial resources. However, nowadays the international oil and gas industry is allocating less and less capital to exploration. Aatisha Mahajan, vice president of analysis, Rystad Energy, stated[32] for example "Global exploration activity has been on a

[30] Mr. Nguyen/BNEWS/VNA. 2021. "Completing institutions to 'untie' oil and gas activities".

[31] Le Viet Trung and Pham Van Chat, "Tổng Quan về Ngành Công Nghiệp Dầu Khí Việt Nam," Petrovietnam Journal 4 (2016): 56–64. section 2.1.

[32] Aatisha Mahajan, "Global Oil and Gas Exploration Shrinks as Companies Shift Focus to Lower-Risk Core Assets and Regions."

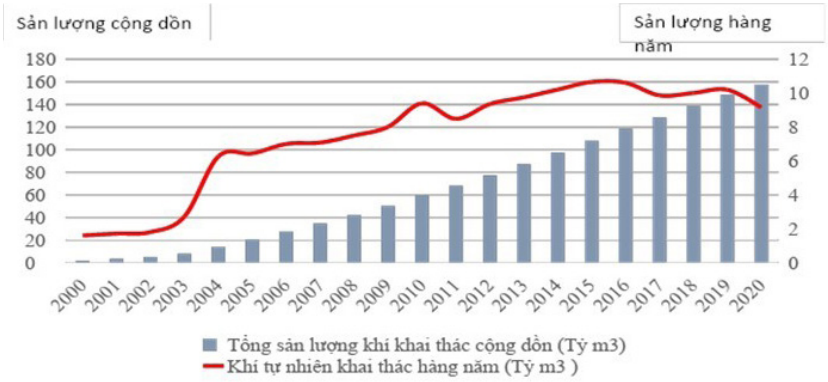
downward trend in recent years, even before the Covid-19 pandemic and oil market crash, and that looks set to continue this year and beyond. It is clear that oil and gas companies are unwilling to take on the increased risk associated with new exploration or exploration in environmentally or politically sensitive areas."

3.3. Reserves may allow to defer the natural gas peak

Natural gas exploitation in Vietnam started after the first gas field was discovered at Tien Hai C field in 1975, in July 1981. However, it was only after 1995 that gas production had a significant industrial scale with the collection of associated gas from fields in the Cuu Long basin and then from natural gas fields in the Nam Con Son basin associated gas in the Malay-Tho Chu basin offshore the East and Southwest regions.

In 2020, the average gas extraction rate is 10 billion m³/year. Gas is mainly exploited in fields of 2 basins Nam Con Son, and Cuu Long. Potential reservoirs are the Red River (SH) and the Malay-Tho Chu. Exploited gas mainly supplies thermal power plants in the South (about 8 billion m³/year), with gas power output accounting for 9.7% of the total primary power source (2018). Currently, there are 48 gas fields under exploitation and 15 fields under development plan. Large fields include Bach Ho (since 1986, accounting for 60% of total crude oil production at present), Lan Tay-Lan Do (2002), Rong Doi (2006), Hai Thach-Moc Tinh (2013), and the VietnamMalaysia PM3-CAA overlap region (2007). The main foreign companies that have product sharing contracts (PSCs) with PVN are Gazprom, Rosneft, Mitsui, METI, KNOC, PTTEP and ONGC.

Figure 8: Gas production in Vietnam, 2000-2020



Source: General Statistics Office, 2022, op. cit.

In the period 2000-2020, Vietnam has exploited a total of 157.8 billion m³ of gas, equivalent to nearly 20% of the discovered gas reserves. At current exploitation rate, the untapped potential gas volume will be 657 billion m³ in 2025 and 554 billion m³ in 2030. There is potential to continue natural gas extraction in Vietnam. Although some existing domestic gas fields are declining rapidly (Lan Tay/Lan Do, Rong Doi...), untapped fields which could make up for them include: Ca Voi Xanh field, lot B 48/95&52/97, Ca Rong Do field and the Ken Bau gas field discovered in 2020.

As Figure 8 shows, it is too early to conclude about Vietnam's natural gas peak. The realization of more geological potential into increased natural output depends on three

offshore gas projects (Blue Whale, Ken Bau, and Block B) which have not reached final investment decision by July 2022. The exploitation of these gas sources is currently facing many difficulties due to their large scale, high investment capital, difficulties in trade negotiations and capital arrangement.

In the future, the reduction of gas mobilization for power generation will affect the exploitation of gas at offshore fields since 80% of total gas production is currently consumed by the gas power industry. As renewable energy sources get priority dispatch due to their zero marginal cost, the natural gas power plants get to run fewer hours per year. According to the Industrial Production Index in December 2021 of the General Statistics Office, in 2021 the electricity production and distribution industry will increase by 5.24%; in contrast, mining decreased by 6.21% as crude oil production fell by 5.7% and natural gas decreased by 19.4%.

3.4. Domestic coal production does not meet the demand

Coal production in Vietnam is dominated by the state-owned entreprise Vinacomin. According to the General Statistics Office of Vietnam[33], in 2020 the state owned companies produced 44 023 kt of coal, non-state owned Vietnamese companies produced 4 349 kt of coal, 10 times less, and the foreign invested sector produced a negligible 5 kt of coal.

After a rapid export-driven expansion phase between 2000 and 2007, the coal output remained stable hovering above the 40 000 kt/yr line. Imports started in 2015 and are now larger than domestic production.

In recent years, EVN has bough a bit less 20 000 kt/yr from Vinacomin. As both companies are state-owned entreprises dominating their sector, the price is not set by market competition but by negotiations coordinated by the government. When the price shown Figure 3 is low, EVN has incentives to buy from international market. When the price is high, Vinacomin has incentives to sell on international market.

Vinacomin will provide EVN with 16.91 Mt of coal in the whole of 2022, equal to 97.1% of the contract amount for the year[34]. The same source states that in 2023, Vinacomin and Northeast Corporation will supply EVN 45.89 Mt of coal, with 17.98 Mt for only EVN TPPs, by 1.5 Mt lower than the long-term coal contract.

There are many difficulties and challenges to expand domestic coal production and consumption in Vietnam. Climate change concerns have led to increasing pressure from the international community. and some provinces. At COP26, Vietnam committed to building no new coal projects beyond those already under development, and to phase out coal power in the 2040s[35]. Air quality concerns have led some provinces to ask the Governemt to remove coal-fired power plants from the Power Development Plan.

As the easy to mine reserves are exhausted, new deposits are less and less competitive.

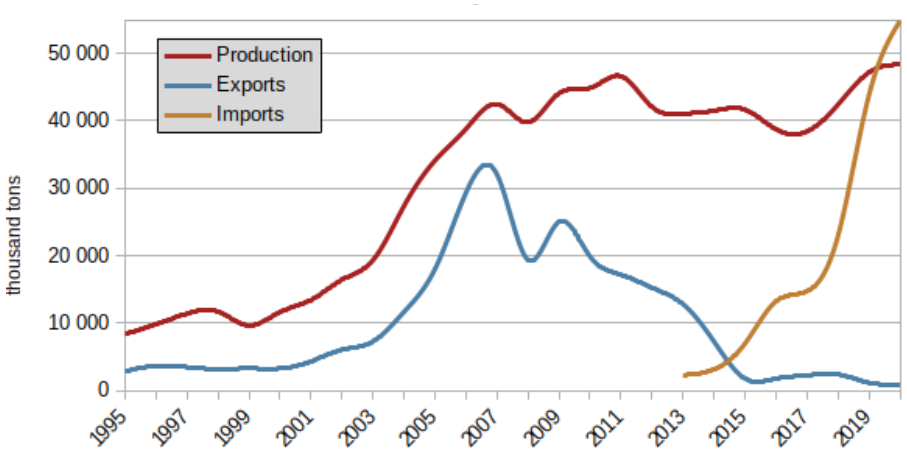
[33] General Statistics Office of Vietnam, Statistical Yearbook of Vietnam 2020 (Vietnam: Statistical Publishing House, 2021).

[34] VietnamEnergy.vn Vietnam Energy, "Vinacomin and EVN discuss solutions to supply coal for power generation in 2023," Vietnam Energy Online, December 20, 2022.

[35] Minh Ha-Duong, "COP26: Việt Nam hướng tới mục tiêu trung hòa carbon vào năm 2050," Tia Sáng, December 5, 2021.

For example, when talking about a resource of several hundred billion tons of coal in the depths of the Red River Delta, this is low grade coal discovered during oil and gas exploration at a depth of thousands of meters underground, mining conditions are extremely difficult and complicated both in terms of technology and ensure social security and environmental safety.

Figure 9: Vietnam coal production and trade



Source: GSO Yearbooks, and Vietnam Customs Office December reports

4 Fossil fuels consumption in Vietnam's carbon emissions

4.1. Energy among other factors explaining Vietnam's carbon emissions

Figure 10 shows the annual CO_2 emissions of Vietnam. The topmost plot shows that Vietnam's CO_2 emissions have been increasing exponentially since the 1990. The four smaller plots under it explain the growth in terms of Kaya factors:

$$CO_2 = Population \, x \, \frac{GDP}{Population} \, x \, \frac{Energy}{GDP} \, x \, \frac{CO_2}{Energy}$$

The factorial decomposition allows to compare the causes of CO_2 emission growth:

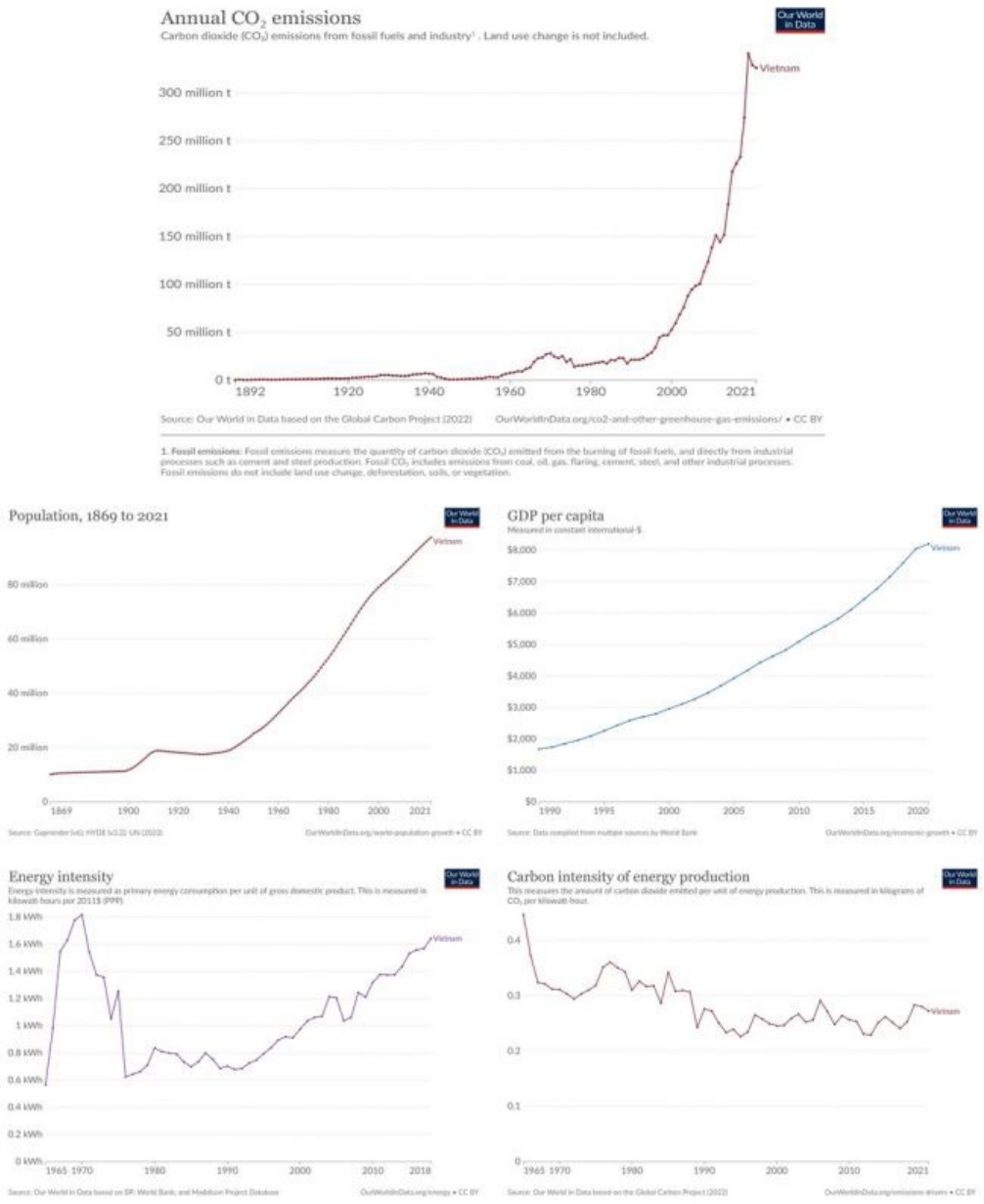
- Historically the population has been growing linearly since the middle twentieth century. Demographic growth has slowed, the population is on a trend to culminate above 110 million people by mid twenty-first century.
- The GDP per capita has been multiplied by four between 1994 and 2020, in constant international dollars, to about $8000 per capita per year in 2020. This is the largest increase of the four Kaya factors.
- The energy intensity of the economy has also doubled from about 0.7 kWh/$ in the early nineties to about 1.5 kWh/$ in 2018.
- The carbon intensity of the energy production has remained stable, slowly declining to around 2.3 $kgCO_2/kWh$.

To sum up, the increase of Vietnam's CO_2 emissions over the last generation is explained by first by Economic growth, second by an increasing energy intensity of the economy, and third by Population growth. The carbon intensity of energy production has been slowly decreasing.

That fourth factor may be surprising, considering the increasing use of coal in the primary energy supply, see the right panel on Figure 11. This is an "electricity is not energy" mental bias. Coal is used for electricity generation, and Figure 12 confirms indeed that the carbon intensity of electric energy production did increase. This intensity, also called the

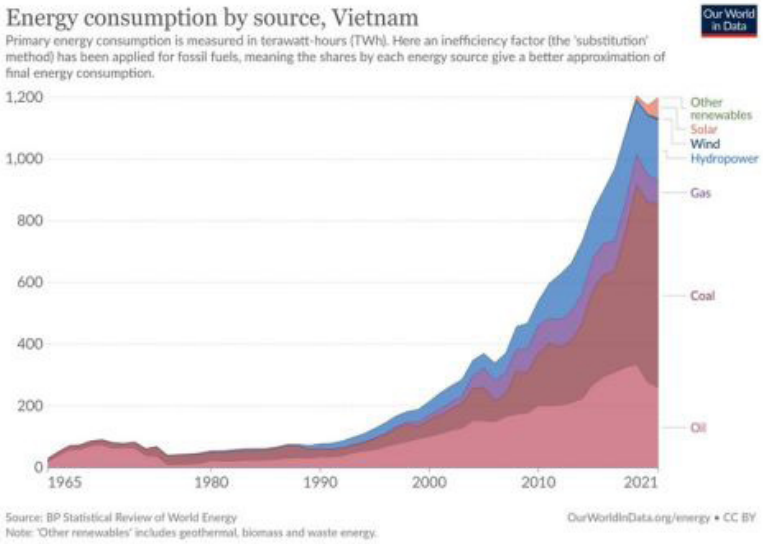
grid emission factor, grew from about 300g CO_2/kWh in 2000 to about 500g CO_2/kWh in 2021. However, the carbon intensity of energy production is the ratio of CO_2 emissions over total primary energy consumption. As the left panel on Figure 11 and Table 3 show, Vietnam's energy consumption has been increasing faster than CO_2 emissions in the period 2000 - 2022.

Figure 10: Vietnam annual fossil fuels&industry CO_2 emissions and its Kaya decomposition



Source: Our World in Data, accessed 2023-01-10

Figure 11: Vietnam's primary energy consumption by source

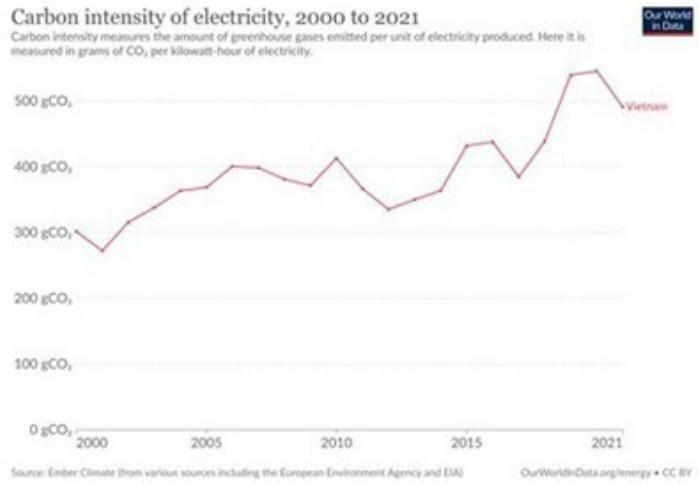


Source: Our World in Data, accessed 2023-01-10

Table 3: Variation of Vietnam's carbon intensity of energy production

	2000	2020	Variation
Annual CO_2 emissions (Mt)	53	254	+3.8
Primary energy consumption (TWh)	210	1136	+4.4
Carbon intensity of energy production (kg/kW)	0.25	0.25	-0.1

Figure 12: Vietnam's carbon intensity of electricity



Source: Our World in Data, accessed 2023-01-10

4.2. Carbon emissions from fossil fuels in Vietnam

Figure 13 shows the history of CO_2 emissions from fossil fuels in Vietnam.

In 2020 Vietnam's greenhouse gases emissions reached 254 Mt, about half of which 126 Mt came from burning coal, and a quarter (58Mt) came from burning oil. The gas sector was only responsible for 16.7 Mt emissions, far behind the cement industry 53 Mt.

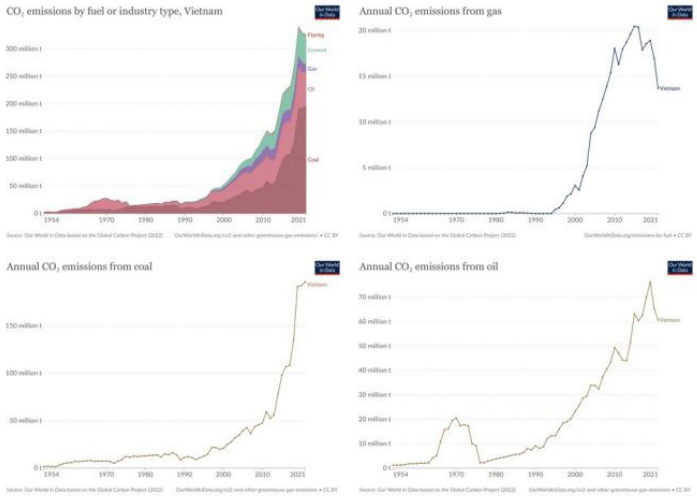
Emissions were 138 Mt in 2010, they have roughly doubled in the last ten years, the absolute increase was 115.7 Mt. Most of this increase came from coal +78.6 Mt, followed by cement +29.3 Mt and oil +9.1 Mt. Emissions from gas decreased by 1.3 Mt during the period. Emissions from coal and oil kept increasing even while domestic production was stagnant, because the country imported these fuels.

Figure 14 shows Vietnam's methane emissions by sector, in terms of $MtCO_2e$ to facilitate the comparisons. Over the 2008 – 2018 period, methane emissions increased modestly from 82.6 to 87.9 $MtCO_2e$. Emissions from the agriculture sector remained dominant but stable, the increase came first from the waste sector. Fugitive methane emissions increased from 15.9 $MtCO_2e$ to 17.6 $MtCO_2e$, while emissions from other fuel combustion decreased from 2.3 $MtCO_2e$ to 2.1 $MtCO_2e$. Accounting for leaks double the global warming impact of the natural gas sector in Vietnam. At COP26, Vietnam pledged to reduce its overall methane emissions by 30% by 2030, compared with 2020 levels.

Finally, Figure 15 shows future CO_2 emissions of Vietnam according to the updated NDC. It states that emissions from the energy sector will increase from 347 $MtCO_2e$ in 2020 to 678.4 $MtCO_2e$ in 2050 in the baseline scenario. The Plan 1 scenario is to limit the growth to 457 $MtCO_2e$. The figure shows that the energy sector is a major contributor to Vietnam's greenhouse gases emissions. Its relative weight crossed the 50% barrier in the last five years, and the trend is expected to continue.

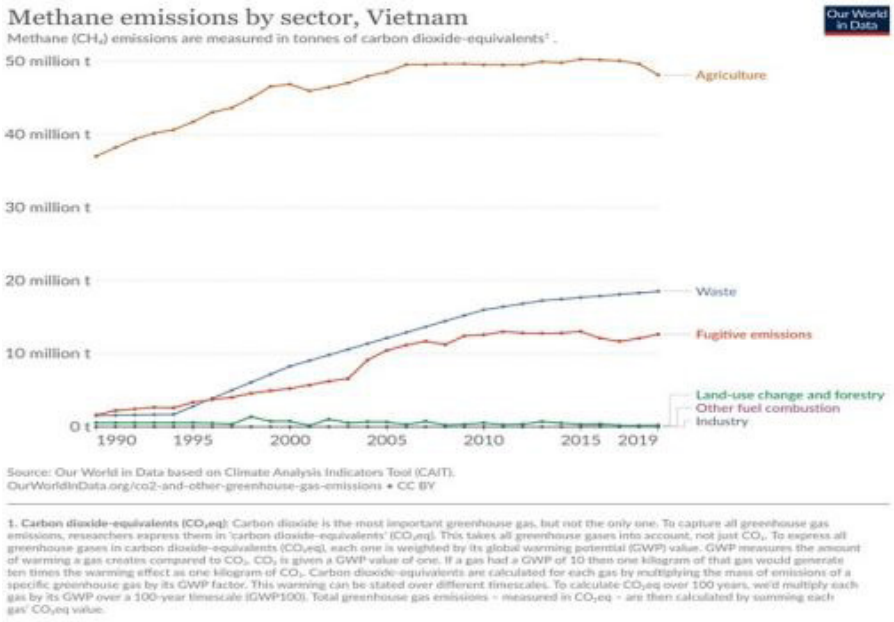
However, while these numbers belong to an official communication to the Conference of Parties to the UNFCCC, they should be approached with great caution when it comes to analyzing the dynamics of fossil fuels consumption in Vietnam. Assessments from the National Energy Masterplan, which is not available in July 2022 but under active discussion, will represent better the state of the system, the new trends after the renewable energy expansion since 2018, and the action scenarios after the adoption of the net-zero target in 2050 at COP26.

Figure 13: Annual CO_2 emissions by fuel type, Vietnam



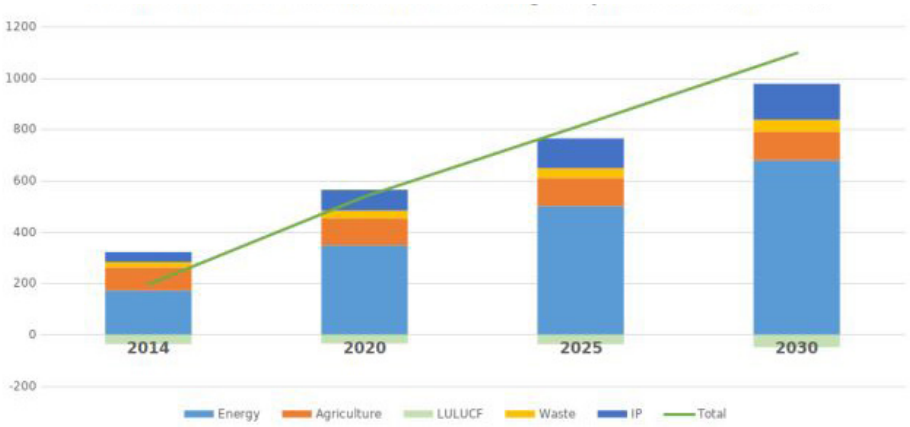
Source: Our World in Data. Vertical scales differ in the stacked, gas, coal, and oil graphs. Accessed 2023 - 01 - 10

Figure 14: Vietnam methane emissions



Source: Our World in Data, accessed 2023-01-10

Figure 15: Baseline Vietnam greenhouse gas emissions according to updated NDC



Source: VIETSE

4.3. Fossil fuels in the transition towards carbon-neutrality

Resolution 55[36] from February 2020 marked a turning point of the energy sector away from fossil fuels and towards renewable energy sources. In November of the following year, at COP26 Vietnam adopted the target to become carbon-neutral by 2050[37]. This requires to reform the development pathway illustrated in Figure 15, and go much farther than Resolution 55. The change needed compares in scope with the economic reforms initiated

[36] Vietnam's Politburo, "Resolution 55-NQ/TW on the orientation of the National Energy Development Strategy of Vietnam to 2030, vision to 2045," Resolution of the political bureau (Central Executive Committee, Communist Party of Vietnam, February 11, 2020).

[37] Phạm Minh Chính, "Remarks by H.E. Mr Pham Minh Chinh, Prime Minister of the S.R. of Viet Nam at the 26th United Nations Climate Change Conference of the Parties" (Discours, COP26, Glasgow, UK, November 1, 2021).

in 1986 to turn towards a socialist-oriented market economy, we can call it Doi Moi 2.0. This time, the goal will be the circular economy.

As of July 2022, less than a year after COP26, the policy reorientation process has only started. Producing the official doctrine, strategy and long term roadmap documents supporting development towards a carbon neutral society would be a logical first step to bridge the policy gap. These can take the form of Party directives, perhaps even a constitutional change. Then the redefinition has to take place in the legal framework and the planning system.

The seminal net-zero by 2050 scenario by the IEA[38], published in 2021, uses a world energy model. It does not detail country-level scenarios. Various organizations have are producing Vietnam development scenarios in the perspective of –if not to achieve the goal of– net zero emissions. Redefining the role of fossil fuels in Vietnam's socioeconomic development is always an essential piece of the puzzle. Examining those scenarios provides a basis to make comparisons and judgments about investment needs, costs for the development scenarios, and assessing current policy gaps as a basis for making recommendations. Unfortunately, many are not published yet:

- VIETSE prepared long-term energy transition scenarios. They are being revisited towards the net-zero goal.
- Nguyen Minh Bao[39] presented energy modeling with LEAP model for net-zero strategy in Vietnam.
- In 2016, WWF-Vietnam and Vietnam Sustainable Energy Alliance (VSEA) published a report showing how 100% of Vietnam's power could be generated by renewable energy technologies by 2050, while significantly reducing carbon dioxide emissions linked to climate change[40]. The vision is being updated in 2022 under the MAP project with financial support from BMZ. To the best of our knowledge, the report has not been published by July 2022.

The public sector, however, does provides access to the studies used to prepare energy and climaterelated policy acts such as the climate change strategy, the energy and power development masterplans, and the Vietnam Energy Outlook.

4.3.1. Draft climate change strategy

The draft Vietnam Climate Change Strategy[41] aims to cap the energy sector emissions to 460 $MtCO_2e$ in 2030, and 110 $MtCO_2e$ in 2050. At that date, forestry should absorb 185 $MtCO_2eq$ per year. Emissions shall peak in 2035.

The study defined three options. Option 1 was simulated with TIMES and includes 73% of renewable energy in 2050. Option 2 was simulated in more detail with TIMES and LEAP

[38] International Energy Agency, "Net Zero by 2050," May 2021.

[39] Nguyen Minh Bao, "Energy Modeling with LEAP Model for Net Zero Strategy in Vietnam" (AFD Macro/Energy modelization of a net zero strategy in Vietnam, Hanoi, June 24, 2022).

[40] WWF, "Power Sector Vision Towards 100% Renewable Electricity by 2050 Greater Mekong Region Vietnam Report," Energy report, 2016.

[41] MONRE, "DRAFT Decision Approving the National Climate Change Strategy to 2050" (Consultation Workshop on the National Climate Change Strategy until 2050, Hanoi, Vietnam

and has more fossil fuels in 2050, the share of fixed solar power is 4-5 times lower than option 1, it relies on CCS after 2035 at 70-90 USD/tCO_2eq stored. Its average reduction cost in the energy sector is 24.9 USD/tCO_2eq before 2030, 8.9 USD/tCO_2eq after. Option 3 modifies option 2 to replace coal by nuclear after 2035. All scenarios were further simulated with the AIM model.

The Climate Change Strategy recommends Option 2, with the expectation that CCS technologies will be more complete and cheaper in the period from 2030 onwards. It notes that option 1 is the lowest cost, and but would require 500 thousand hectares for installing fixed solar panels (according to General Statistics Office, Vietnam area is 33,212 thousand hectares, of which 3774 is non-agricultural land, 795 is water surface land for fishing, 212 is unused flat land).

4.3.2. Draft energy and power masterplans

The draft PDP8 was prepared prior to the adoption of the carbon neutrality target. The draft follows the 2015 Renewable Energy Development Strategy and the Resolution 55, but is not defined towards a net-zero goal.

The draft Vietnam Energy Masterplan[42] study used the TIMES model to represent the whole national energy system with 9 energy carriers and 7 economic sectors. In that scenario, the total primary energy supply reach 154 Mtoe in 2030, 335 Mtoe in 2050. At that horizon, fossil fuels still participate in that supply: coal provides 16.8 Mtoe, oil 17.2 Mtoe and gas 31.1 Mtoe. Wind and solar roughly provide 100 Mtoe each in 2050.

The total CO_2 emissions from energy reach 401 Mt in 2030, falling to 96 Mt in 2050. Since this is non zero, it is assumed that other sectors are carbon negative on aggregate.

Technology pillars for the scenario are energy efficiency, electrification, RE, hydrogen and hydrogen-based fuels, and carbon capture and storage.

4.3.3. Vietnam Energy Outlook

The Vietnam Energy Outlook[43] 2021 produced three scenarios: Baseline (BSL), Renewable energy (RE) and Net-Zero (NZ). They analyzed them with three energy models: TIMES, Balmorel and PSS/E. Electricity generation and storage capacity in 2050 net-zero scenario are mainly composed of: Storage: (47%); Solar (43%) and Wind (7%). The primary sources of RE-based power production are solar and wind. Solar dominates the electricity mix (75%) compared to wind (21%). The large majority of solar is utility-scale (838 GW installed in 2050). Floating PV and rooftop are subsidiary. For wind, onshore and offshore are balanced. Coal and gas power generation are fully phased out in this scenario. The study finds that:

- *To reach net-zero emissions by 2050 at least cost, renewable electricity should be the main substitute for fossil fuels, either directly or indirectly through production of electro-fuels.* As electricity substitutes for fossil fuels everywhere possible, the power system is larger. It exploits the full solar potential for both traditional fixed-

[42] Nguyen Ngoc Hung, "Net Zero Pathways for Energy Sector in Vietnam" (AFD Macro/Energy modelization of a net zero strategy in Vietnam, Hanoi, June 24, 2022).

[43] EREA and DEA, "Vietnam Energy Outlook Report 2021" (Hanoi, May 2022).

mount PV and rooftop PV and roughly 65% of the full wind potential in Vietnam, relying on existing reservoir hydro, 437 GW batteries, and 9 GW pumped hydro to balance the system. The power sector achieves net-zero emissions by 2050, but full decarbonisation was not achieved, the remaining carbon emission by 2050 was 65 $MtCO_2$. Further modeling of synthetic fuels and power-to-X would allow to simulate deeper decarbonisation level.

- *Achieving net-zero emissions is possible, green energy system comes at a 10% additional cost in the period 2020-2050.* The costs of the net-zero scenario do not differ markedly from the baseline until 2040, the difference increases in the last decade. The power systems investment are 5-6 times greater in 2050 for the net-zero scenario compared to the baseline, but the entire cost are only 3.2 times greater due to the absence of fuel costs. In the main scenario, natural gas price is assumed to drop to 6.7 $2019/Mbtu in 2025 and rise progressively to 9.0 $/Mbtu in 2040-2050. This is very low compared to real market values (Figure 1), even for the high LNG price sensitivity analysis case of +20%.
- *Fuel Import share could increase from 36% in 2020 to 60% in 2030 and 70% in 2050 in the baseline scenario.* Coal and oil products imported to Vietnam will almost triple compared to current imports by 2030, and LNG will become a major new imported commodity in Vietnam. By 2050, the share of imported fuels could reach 70% in the baseline scenario.
- *A cost optimal use of LNG is highly sensitive to fuel price variations.* A price increase of 20% leads to a 50% reduction in the use of LNG in the power sector in the baseline scenario. An even higher LNG price will lead to even lower need for LNG.
- *Reaching net-zero will make Viet Nam independent of fuel import.* By reaching net-zero emissions in 2050, the long-term energy security can be substantially enhanced by greatly reduced reliance on fuel imports in the next decades and lower import costs. The net-zero scenario reaches an almost self-sufficient energy supply in 2050. This can be achieved by electrification of end-use sectors.

4.3.4. ASEAN Centre for Energy Net-zero Emissions

The ASEAN Centre for Energy published net-zero emission[44] scenarios for the region, using LEAP to model the power sector in each member country. The scenario foresees an electricity demand in 2050 for Vietnam of 924 TWh for a generation of 1071.3 TWh. Under the current renewable energy targets scenario, emissions in 2050 would be 198.8 ton CO_2e.

In the net-zero scenario by 2050, CO_2 emissions peak in 2035. They overwhelmingly come from coal-based power generation. The study predates the COP26 announcements. In terms of renewable energy, the installed wind power capacity in 2050 goes around 70 GW, while solar PV gets to around 570 GW. The model scenario installs more than half of this solar capacity is between 2045 and 2050, which is not very realistic.

[44] Kamia Handayani et al., "Moving beyond the NDCs: ASEAN Pathways to a net-zero Emissions Power Sector in 2050," Applied Energy 311 (April 1, 2022): 118580.

The study does not take into consideration the possibility of additional power exchange between the ASEAN countries. This is a surprising shortcoming given where it comes from.

4.3.5. Conclusion on net-zero scenarios

The variety of existing scenarios explore at a variety of strategies to achieve deep decarbonisation: Buildup lots of solar PV; Balance the contributions of Wind and Solar; Capture and Store Carbon; use Nuclear energy. We miss a scenario using offshore wind as a backbone. Most studies do not achieve full net-zero from the energy sector, they keep some fossil fuels and rely on carbon sequestration in forests.

Existing studies also have limits:

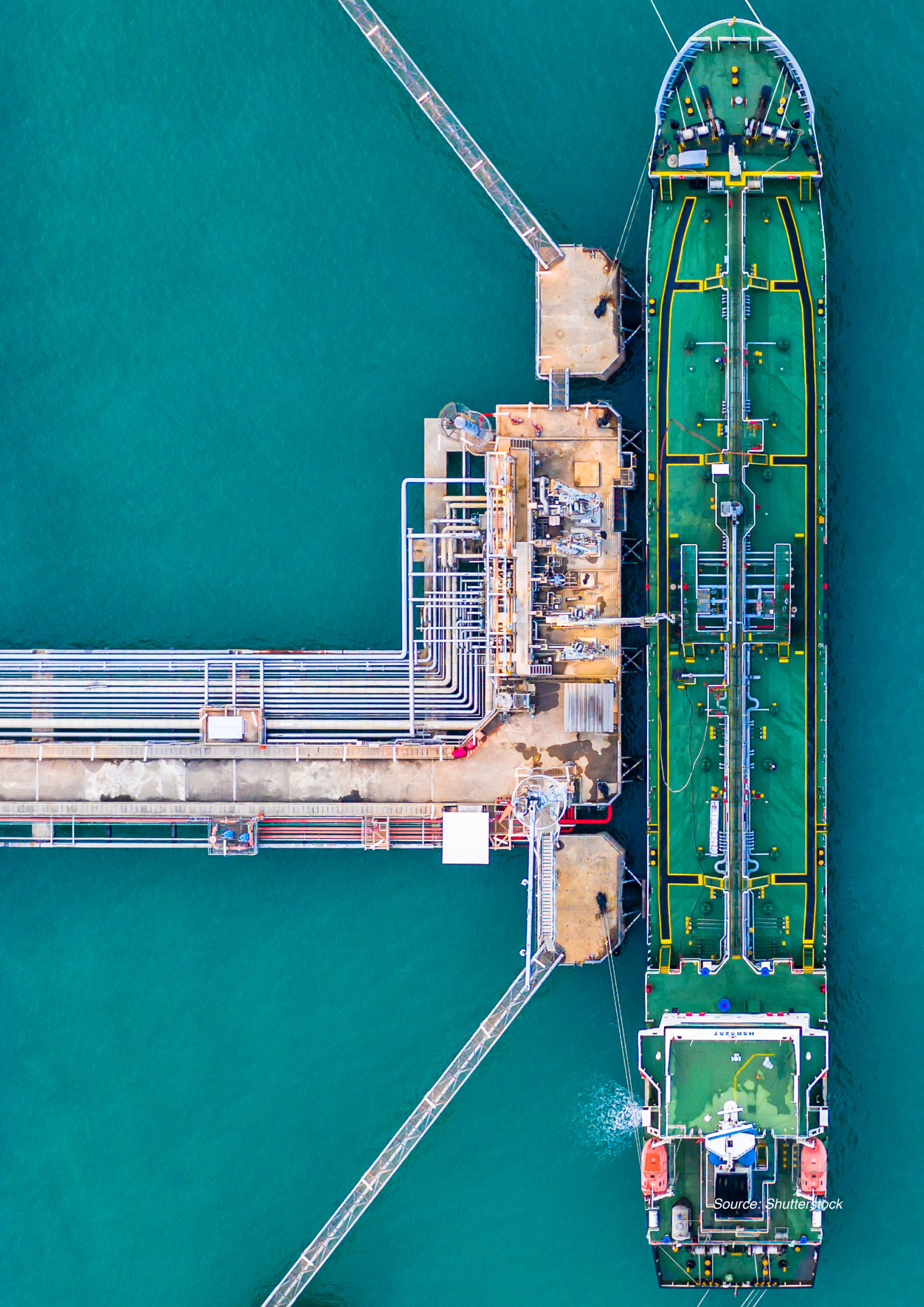
- Methane emissions reduction receive little attention compared to its urgency.
- They overlook the Carbon Market mechanism which is due to open in 2028 according to the Law on Environment.
- Long term scenarios have low connection to the immediate problem of financing the sector in the next five years, and providing electricity to the Northern area next year. For example the Energy Outlook notes that the optimal use of LNG is very sensitive to price levels, but does not go as far as recommend policies to answer the prices level seen today.

Scenario studies are not predictions but explorations. They are hardly comparable, because they explore different facets of the future. Moreover, the state of Vietnam's energy system and the regulations are constantly changing, so that baseline scenarios become obsolete after one year. Game-changers include the rise of solar and wind power in 2020 and 2021, the adoption of the carbon-neutrality goal and the coal exit pledge at COP26, and more recently the JETP declaration.

Another limiting factor is the limited data availability, for example studies conducted by the Ministry of Environment and Natural Resources have difficulties to access information about the energy system, which is under the responsibility of the Ministry of Industry and Trade.

Scenario studies also have theoretical limitations about uncertainty analysis. Sustainable development can be defined as "meeting the needs of the current generation without preventing the next generations to meet theirs". The problem for the Climate Strategy is to find a robust trajectory between now and 2030, which will be revised depending on how technology costs and fossil fuel prices resolve. We have not seen modeling studies taking into account such adaptation.

It would be convenient for decision-making if one model could predicts the future, but no model can. Each study can brings a few pieces of evidence, and the useful knowledge is mostly qualitative, when all analysis point in the same direction. Net-zero scenarios agree that Vietnam's emissions should peak in 2035. They also agree about pursuing electrification with renewable electricity sources, to reduce the use of fossil fuels.



Source: Shutterstock

5 Conclusion: The LNG role is limited

Vietnam has two sources of natural gas: domestic offshore fields and imported LNG. Domestic natural gas production costs are determined by geology and technology, unlike LNG where Europe and Japan outbuy developing countries.

We have only used domestic natural gas in the past, but this is about to change. Several regions are planning LNG import terminals to receive natural gas to make electricity. Building an LNG infrastructure in Vietnam improves energy security: More storage capacity allows for higher strategic fuel reserves. And it is always helpful to have more technology options to generate electricity. But large investments – for example the 3.2GW Bac Lieu LNG project is about 4 billion dollars – raise large questions. Can it be done, what will be the role of natural gas in Vietnam's energy system?

Between 2015 and 2020, the global price of liquefied natural gas for Asia was relatively low, trading between 2.0 and 11.6 US$/mmbtu. Many saw it as the backbone of Vietnam's future electricity system. This explains why a large number of LNG-to-power projects have been authorized and the accompanying decision to build the necessary LNG import infrastructure. In the recent years, fossil fuels prices have increased so much that the world is facing not only a climate crisis, but also an energy crisis. The spot price of LNG reached a record high of 59 US$/mmbtu in early 2022.

Even if the price of gas returns to pre-war in Ukraine levels, it would remain cheaper to make electricity from solar and wind. But these power generation sources are variable. They need other sources to complement them, namely hydroelectricity, batteries, interconnections with other countries and natural gas power plants. Thus natural gas keeps a role in the electricity mix to complement variable sources. At lease until other, carbon-neutral, flexibility solutions are built.

Natural gas power plants already provide flexibility in Vietnam's electricity system today. For example, in 2022-2023, EVN expects gas turbines in the Southern region to run around 2000 hours per year, which is 25% of the year to complement the must-run solar and wind power plants.

Gas power plants work better than coal power plants as flexible electricity sources, because they have lower fixed investment costs and lower start-up/shut-down time. But they have higher fuel costs, so using imported LNG instead of imported coal aggravates the national fossil fuel bill. There are two answers to mitigate this energy security issue.

The first would be to produce natural gas from domestic sources. Domestic production costs would be isolated from the speculation and geopolitical games driving the international fossil fuels markets. Historically, offshore natural gas produced in Vietnam costs under 5 US$/mmbtu. Even if gas from the recently discovered Ken Bau field costs a bit more, that would remain cheaper than the international spot market prices in the foreseeable future. However, the economically exploitable offshore gas reserves of Vietnam are too limited to satisfy all the needs. Imports have to be considered.

Therefore we need the second energy security measure: to enter long-term supply agreements with diverse providers. The US is the first potential trade partner since they are already involved in LNG infrastructure development in Vietnam, but the Biden's administration is much less positive about exporting LNG than the previous one. For example, there is no LNG export terminal on the US Pacific coast. Other large exporters to diversify the supply can be Qatar, Russia, Mozambique, Australia, Turkmenistan and Iran. Negotiations on fuel sourcing and prices will be long and difficult. Several LNG to power projects in Vietnam may suffer fatal delay.

In conclusion, power from gas is a flexibility solution that works well technically, but the economics are difficult. Every year the international situation, technical progress and climate preservation policies make building new fossil fuel power plants less and less profitable. The role of natural gas in Vietnam's electricity system is limited in time as much as in scope.

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