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Power is not energy, Watts are as valuable as Joules

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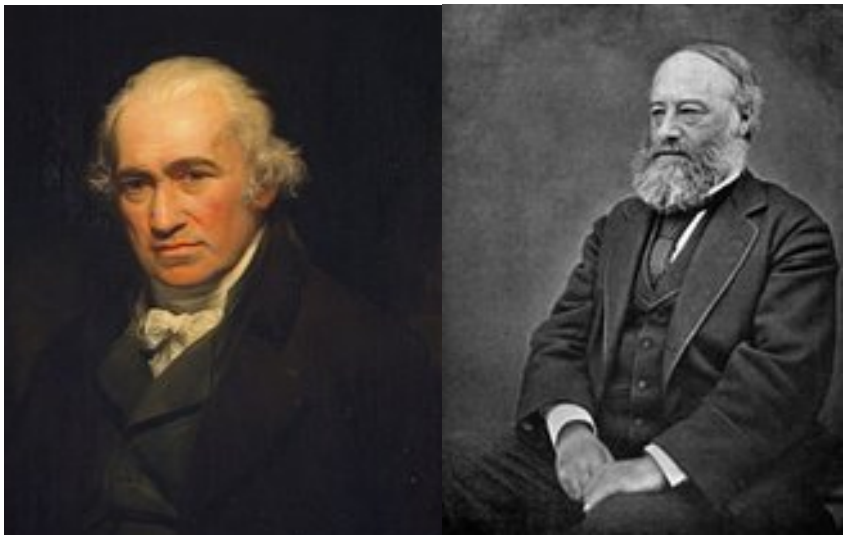

James Watt (1737 – 1819) and James Prescott Joule (1818 - 1889). (c) Wikimedia commons

1. Introduction

Vietnam's electricity system faces significant challenges in ensuring a stable and reliable power supply as temperatures soar above 40 degrees Celsius nationwide. Meeting rapidly growing electricity demand while transitioning to cleaner energy sources requires substantial investments in new generation capacity. However, attracting these investments is difficult due to regulatory uncertainties, the financial constraints of the state-owned utility EVN, and the lack of a transparent and competitive wholesale electricity market.

In this context, reforming the structure of electricity markets and tariffs could play a key role in addressing these challenges. This article will discuss the proposed introduction of a two-part tariff in Vietnam's electricity markets. A two-part tariff in the electricity sector refers to a billing mechanism where consumers are charged based on two distinct components: **capacity** and **consumption**. The **capacity charge** is determined by the maximum power capacity (in kilowatts, kW) that a consumer can draw from the system at any given moment. This is akin to paying a rental fee for accessing power up to a certain limit. The **consumption charge**, on the other hand, is based on the actual amount of electricity used by the consumer over a period, measured in kilowatt-hours (kWh).

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We will then examine how a similar two-part tariff, including capacity payments, could be applied to the wholesale electricity market to support investment in dispatchable generation like gas power plants. These plants are needed to complement the growing share of variable renewable energy sources like wind and solar. The article will draw on international experiences, such as the recent introduction of capacity payments for coal power plants in China, to explore the potential benefits and design considerations for such a mechanism in Vietnam.

2. Overview of Vietnam's electricity market structure and challenges

Vietnam's electricity market has undergone significant reforms in recent years but remains dominated by the state-owned utility, Vietnam Electricity (EVN). EVN owns and operates much of the country's generation, transmission, and distribution assets, as well as being the sole buyer of electricity from independent power producers (IPPs) through long-term power purchase agreements (PPAs).

Since 2012, Vietnam has been gradually introducing competitive markets for electricity, starting with a competitive generation market (CGM) for IPPs. Under the CGM, generators compete to sell electricity to EVN based on their marginal costs, with the aim of improving operational efficiency. The government plans to further develop the CGM and introduce a competitive wholesale market and competitive retail market in the coming years.

However, Vietnam's electricity sector faces several pressing challenges:

1. Rapidly growing demand: Electricity consumption has been increasing at an average annual rate of over 10% in recent years, driven by economic growth, industrialization, and rising living standards. This puts immense pressure on the power system to expand generation and grid capacity to keep pace.
2. Financial losses at EVN: Despite recent tariff increases, EVN continues to incur significant financial losses due to high costs of generation, investment needs, and the provision of subsidized electricity to certain customer groups. This limits EVN's ability to invest in new infrastructure and poses risks to the long-term sustainability of the sector.
3. Investment challenges: Vietnam needs to attract substantial investment in new generation capacity to meet the growing demand. However, private investors face difficulties in securing bankable PPAs due to regulatory uncertainties, EVN's financial constraints, and the lack of a transparent and competitive wholesale market.
4. Energy transition: Vietnam has set ambitious targets to increase the share of renewable energy and reduce greenhouse gas emissions. This requires not only accelerated deployment of wind and solar power but also flexible sources of generation, such as gas and

storage, to balance the variability of renewables. Attracting investment in these technologies while ensuring system reliability and affordability is a complex challenge.

In this context, reforms to retail and wholesale electricity pricing, such as the introduction of two-part tariffs and capacity payments, could play an important role in addressing Vietnam's electricity sector challenges. By providing more stable and cost-reflective revenue streams for generators, these mechanisms could help to mitigate investment risks and ensure adequate capacity to meet demand. At the same time, retail tariff reforms could improve the financial viability of EVN and create incentives for efficient consumption. The following sections will explore these issues in more detail.

3. The two-parts tariff for the retail electricity market: capacity-based subscription fees

Having seen the difference between power and energy, we now understand that the electricity transactions in Vietnam today are based on energy used. This is the case in the retail market, when people, firms and administrations buy electricity from EVN, and also on the wholesale market, when EVN buys electricity from the power plants. On both markets, payments are determined by the multiplication of the amount of electricity sold and the unit price. Refer to ERAV website[2] for the retail market prices, and to the appropriate regulation[3] for wholesale market prices.

This may be about to change. On April 8th at the Vietnamnet seminar "Peak power supply in the dry season", Mr. Vo Quang Lam, Deputy General Director of EVN said that the group proposes a two-component electricity price mechanism pilot to be launched this year, aiming for widespread deployment from 2025. In other words, next year Vietnamese customers will see contracts based not only on energy, but on both power and energy.

The power rating of an electricity connection is called its capacity. This is the maximum power that the consumer can draw on during its contract period. This is also the minimum power that the producer must be able to generate.

For the retail market, two-parts prices are straightforward to implement. When subscribing an internet plan, a 1000 Mbps connection costs more than a 250 Mbps connection. In the same way, consumers can see why an electric connection capable of 12 kW should cost more than a connection capable of only 6 kW. The larger capacity needs better wiring and hardware.

In many countries, households' power bills have a fixed part, which depends on the capacity subscribed in kW, and a variable part, which depends on the electricity consumed in kWh. This international experience shows that a two-parts tariff can be designed with mechanisms to support retail electricity for living purposes for poor households. It is also compatible with time-

[2] https://www.erav.vn/gioi-thieu/c75/gia-ban-dien.html, and Decision No. 05/2024/QD-TTg.

[3] At the time of writing, MOIT Circular 57/2020/TT-BCT Stipulating Methods of Determining Electricity Generation price and Power Purchase Agreement.

of-use pricing for the variable part, in which the price of electricity bill is higher during peak hours, to entice customers to move their energy demand to off-peak hours.

Restructuring the tariff will also be an opportunity to reduce the cross-subsidies between consumer groups. At the moment, manufacturing industries enjoy retail electricity prices going as low as 999 - 1.133 VND/kWh during off-peak hours. On average, this customer category pays less than households. While it is important to create favorable conditions for industrial investments, subsidizing heavy energy-using industries is less a priority when the development goal is to achieve a high-income economy with net zero emissions.

Finally, increasing the retail tariff is necessary because it is unhealthy for the economy to let an essential state-owned entreprise bleed money too much. The average retail electricity price, which was set at 2006.79 VND/kWh (excluding value-added tax) on November 8, 2023[4] is still not enough to cover EVN's electricity production and business costs, which were estimated at 2,098 VND/kWh in 2023. Increasing EVN's income is necessary to restore its capacity to invest in the national power generation, transmission and distribution infrastructure. This is urgently needed. For example, according to the company, electricity consumption during the holiday period April 30th - May 1st this year increased by 37.2% compared to the same holiday period last year due to the heatwave.

Overall, the two-parts tariff for retail electricity is simply a fixed monthly fee based on the maximum capacity subscribed.

4. On the wholesale electricity market: capacity payments

The two parts tariff for the wholesale electricity market is not much different in principle, but the economics are much more interesting. First, the roles are reversed in that the buyer is the national electricity company, while the seller is the privately owned power plant. Second, the government can adjust the retail electricity tariff every 3 months, but on the wholesale market the power purchase agreement contract is typically signed for 20 years at least. The final investment decision will not take place until a contract is signed, at conditions acceptable for both sides.

In the wholesale electricity market, power plants sell electricity to EVN through long-term power purchase agreements (PPAs). The simplest PPA is an energy-only contract, where the power plant is paid a pre-agreed price for each unit of electricity delivered to the grid. This price is typically adjusted by a formula accounting for changes in key costs such as fuel prices, inflation, and exchange rates. However, under an energy-only contract, the plant only earns revenue when it is actually generating electricity. This creates significant financial risk, especially for thermal power plants facing reduced operating hours due to competition from renewable energy.

[4] Decision No. 1416/QD-EVN dated November 8, 2023.

The economic challenges facing thermal power plants are exemplified by the case of China's coal fleet. Between 2015 and 2022, the average annual operating hours of coal plants in China fell from 5000 to 4300, as increased solar and wind generation reduced the demand for coal power during daytime hours. This loss of revenue threatens the financial viability of coal plant operators.

Figure 1: After document 118. Source: author.

To address this issue, China introduced a two-part tariff for coal plants starting January 1st, 2024. In addition to the energy price, plants now receive a capacity payment of 100 yuan/kW/year (with some localities allowed to go up to 165 yuan), rising to 165 yuan/kW/year nationwide after 2026. This payment, which covers around half of a plant's fixed costs, is conditional on the plant being available to generate when called upon.

While the energy transition requires to phase out coal power as soon as possible, the sector is too big to fail in the energy system. Until there are solutions to provide electricity in the evening, the thermal plants are needed to ensure the system stability. However, the capacity payment system implemented by China has several shortcomings in my view.

First, it also applies to new coal power plants. This increases the risk of a catastrophic climate change.

Second, it applies only to coal power plants. A technology-agnostic approach would be economically more efficient. Coal is not the only option to fill the gap when solar and wind electricity are not available. In the UK Capacity Market 2022/2023, for example, most capacity was provided by gas to power units, followed by interconnectors, and then battery or pumped storage. Other important options include Distributed Generation, Energy Efficiency, and Demand Response. For example, facing the summer 2024 electricity demand peak, EVN increased capacity by borrowing diesel generators from its customers, and by signing agreements with dozens of industrial partners to reduce their electricity demand.

Thirdly, the capacity payment is an administratively fixed constant for all China, between 100 yuan and 165 yuan. This does not adapt to the local balance between capacity supply and need. This is less efficient than a system with locational pricing to reflect the limitations on the transmission system, such as the Pennsylvania-New Jersey-Maryland (PJM) capacity market. If capacity

payments were implemented in Vietnam, the fact that the North needs more capacity in the South at the moment would matter.

5. Summary and concluding remarks: capacity payments in Vietnam to support gas-to-power?

To summarize, a two parts electricity tariff pays the producer for both the electric energy and the power capacity it provides. On the retail market, this is straightforward: it is a fixed monthly fee, depending on the subscribed power. On the wholesale electricity market, it helps the thermal power producers. They are selling and less electric energy due to competition from renewable electricity sources. But because they do not depend on a variable natural resource flow, they are better positioned to provide guaranteed capacity to the system.

In Vietnam, capacity payments could potentially be used to support investment in gas-fired generation, which is currently challenging to finance. By providing a guaranteed revenue stream to cover fixed costs, capacity payments would reduce investment risks and make projects more attractive to developers. However, to be effective and efficient, a capacity mechanism should be technology-neutral, market-based, and locational to reflect Vietnam's transmission constraints and the regional imbalance between generation and load. Policymakers should study international experiences, such as the PJM and UK capacity markets, in designing an approach suitable for Vietnam's context.

Technical Box 1: The difference between Power and Energy

Most people in the street can hardly tell the difference between a kW and a kWh, and indeed the casual language often mix up power and energy. Energy is what allows to do work, but Power is what allows to do it quickly. Let's go back to the science, more precisely the high-school physics class, to dissect the difference between energy and power.

Physicists measure energy in Joule, in memory of James Prescott Joule's 1845 experiment on "The mechanical equivalent of heat", which led to the understand that work and heat amount was all the same thing: energy. One J is the work done by a force of 1 Newton over 1 meter. Considering a mass of 1 kg, any upwards force greater than 9.8 N – the acceleration of gravity is 9.8 m/s^2 – will make it move up. The minimum energy to move 1 kg up 10 m is 98 J. My rooftop tank is located 10 m above the yard tank and contains 1000 l that is 1000 kg of water: I need at least 98.000 J, or 98 kJ, to refill it. This is the minimum energy required, not accounting for any energy losses due to inefficiencies in the system used to lift the water.

How fast the tank will refill depends on the Power applied. Physicists measure power in Watt, in memory of James Watt, whose steam engine design patented in 1769 greatly contributed to the industrial revolution. One Watt is 1 Joule per second. It would take at least 98 kW to fill my rooftop water tank in one second. This is a very high power requirement for such a short duration, and it would be challenging to design a practical system that could deliver this much power instantaneously. In real-world applications, the power requirement would typically be lower, and the time taken to lift the water would be longer. A 500 W domestic water pump would require at least 196 seconds to provide the required 98 kJ. Again, this is the minimum time based on physics, in reality it takes much more than 3 minutes.

Instead of using Joules, domestic energy use is usually given in kW h. One kW h is the energy to run a 1000 W appliance during 1 hour. If it takes 12 minutes to fill the tank with my 500 W pump, the energy consumed is 12/60 *0,5 = 0.1 kWh. Using kW h is convenient alternative for everyday use as it is a much larger unit than the joule: one kW h is 3.6 million joules.

As of May 2024, the retail price for household electricity using prepaid card meters is 2 535 VND/kWh. At this rate, the electricity cost for 0.1 kWh to fill my water tank is about 253 VND. This is cheap. On the other hand, a 1 kW air conditioner running 24 hours per day during a 30 days month uses 720 kW h, costing more than 1.8 million VND.

I could fill my tank faster using a pump with more power, but physics reminds that this would not change the bill much. Energy used is the product of duration times power, so the savings of a shorter duration would be offset by the costs of a more powerful pump.