International Journal of Multidisciplinary Research and Growth Evaluation.

The synchronization of the electricity market within the energy market in Vietnam

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Article Info

ISSN (online): 2582-7138
Impact Factor: 5.307 (SJIF)
Volume: 05
Issue: 01
January-February 2024
Received: 22-10-2023;
Accepted: 26-11-2023
Page No: 112-118

Abstract
Electricity plays an important role in both daily life and production. Therefore, it affects the entire development of the national economy, especially in the process of industrialization. At the national level, electricity is a prerequisite for improving quality of life and creating opportunities, it helps filling the gap between the urban and the rural. Consequentlye, universal access to electricity is often considered a key driver of growth.
The escalating demand for energy and the dynamic nature of energy markets create an urgent need for a coordinated approach to electricity markets in the broader context of the energy sector. This article explores the need to achieve harmonization in electricity markets, focusing on the relationship between price mechanisms, especially in coal power plants and gas turbines, and the consequent effects of them for performance amid volatile prices. Additionally, the article delves into a comprehensive overview of the gas coal market and its impact on the electricity market, emphasizing the need for synchronization in the spot market.
The study uses a multidimensional research approach, combining data analysis and modeling tools to study the complexities of market dynamics. The results highlight important findings related to optimizing performance and synchronization in energy market. A comparison with previous research highlights the significance of the proposed improvements.
The discussion discusses the subtle effects of synchronization on the energy landscape, provides insight into the feasibility and potential challenges of implementing proposed solutions in real-world scenarios.
Analyzing the strengths and limitations of research enhances understanding of its contribution. The paper concludes by offering recommendations for future research and development directions, providing a roadmap to advance the conversation on achieving electricity market convergence within the larger context of the energy sector. This study provides valuable information to policymakers, market participants and researchers dediicated to enhancingthe efficiency and integrity of the energy market.

Keywords: synchronization electricity market, energy market

1. Introduction

Through analyzing the experience of Vietnam in reform and development of the electricity industry from the 1990s to 2020, we can see some of the following major features. Total electricity consumption in Vietnam continues to increase rapidly over the years to serve the country's economic development needs. This growth is consistent with Vietnam's industrialization and integration into the global economy after Doi Moi in 1986. From 1986 to present, Vietnam's electricity industry has achieved impressive growth, leading leads the world with an average annual growth rate of electricity production and consumption of 10-12% (based on CEIC data). This rate is equal to the level that Korea achieved during its period of miraculous development. Thanks to that, from a very low level of development, Vietnam has quickly surpassed many countries in the region in terms of production capacity and management efficiency of the electricity industry. A specific example is that, according to data from CEIC, in 1986, Vietnam's per capita electricity consumption was only 68 kWh, 4.7 times lower than the Philippines and 6.4 times lower than

Thailand. In 2018, this index in Vietnam reached approximately 2,300 kWh, nearly 3 times higher than the Philippines and equal to 85% of Thailand's. Meanwhile, Vietnam's 10% increase in real GDP has generated an 18% increase in electricity, more than any other major economy in ASEAN (Association of Southeast Asian Nations) or China or India (Dapice *et al*., 2022) [4].

The achievements of Vietnam's electricity industry are not only output growth but also management quality. Among developing countries, Vietnam's power sector has achieved significant progress in indicators of power supply reliability, transmission and distribution loss management (Lee and Gerner, 2020) [5]. In particular, Vietnam's meaningful efforts and significant success in bringing electricity to rural areas have been recognized internationally (Gencer *et al*., 2011; Baum, 2019) [6, 7]. Vietnam's electricity industry has played an important role in improving Vietnam's business environment over the past five years. In the World Bank's 2020 Global "Doing Business" Rankings, Vietnam ranked 27th in electricity. Access index, much higher than the 70th overall index in the country.

In nearly 30 years from 1990 to 2019, annual electricity production has increased more than 20 times, from 8.6 TWh in 1990 to 240.1 TWh in 2019 (GIZ, 2020). By the end of 2020, Vietnam had a solid electricity system with a total source capacity of more than 61,000 MW. The national power grid has covered the whole country with over 8,500km of 500kV lines, 33,000km of 110kV-220kV lines and hundreds of thousands of kilometers of distribution networks of all kinds. Commercial electricity output in 2020 is 225.4 billion kWh, achieving an average annual growth rate of 9.66% in the period 2010-2020, about 1.6 times higher than GDP growth (Figure 1).

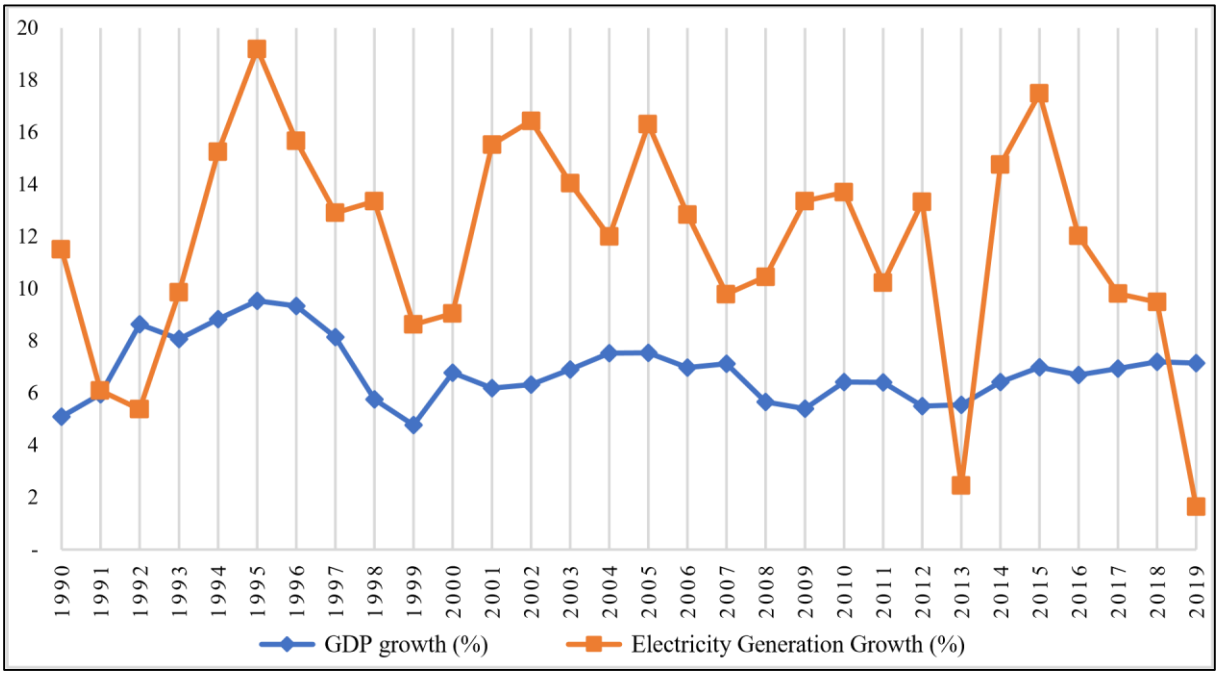

Fig 1: GDP Growth and Electricity

By 2020, one hundred percent of the population will have access to electricity (World Bank, 2022). Average commercial electricity output per capita by the end of 2020 is estimated to reach about 2,200 kWh/person/year, an increase of 2.24 times compared to 2010 (982.7kWh/person/year).

The energy industry in Vietnam is currently mainly managed by the Government through the Ministry of Industry and Trade (MOIT) and is dominated by large state-owned enterprises (SOEs). Vietnam Electricity (EVN) is the main electricity producer in Vietnam. In addition, EVN holds a monopoly position in transmission, distribution and operation of the power system, as well as accounting for a large proportion of the power production/generation market. The remaining shares in power generation belong to other large suppliers.

State-owned enterprises such as PetroVietnam (gas thermal power plant) or Vinacomin (coal thermal power plant). Most foreign investors use the Build-Own-Transfer (BOT) model while domestic investors use the independent power plant (IPP) model. Electricity produced from IPP is sold to EVN under a long-term contract. The number of IPPs has increased significantly in recent years with the remarkable growth of solar and wind power.

In the context of constantly increasing energy demand and the typical fluctuations of the energy market, ensuring synchronization in the electricity market becomes extremely important. This article focuses on exploring the challenges and opportunities in synchronizing electricity markets, especially in the context of the price regimes typical of coal-fired power plants and gas turbines.

At the same time, the article also presents an overview of the gas coal market, an important raw material for the energy industry, and how it interacts with the electricity market. Grasping the important details in the gas coal market is key to better understanding how energy markets work and how these factors can affect synchronization.

2. Curent state of the energy market

Vietnam wholesale electricity market

A. Members participating in the competitive wholesale electricity market (VWEM) include

a) Electricity sellers

- Power generation units that own power plants with an installed capacity of over 30 MW directly participate in the electricity market. Hydropower plants with an installed capacity of 30 MW or less have the right to choose to participate in the electricity market when they meet all infrastructure conditions.
- In the current period, power plants are invested in the form of Build - Operate - Transfer (BOT), strategic multi-purpose hydropower plants (SMHP), power plants using renewable energy sources indirectly participate in the competitive wholesale electricity market. According to the VWEM design, BOT and SMHP plants are expected to participate in the electricity market in one of the following forms: i) Directly participate in the market; ii) Participate in the market through the price offering unit of EVN.

b) Electricity buyers

- Power Corporations;
- Large electricity customers who buy electricity from the 110 kV voltage level or higher and connect directly to the 220 kV voltage transmission transformer station that meets the conditions prescribed by the Ministry of Industry and Trade have the right to choose to participate in the market;
- Electricity Trading Company (under EVN): Performs the task of purchasing electricity from power plants that do not participate in the competitive wholesale electricity market and selling this electricity output to Power Corporations according to the regulations of MOIT;
- New electricity purchasing units are allowed to participate in the competitive wholesale electricity market when they meet the conditions prescribed by the Ministry of Industry and Trade.

c) Service providers

- Electricity system and electricity market operating unit: National Load Dispatch Center;
- Power transmission unit: National Power Transmission Corporation;
- Electricity distribution units: Power Corporations;
- Service provider for collecting and managing electricity measurement data.

d) Spot electricity market

- Market model: Apply the cost-based pool market model;
- Transaction cycle: 30 minutes;
- Moderation cycle: 30 minutes;

Price offer mechanism: apply day-ahead price offer. On day D-1 (1 day before operation day), the electricity generating unit prepares a price offer for 48 trading cycles of day D and sends it to the electricity system and market operating unit. The power generation unit makes bids within the range of floor price and ceiling price for the entire available capacity of the generating sets. The ceiling price offered for thermal power units is calculated according to the Regulations on the competitive wholesale electricity market. The quoted ceiling price of hydroelectric power units is determined on the basis of the water value calculated by the electricity system and market operating unit. The price quote of the power generation unit includes a maximum of 10 pairs of price (VND/kWh) and capacity (MW) of each generating unit in each transaction cycle.

E. Contract mechanism

Contractual mechanisms in the competitive wholesale electricity market include:

- Allocation contract (vesting contract): Implement the allocation of contracts for difference (CfD) signed between the power generation unit and EVN into contracts for difference (CfD) signed between the power generation unit and the Power Corporations;
- Bilateral contract: The seller and the buyer negotiate, agree on the price and committed output, sign a bilateral contract in the form of a difference contract;
- Centralized contract trading mechanism: Units participate in offering to sell or buy contract output on the trading floor according to the Regulations on the competitive wholesale electricity market. Centralized contract transactions aim to handle differences (excess or shortage) between the signed contract output and the load demand or actual generation capacity of the units.

F. Mechanism for providing auxiliary services

- For frequency adjustment services (including: frequency adjustment services and rotation backup services): Buy on the spot market. When applying ex-ante market price determination, implementing a co-optimization mechanism between electricity and frequency regulation services;
- For other ancillary services serving the operation of the power system: The electricity system and market operator signs contracts with service providers through the competitive bidding mechanism or appoints service providers.

G. Payment mechanism

- Payment on the spot market: The electricity system and electricity market operator calculates payments and makes payments to units on the spot market according to the Regulations on the competitive wholesale electricity market. Units purchasing electricity on the spot market are responsible for implementing regulations on payment guarantees for electricity on the spot market.
- Contract payment: The electricity seller and electricity buyer directly make payments according to the provisions of the electricity purchase contract signed between the two parties.
- Payment of service costs in the competitive wholesale electricity market.

3. Offer prices in the market through variable costs in vietnam's electricity sector

The current operational framework of Vietnam's wholesale electricity market is currently operated by mandatory cost-based offers, incorporating ceiling and floor price regulations for each type of technology and for the entire market. The primary objective of this pricing mechanism is to facilitate power generators in the comprehensive recovery of all incurred costs. However, some challenges are inherent in this approach:

The complexity of the quote structure arises when integrating both variable and fixed costs into the quoted price.

Additional capacity billing mechanisms are often necessary to ensure the full recovery of costs, introducing further intricacies to the pricing model.

This cost-based pricing mechanism is more apt for constrained markets characterized by a high concentration of

market power.

To elucidate, consider the illustration below, outlining the calculation of the quoted price based on the fuel consumption rate of a gas turbine unit. For example, fuel price is 3.82 USD/MMBTU or 0.08 VND/BTU. The actual fuel consumption of the measured power levels is as follows: At the lowest power level of 54 MW, the consumption is 16,270 BUT/kWh, whereas at the highest capacity of 135 MW, it decreases to 11,441 BTU/kWh. This data underscores the inverse relationship between power level and fuel consumption, as depicted in Table 1.

Table 1: Fuel consumption table

Pkd	Pgas (MW)	BTU/kWh	đ/kWh
100%	135.0	11441	917.1
90%	121.5	11759	942.6
80%	108.0	12173	975.7
70%	94.5	12761	1022.9
60%	81.0	13494	1081.6
50%	67.5	14573	1168.1
40%	54.0	16270	1304.1

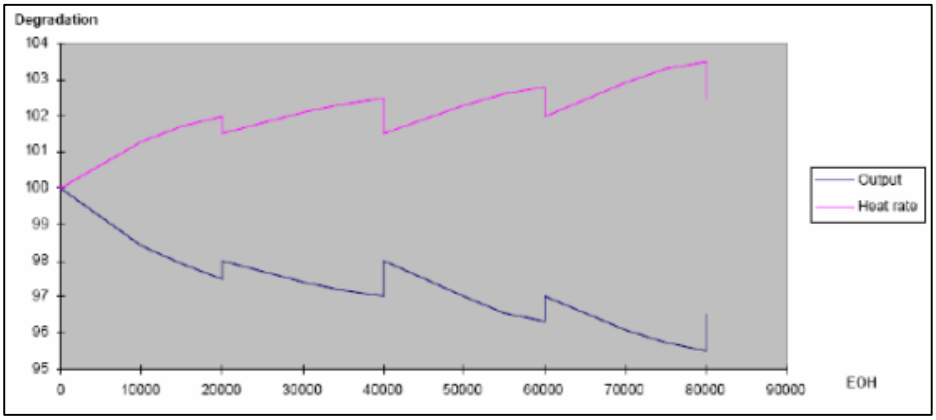

Fig 2: Reduced efficiency of single cycle and combined cycle gas turbines

Based on Figure 2 and Vietnam's conditions, a 2% efficiency reduction will be applied during the first 3 years of operation for the TBK plant and a 0.5% reduction for each subsequent year. Apply a performance increase of 0.5% after each maintenance session. The allowable performance reduction factor will be calculated cumulatively but must not exceed 9% corresponding to the average life of the plant of 30 years. In addition, for steam turbines, including coal and oil plants in Vietnam, an annual efficiency reduction of 2% and an efficiency increase of 6% will be applied after each overhaul as shown in Figure 3. (according to ERAV, 2009).

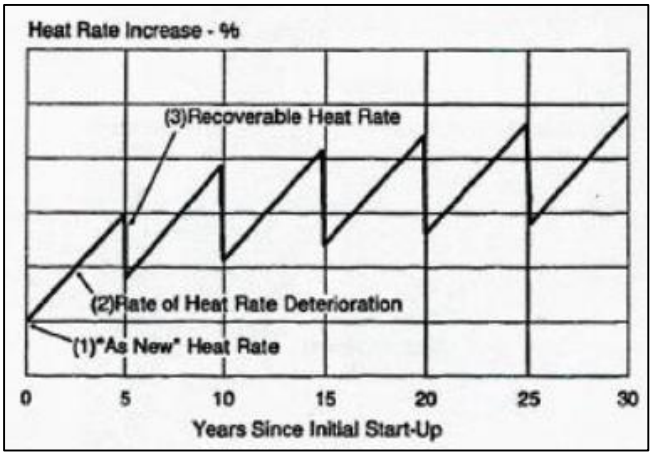

Fig 3: Change in thermal coefficient over time of steam turbine

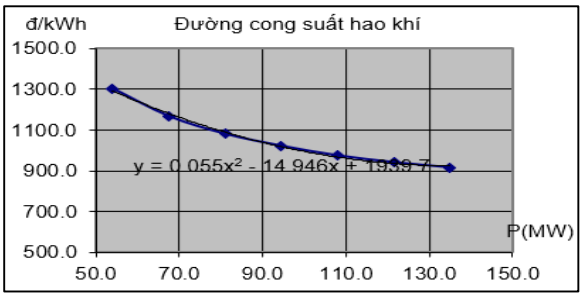

Fig 4: Air consumption curve of the unit

Based on the characteristics and relationship between the power plant's fuel consumption rate and available capacity (MW), the chart shows the fuel consumption rate relationship curve function (MW-VND). The function shows how much each additional MW will increase the cost (VND) of the power plant. Power generation units need to have an appropriate pricing strategy to ensure full recovery of power generation costs in the electricity market.

The generator set has the following measured input cost and output power characteristics:

Table 2: Characteristics of input costs and output capacity

Pkd	Pgas (MW)	Price (.mil VND)
100%	135.0	123.80
90%	121.5	114.52
80%	108.0	105.38
70%	94.5	96.66
60%	81.0	87.61

50%	67.5	78.85
40%	54.0	70.42

Using the quadratic function, we can determine the cost curve as follows:

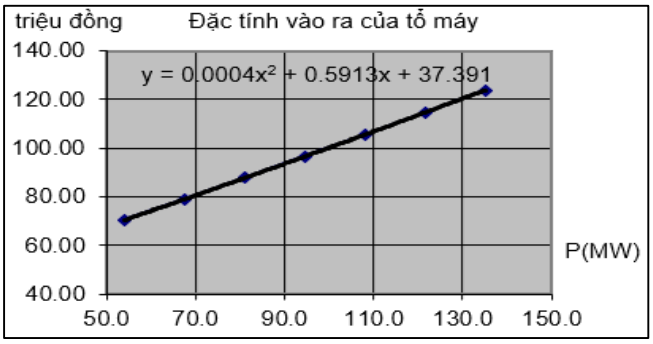

Fig 5: Input - output characteristics of the generating unit

$$\text{Price (VND)} = 0.0003603\ P2 + 0.591295\ P + 37.391243$$

The construction of the unit quotation is often built by the method of showing how much each additional MW will cost, also known as the cost increase rate. Thus, it is necessary to differentiate the cost function:

$$\text{The variable costs (VND/kW)} = 0.0007207\ P + 0.591295$$

The variable component (Vc) of the Price Block will depend on the variable costs. As follows:

Table 3: Calculate variable costs for each price block

Block	Pgas (MW)	The variable costs (VND/kWh)
Block 1	50.0	627.33
Block 2	60.0	634.54
Block 3	90.0	656.16
Block 4	120.0	677.78
Block 5	135.0	688.59

The fixed cost component of the Price Block depends on the variable cost which is the no-load capacity of the generating set. The unit has available capacity Pkd = 135 MW, no-load cost is Ckt = 37.39124 million VND, therefore no-load unit price is: Ckt/Pkd = 276.97 VND/kWh. This is the fixed cost (Fc).

Combining these two costs, we can build a factory price quote as follows:

Table 4: Determine the specific price for each price block

Block	Pgas (MW)	Price (VND/kWh) = Vc + Fc		
		Vc (VND/kWh)	Fc (VND/kWh)	Price (VND/kWh)
Block 1	50.0	627.33	276.97	904.30
Block 2	60.0	634.54	276.97	911.51
Block 3	90.0	656.16	276.97	933.13
Block 4	120.0	677.78	276.97	954.75
Block 5	135.0	688.59	276.97	965.56

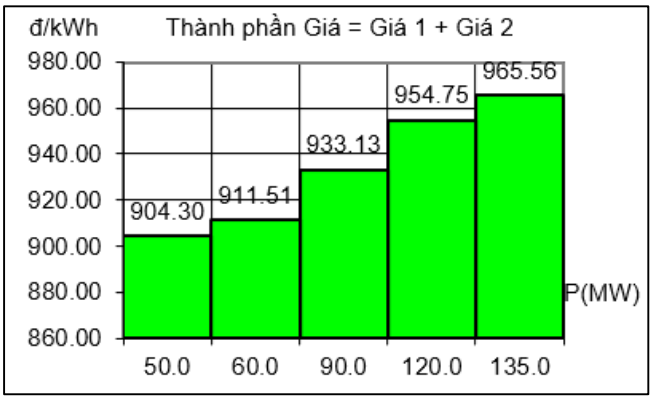

Fig 6: Price Block components of the quotation

The principle of offering prices in the electricity market as presented in the article is through offering blocks (5 blocks), corresponding to expected output and offering price. The price component is made up of two main components: fixed price and variable price. Basically, as output increases corresponding to increased fuel consumption, costs will increase. This relationship is depicted in Figure 4, illustrating the power plant's power loss characteristic curve.

4. Gas and coal market

A. Current status

The coal and gas market plays an important role in the global energy industry, providing the main energy source for many countries and regions. Gas coal is extracted from coal layers containing hydrocarbon compounds, which is a cleaner energy source than traditional coal, providing high efficiency and reduced emissions.

For most countries and economies with developed markets, the first market to be implemented and organized should be the primary energy market. There fuel sources such as oil, coal, gas,... are traded to establish fuel prices. From the fuel price determined in the energy market, other markets such as electricity, transportation, and secondary energy market continue to carry out transactions and form a chain from production to consumption that operates according to market mechanisms, reflects the laws of supply and demand, is clear, transparent and fair. A number of large-scale primary energy markets in the US, Europe, Singapore, Hong Kong... operate smoothly and regularly, often determining market transactions and prices worldwide. Normally, trading floors often combine to operate many markets simultaneously such as coal, gas, and electricity markets.

The bidding process of coal-fired power plants and gas turbines not only affects the rate of loss characteristics under fluctuating prices but also has a significant impact on the performance of the entire system. This poses a big challenge in managing and optimizing energy supply.

Up to now, fossil fuel power plants have been quoting raw material purchase prices in month M-2 for the current price quote, a practice that inadequately reflect the actual electricity production price.A noteworthy drawback identified is the asynchrony in the spot market, which poses a need for connectivity between components of the energy market. This articleproposes solutions and measures to address e this shortcoming, maiming to establish a synchronous, flexible and effective electricity market system. This initiative not only helps enhance efficiency but also

ensures stability and sustainability for the energy industry in the future.

Relationship with the electricity market

- Energy Supply: Coal and gas play an important role in supplying energy sources for the electricity market. Both of these energy sources often make up a large part of the energy mix of many countries, especially during the process of development and industrialization. Price and Volatility: The price of coal and gas both have a great influence on electricity prices. Fluctuations in the coal and gas market pose both challenges and opportunities in management of electricity prices and overall energy production costs. Influence on the Decision to Use Energy Sources: Price also affects the decision of which energy source to use in the electricity production process. Rising coal and gas prices could stimulate a shift to renewable energy sources or gasification, affecting energy supply diversification.
- Synchrony and Connectivity: The relationship between the coal - gas market and the electricity market is an important aspect of synchronization within the energy system. The flexibility in energy use and the capacity to respond quickly to price fluctuations can affect the stability of the electricity market.

B. Requirements for the Development of the LNG market

The advantages and necessity of LNG gas power, as well as the implementation status and difficulties and challenges of LNG power projects have been evaluated by many experts and analysts; At the same time, many solutions have been proposed and introduced. However, with the responsibility and status of a professional social organization - Vietnam Petroleum Association proposes solutions to remove difficulties in the process of realizing the LNG gas power target in PDP VIII.

Expanding and developing the LNG electricity consumption market closely follows the goal of supplying LNG electricity in PDP VIII. Accordingly, centralized and synchronous construction of industrial parks/factories with large enough electricity consumption scale along with the implementation of port warehouse and LNG power plant projects. They are the consumers and the important basis for committing to electricity consumption (Qc) and then the commitments in the Power Purchase Agreement will become easier and more convenient. This is also a policy to help attract and encourage investors in the type of industrial park/factory to commit to long-term electricity consumption along with a chain of power plants and LNG terminals. In addition, we need to have additional policies to stimulate electricity demand, stimulate production and stimulate consumption in parallel with encouraging electricity saving.

That is to soon amend the Electricity Law, Environmental Protection Law, Tax Law and related guiding decrees. First and foremost, it is necessary to accept that the LNG gas and electricity business chain operates according to the market mechanism and that State management agencies will supervise and post-inspect all operational processes of the chain. Next, allow the entities of gas power plants to negotiate and sell electricity competitively between EVN and electricity consumers. At the same time, power plants are allowed to directly buy LNG and rent warehouses to store and regasify LNG terminals. In parallel with that process, it is necessary to supplement the tax framework and CO2 emission fees in the Tax Law and the Environmental Protection Law.

Update and amend the Charter and Financial Regulations of Vietnam Oil and Gas Group (Petrovietnam) and EVN. The fact that the Government no longer directly guarantees gas and electricity purchase and sale contracts is a correct decision. However, with the current legal framework, Petrovietnam and EVN do not have enough basis to make replacement guarantees. Therefore, it is necessary to update and amend the Charter and Financial Regulations of the two corporations that have been participating in the chain of LNG gas power projects in particular and other large project chains in general. At that time, the bottleneck of Government guarantees will be removed.

The Government or State Bank still needs to commit and guarantee the volume of foreign/local currency conversion and the exchange rate will be determined by the market. Investors will be completely convinced if we accept this approach and the bottleneck will be removed.

That is to strengthen and expand international cooperation. Extensive international cooperation will give us the opportunity to: Build and perfect energy policy mechanisms in general and LNG gas power in particular; Build and perfect the management model for investment in construction, operation, exploitation and optimal use of LNG gas power; Select investors with technological, financial potential and implementation experience. We believe that good and effective international cooperation will be one of the necessary and sufficient conditions to realize LNG power projects according to PDP VIII.

5. Conclusion

In conclusion, this article has thoroughly examined the imperative for achieving harmonization in electricity markets, with a specific focus on the intricate relationship between price mechanisms, particularly in coal power plants and gas turbines. The resulting impacts on performance amid volatile prices have been scrutinized to provide a comprehensive understanding of the dynamics at play. Furthermore, a detailed exploration of the gas coal market and its influence on the electricity market underscores the necessity for synchronization, particularly in the spot market. The synchronization of electricity markets within the energy sector presents a myriad of advantages, ultimately contributing to the establishment of a more efficient and reliable energy system.

Real-time synchronization of the electricity market within the broader energy market offers paramount advantages. This synchronization is crucial for delivering precise price signals that accurately mirror the current supply and demand conditions. Such synchronization empowers market participants, enabling them to make well-informed decisions based on real-time data.

Notably, synchronized exhibit markets tend towards lower electricity prices and adopt more transparent billing practices. This not only fosters cost-effectiveness for consumers but also instills a greater sense of trust and fairness within the market. As a result, the collective impact of synchronization extends beyond mere operational efficiency, positively shaping the economic landscape of electricity markets.

6. Proposed recommendations

The following recommendations are formulated to establish a coherent framework addressing the intricacies of

synchronizing electricity markets while concurrently fostering a sustainable and resilient energy ecosystem.

Evaluate and Enhance Market Design: Conduct a thorough assessment of the existing market design to ensure that price signals accurately mirror the true value of electricity across different times and locations. Implementing flexible pricing mechanisms, such as time-of-use tariffs, is recommended to incentivize efficient resource allocation. This enhancement will contribute to a more responsive and adaptive market, aligning with the dynamic nature of energy supply and demand.

Foster Collaboration Across Energy-Intensive Sectors: Actively promote collaboration between the electricity sector and other energy-intensive industries to optimize overall energy utilization. Aligning policies with the transportation and industrial sectors is crucial to encourage electrification and enhance energy efficiency on a wider scale. Coordination efforts should be strategically directed towards achieving synergies that mutually benefit the electricity sector and the larger energy landscape. This collaborative approach ensures a comprehensive and integrated strategy for sustainable energy practices.

7. References

1. Vietnam's Eighth National Power Development Plan (PDP VIII), Ministry of Industry and Trade (MOIT)
2. Decision No. 24/2017/QD-TTg about the mechanism for adjustment of average retail electricity price, The Prime Minister of Vietnam
3. Scheme detailed design of the competitive power generation market, ERAV, 2009
4. Dapice D, Le V, Le TH. Phase Change: Getting to a Sustainable Energy Future in Vietnam", In: Handbook of Energy and Environmental Security. Ed: Muhammad Asif. Elsevier, Forthcoming, 2022.
5. Lee AD, Gerner F. Learning from Power Sector Reform Experiences: The Case of Vietnam. World Bank Policy Research Working Paper, 2020, (9169).
6. Gencer D, Meier P, Spencer R, Van HT. State and people, central and local, working together: The Vietnam rural electrification experience. World Bank. Retrieved on April 10th, 2011-2021. Available at http://documents1.worldbank.org/curated/en/601001468027856008/pdf/604380WP0P11051ification0Experience.pdf
7. Baum Anja. Vietnam's Development Success Story and the Unfinished SDG Agenda. IMF Working Paper WP/20/31, 2019. Retrieved on April 10th, 2021. Available at https://www.imf.org/-/media/Files/Publications/WP/2020/English/wpiea2020031-print-pdf.ashx