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ACHIEVING NET ZERO

IN THE THAI POWER INDUSTRY : RATIONALE AND GUIDELINES

2 December 2021

KEY SUMMARY

- **Power generation is one of the main sources of greenhouse gas (GHG) emissions**, accounting for approximately 30% of total global emissions. The power industry's transition towards cleaner energy use is crucial to achieving net-zero – as it can mitigate the impacts of climate change through the adoption of cleaner generation capacity and clean technologies, which are declining in cost.

- **Investments in fossil fuel power plants are no longer deemed to be low-risk** due to greater transitional risks from policy changes and stricter environmental and GHG emission regulations. Fossil fuel power plants risk becoming stranded assets as transitional risks intensify.

- **The Thai power industry cannot avoid the energy transition, given the pressures to meet the national target of net-zero by 2065 as announced at COP26.** Likewise, the industry faces pressures from the private sector, which must achieve their own net-zero targets at the organizational level, and from stricter environmental policies imposed by Thailand's trading partners.

- **Within the next decade, Thailand will need to dramatically increase the use of electricity from clean energy to maintain the country's competitiveness.** As trading partners adopt carbon border tax/adjustment mechanisms, which will add the impact of GHG emissions into the cost of goods, Thai businesses will benefit from having higher proportions of cleaner electricity as they would face lower carbon adjustments in trading markets.

- **Thailand has a highly reliable power generation capacity, which allows it to focus more on policy adjustments and investments in the energy transition**, such as new renewable generation capacity and smart grids. With higher system reliability, it would be possible to revise energy policies to remove inflexible long-term agreements, as well as speed up policy revisions on 1) electricity purchases to reduce the grid emission factor (GHG emissions associated with the production of electricity), 2) creating a transparent market mechanism to pass on costs, and 3) promoting efficient electricity consumption and clean electricity.

- **Optimal policy designs, market mechanisms, and widespread cleantech adoption are the key driving forces that will enable the power industry and Thailand to meet its net-zero ambition**, as announced to the global community. This transition will not only reduce harmful environmental impacts but strengthen Thailand's competitiveness as well.

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Clean technology (cleantech) has a vital role in reducing GHG emissions in the power generation sector. This is prompting investments to expand clean power generation projects around the world.

One of the primary sources of GHG emissions is the power generation industry, which accounts for approximately 30% of total global emissions. Such emissions mainly originate from the combustion of fossil fuels in thermal generation plants, including coal power plants, natural gas power plants, and diesel generators, which are the most prevalent power generation technologies adopted around the world.

Renewable power generation technologies have been acknowledged as important instruments for reducing GHG emissions. For this reason, investments in clean power generation are surging around the world. Such investments can reduce a country's grid emission factor by increasing the proportion of renewable energy in the generation mix. Meanwhile, the emissions intensity of each type of power plant over its lifetime (Levelized Carbon Intensity) depends on the technology and fuel used to generate electricity. For renewable power plants, such as wind and solar, the Levelized Carbon Intensity is considerably lower than fossil fuel power plants.

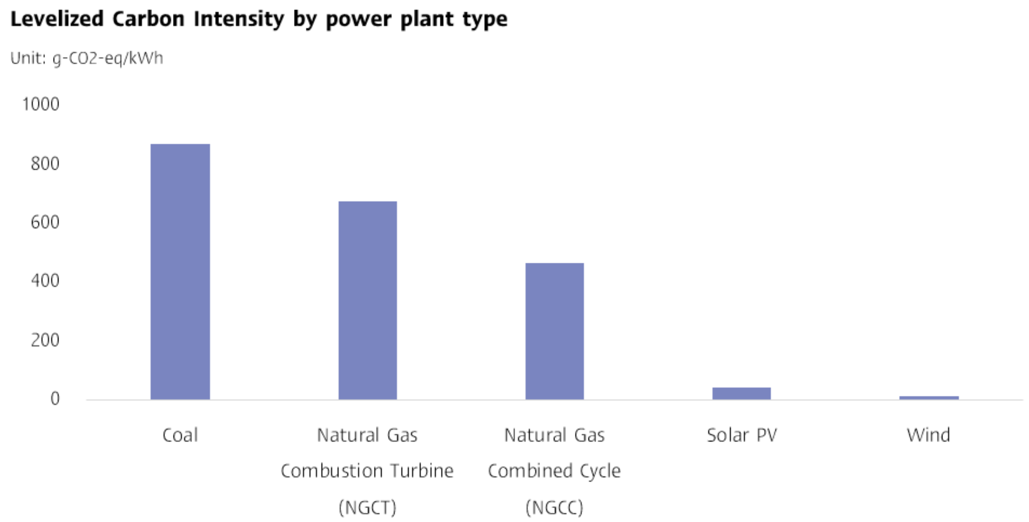
This article will focus on illustrating the dynamics of the power industry landscape, both from the global and Thai perspective, and will address the following issues:

- Drivers: The major drivers of GHG emissions reduction in the power generation sector,
- Challenges: The three challenges that the global power industry must confront from rapidly replacing fossil fuel power generation with renewable power, and
- Implications on the Thai power sector, which cannot avoid the energy transition.

Three key factors accelerating the reduction in GHG emissions in the power generation sector:

- **Net-zero commitments,** or, targets to reduce net GHG emissions to zero. Countries that have announced plans to achieve net-zero by 2050 include the US, the EU, the UK, Japan, and South Korea. Meanwhile, China plans to achieve net-zero by 2060.
- **Zero GHG emission technologies,** which have been technically and commercially proven, are seeing an immense expansion in generation capacity. In particular, technologies with zero marginal costs[1] will help to strengthen the country's competitiveness.
- **The costs of clean energy** will continue to decline as a result of competition between project developers and advancements in technology.

Figure 1: The Levelized Carbon Intensity of wind and solar power plants is more than 20 times lower than fossil fuel power plants.



Remarks: Utility scale

Source: EIC analysis based on data from UT Austin

Net-zero policies will speed up clean energy investments.

Around the world, more investments are being made to increase renewable energy power generation capacity to replace fossil fuels. As more countries are announcing net-zero policies, this trend will be further accelerated. According to the International Renewable Energy Agency (IRENA), from 2011 to 2020, the generation capacity of renewable power plants (excluding hydropower plants and off-grid systems) expanded by 17% per year. Solar generation capacity, especially photovoltaics, continued to increase, with a growth rate as high as 29% per year. Similarly, wind generation capacity increased by 14% per

[1] The marginal cost of producing one more unit of electricity (marginal cost of electricity generation) for fuels, such as wind or solar, is close to zero (zero marginal cost).

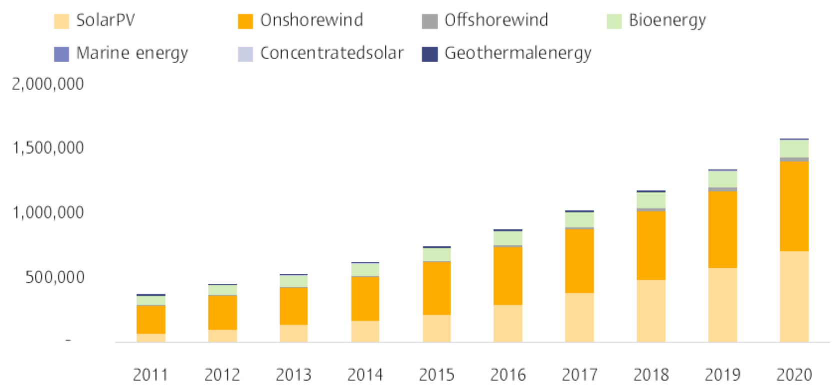
year. With such growth, as of 2020, the total global renewable generation capacity was around 1,600 GW, equivalent to 53 times the capacity demanded during Thailand's peak load, where over 90% was attributed to solar energy (solar constituted 46% of the cumulative generation capacity as of 2020, while wind comprised 45%, and the remainder came from other renewable sources such as those that required combustion, including biomass and biogas (8%), and geothermal (1%)).

Over the last decade, the value of global renewable investments increased by 3.7% per year, led by investments in the Asia-Pacific region. Of these investments, 50% were in solar power, and 40% were in wind power. Despite the global COVID-19 pandemic, renewable energy investments in 2020 totalled approximately USD 300 billion – a continued increase from 2019. In terms of renewable investments by region, investment growth in the Asia-Pacific region was 9.6% per year (2010-2020), higher than in the Americas and Europe.

Figure 2: Generation capacity and investments in renewable power plants continue to increase.

Global renewable generation capacity*

Unit: MW

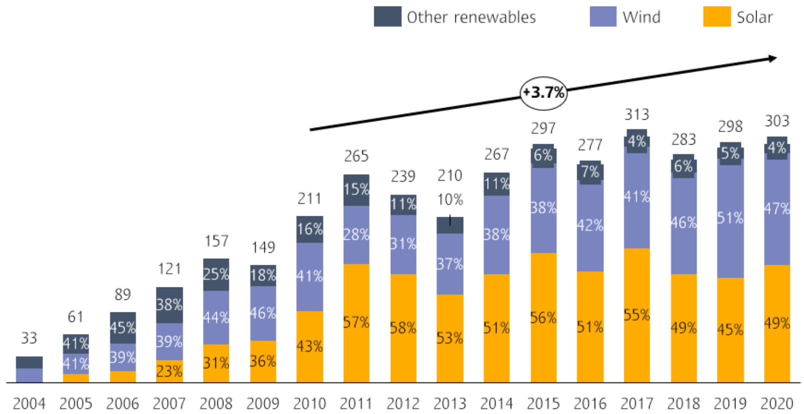


Remarks: Excluding large-hydro, small-hydro, and off-grid systems

Source: EIC analysis based on data from IRENA

Annual global investments in renewable energy by fuel type

Unit: billion USD per annum



Source: BloombergNEF

The cost of cleantech, especially for renewables such as wind and solar, have dropped significantly and will continue to drop further.

The costs of cleantech, such as wind and solar power technology, have dropped considerably as the efficiency of wind turbines and solar panels improved. Such efficiency improvements have provided higher electricity outputs and thus lowered the price per unit. Meanwhile, the technology of thermal power plants has reached maturity, as well as its physical limit for efficiency improvements[2]. Therefore, when including fuel costs, the cost of wind and solar electricity could be cheaper than fossil fuel-based electricity in all markets in the periods ahead.

As the costs of clean electricity declined, power purchase policies accordingly shifted from a subsidy-based approach to one that reflected the true cost of the technologies. Before this, incentives were required to promote clean electricity as the costs of renewable technologies, such as solar PV and wind turbines, were extremely costly. Government support was therefore mainly financial and included schemes such as feed-in-tariffs, a quota-based program that offered a fixed power purchase rate throughout a project's lifetime, to enable projects to generate returns on investments. This support was offered as the price of renewable technologies was so high that they were unable to compete with other technologies. However, as explained above, the cost of producing clean electricity per unit continued to drop, and measures to support renewable power generation in various countries shifted from a subsidy-based program to a program that reflected the actual cost of the technology. Such new support measures included the reverse auction scheme, where utility-scale renewable power project developers would bid according to the lowest price per unit of electricity that they anticipated generating from their projects. In addition, some markets, such as the EU, introduced mechanisms that allowed renewable technologies to compete with each other, for example, the price of wind generated-electricity could compete directly with solar. In other markets, such as the US, the price of electricity generated from renewable energy could compete directly with fossil fuel-generated electricity, as with the California Independent System Operator (CAISO) and PJM.

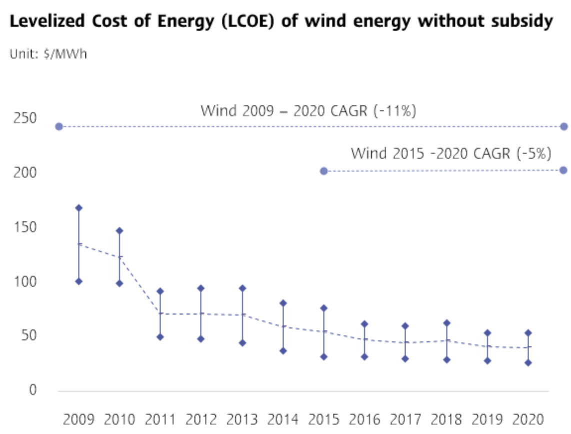
Competition among project developers is crucial for lowering clean energy electricity tariffs.

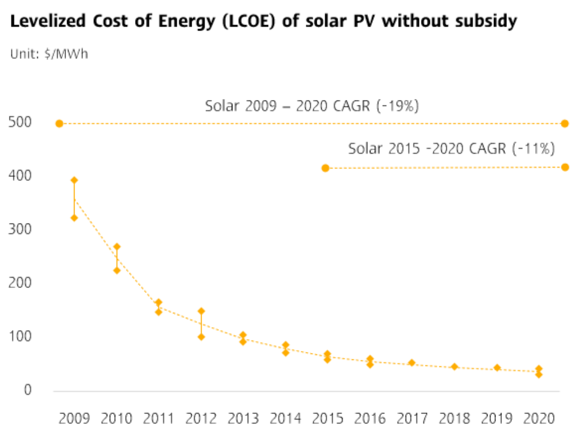
The highly competitive environment that project developers are facing around the world is triggering a virtuous cycle of demand for more efficient and cheaper cleantech. IRENA has reported that the weighted-average price from auctions during the first half of 2021 for winners of solar projects with signed power purchase agreements for commercial operation in 2021 was around USD 0.039 (approximately THB 1.2 baht) per kWh. Furthermore, the world record for the lowest bid during the same period was USD 0.0104 (approximately THB 0.32 baht) per kWh, for a solar project in Saudi Arabia. This auction price was lower and dropped faster than the estimated cost per unit of electricity that

[2] The upper limit of thermal efficiencies according to the 2nd law of thermodynamics.

would be generated during the project's lifetime (also known as Levelized Cost of Energy: LCOE). Such situations will force the price of clean energy technology to further decline. Going forward, competition will benefit a power generation industry that will continue to demand clean electricity at lower prices, whilst global power demand increases.

Figure 3: The cost of increasing electricity generation from renewable sources is currently much lower due to more efficient clean energy technologies, including solar and wind. Efficiency improvements allowed the cost per watt of electricity to drop significantly since 2009, which was reflected in much lower LCOE readings. From 2009 to 2020, the cost per unit of wind and solar electricity dropped annually by -11% and -19%, respectively.





Remarks: Utility scale

Source: EIC analysis based on data from Lazard

Ramping up renewable power generation to replace fossil fuel-based energy will create three challenges for the power industry.

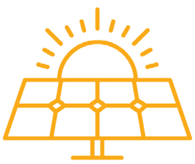
- **Higher demand for infrastructure investments:** Large investments are needed for transmission and distribution infrastructure to access potential renewable energy sources. The grid will also need to be able to accommodate and manage the unique variability of electricity generated from all types of renewable sources with high prospective growth, and balance electricity with the demand in the system.
- **Industry regulations:** Industry regulations need to be more flexible to accommodate a changing industry structure caused by growing renewable electricity demand, as well as the higher adoption of new technologies in the power generation supply chain, including smart grids.
- **Risk of stranded assets:** Fossil-fuel based assets risk becoming stranded due to changes in climate-related regulations.

The world must accelerate the expansion of transmission and distribution lines to accommodate clean electricity as well as adopt more digital grid management technologies.

The International Energy Agency, or IEA, estimates that the world urgently needs to increase investments in transmission and distribution infrastructure by threefold to accommodate the surge in electricity generated from renewable sources, especially as the world moves towards net-zero. IEA has reported that global investments in transmission and distribution infrastructure must increase from USD 260 billion per year to USD 820 billion per year by 2030. These investments in transmission lines to support higher generation capacity will mitigate the problems occurring from full transmission capacity, as well as increase access to more renewable energy sources.

Moreover, investments in new electricity grids should be designed to integrate various types of renewable energy technologies with different production profiles into the power system. For example, the system could integrate solar capacity that generates large amounts of electricity during the daytime with wind capacity that generates significant amounts of electricity during the nighttime. The transmission and distribution networks should also be upgraded into smart grids, as this will facilitate efficient grid management at lower costs. However, funding for transmission and distribution infrastructure investments, which are large-scale projects, requires cooperation from government bodies, project developers, and investors. Likewise, in cases where transmission and distribution (T&D) businesses are solely reserved for government entities, laws and regulations should be revised to allow for private investments, as this will take the burden off government investments and facilitate faster action to expand T&D infrastructure to match the growing demand for renewable electricity.

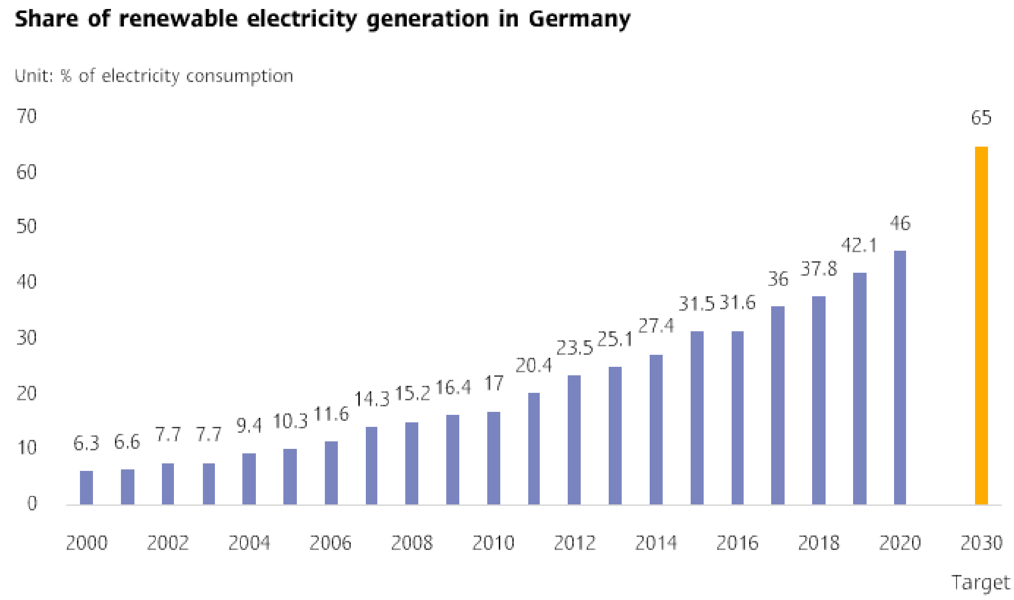
> “The intermittency of solar and wind in generation profiles and generation planning could be mitigated with new T&D investment, digital technology adoption, and suitable market mechanisms.”



The adoption of appropriate technologies will enable System Operators (SO) to effectively plan electricity supply and accurately forecast incoming electricity from solar and wind power plants at any given time, which will optimize system balancing. In this case, advanced forecasting is one such technology that will help to predict generation output from an intermittent supply of renewables – using real-time weather data. This weather forecasting technology is currently being developed by companies with industry-specific knowledge and expertise. One example is Google, whose artificial intelligence subsidiary, Deepmind, is currently developing machine learning algorithms that train on actual weather data to offer more accurate predictions as early as 36 hours in advance. Meanwhile, investments in storage technologies or batteries that dispatch stored electricity on a predetermined schedule will make it easier for SOs to balance between power supply and demand. Beyond investments, market mechanisms should be designed to facilitate the adoption of appropriate technologies and increase renewable power generation capacity without affecting the stability of the whole power system. A clear case study is the Feed-in Premium (FiP) for solar and wind projects in Japan, which requires power producers to communicate an energy output forecast every 30 minutes. Penalties will be applied in the case of forecast discrepancies, otherwise, producers will be required to operate backup generators to fill the output gap (this measure is expected to launch in 2022). With such measures, power plant projects will therefore need to adopt accurate power forecasting systems that make it easier to balance between electricity consumption and production – or system balancing – at all times.

Markets that support the trading of other power services, such as demand response[3] and ancillary services, with pricing based on demand, supply, and costs of electricity generation at any given period, will also help to maintain the quality of electricity in the system and further back clean energy adoption. Examples include Germany's transmission and distribution system, which can handle the country's 46% share of clean energy amid continually declining System Average Interruption Duration Index (SAIDI) figures. Furthermore, Germany aims to increase their share of clean energy production to 65% by 2030.

Figure 4: The transmission and distribution system in Germany can handle the country's 46% share of renewable electricity generation.



Remarks: Includes onshore wind, solar, biomass, offshore wind, and hydro

Source: The German Environment Agency (UBA)

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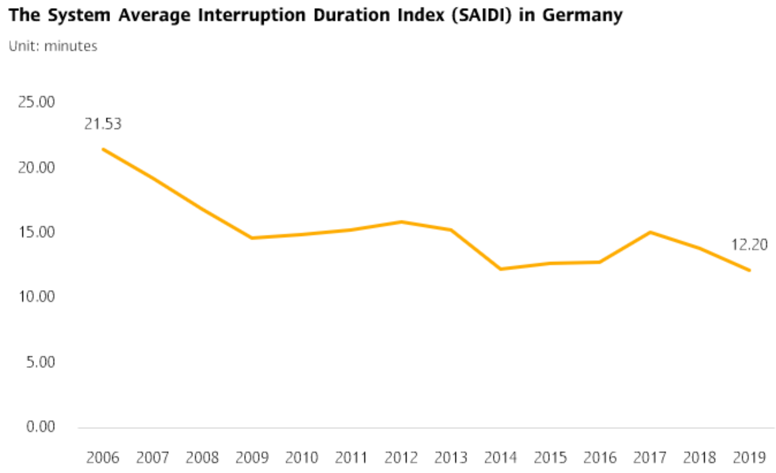
[3] Demand Response (DR) is a scheme or a special electricity price that incentivizes electricity users to reduce electricity consumption based on higher electricity prices in the market or during times when the power system is at risk of an unusual event or emergency.

Figure 5: The System Average Interruption Duration Index (SAIDI) in Germany continued to decline.



Source: Federal Network Agency (BNetzA) and Bundesnetzagentur

The energy transition is pushing the transformation of the power industry.

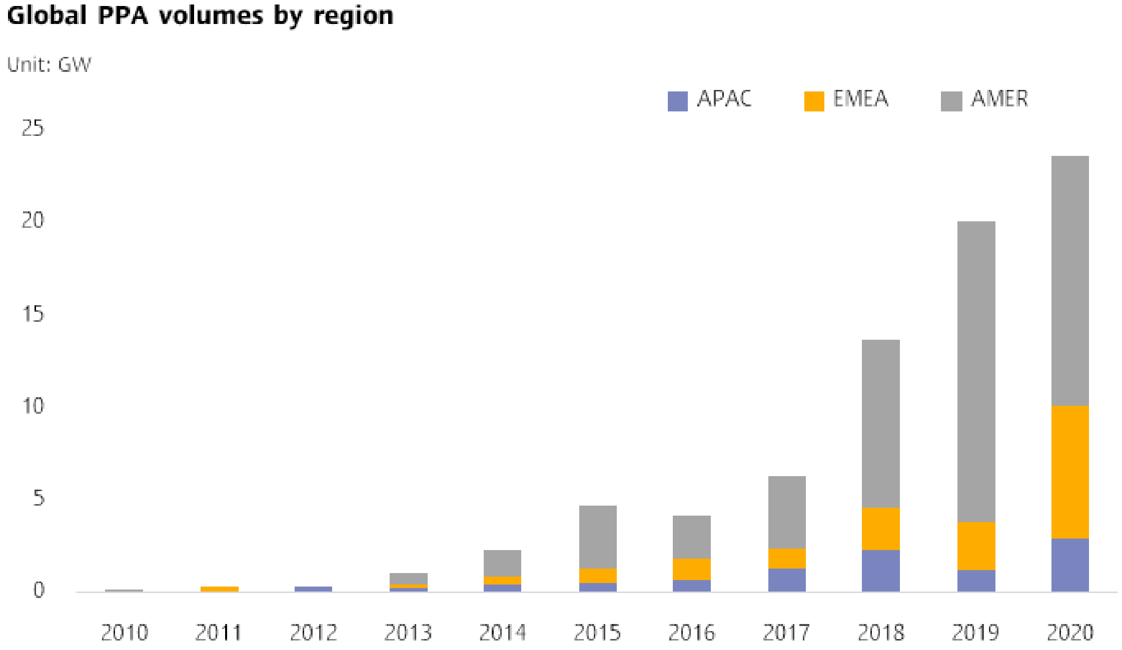
Going forward, the power industry will become more complex. Activities will not be confined only to electricity trading, as other power-related services will be added to the picture. Regulatory changes and market mechanisms to facilitate versatile grid applications will streamline the industry's energy transition pathways. And, as demand for clean electricity increases, the roles of different players in the power sector will also change. For example, electricity users with solar rooftop systems will become prosumers[4], while large-scale consumers in the private sector that need to purchase electricity from clean energy sources to offset operational GHG emissions for their net-zero targets will shift from purchasing electricity from utility companies and become off-takers – i.e., consumers that buy clean electricity directly from renewable energy generators. These prosumers are continuing to sign purchase contracts with clean energy producers. According to data from BloombergNEF, the installed capacity under the Private Power Purchase Agreements (Private PPAs) for power that is purchased from producers whose systems are not located in the same area as buyers[5] increased from 20.1 GW in 2019 to 23.7GW in 2020. These purchases grew despite the impact of COVID-19.

The increase in corporate Private PPA volumes reflects companies' dedication to embedding ESG factors in their business operations. As one example, various multi-national companies including Samsung, Nike, and H&M, which have production bases in Vietnam, urged the Vietnamese government to allow direct electricity purchases from solar and wind power plants. This incident subsequently prompted the government to consider developing pilot projects for large power users.

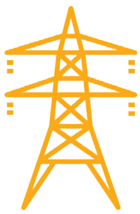
[4] When an electricity user becomes both a producer and consumer of electricity.

[5] In earlier stages, rooftop solar systems under Private PPAs were mostly on the buyer's own property or asset.

Figure 6: Increases in the volume of corporate Private PPAs with clean energy producers

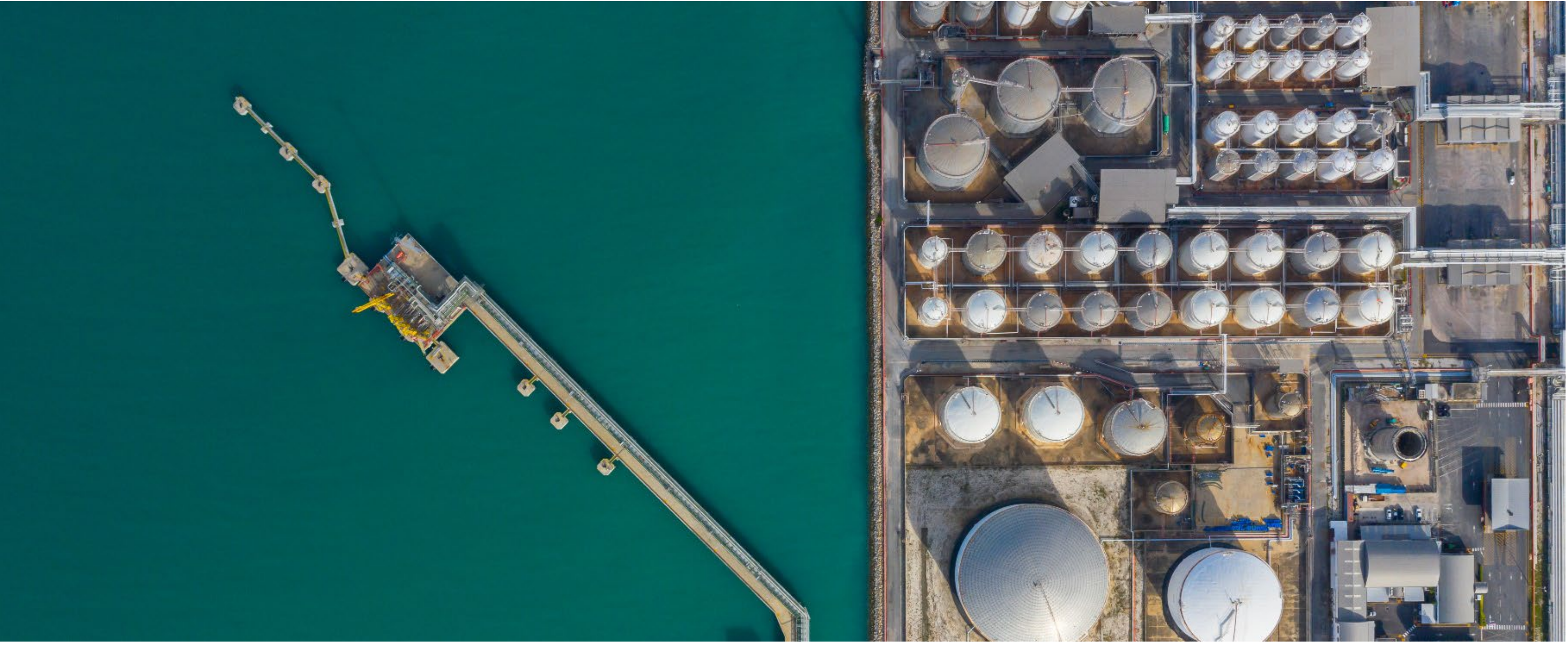


Source: BloombergNEF



> Business models may also shift more towards the trading of power-related services, as the wider adoption of renewable energy and related technologies into the power industry's value chain will change and complicate the operatingconditions of the power system. Fair market competition for ancillary services is therefore vital to maintaining the reliability of the system. In turn, supportive rules and regulations will be required to nurture flexible market conditions as well as ensure fair competition, sufficient supply, energy access and the lowest true costs of electricity.

Apart from the changing landscape for players, power industry business models may also shift more towards the trading of power-related services, as the wider adoption of renewable energy and related technologies into the power industry's value chain will change and complicate the operating conditions of the power system. Fair market competition for ancillary services is therefore vital to maintaining the reliability of the system. In turn, supportive rules and regulations will be required to nurture flexible market conditions that can readily adapt to the structural changes brought on by new technology as well as ensure fair competition, sufficient supply, energy access and the lowest true costs (technology and environmental costs) of electricity.



The energy transition is demonstrating the unique challenges that each country faces in transitioning to reliable, affordable, and cleaner energy in their respective power industries.

The energy transition is prompting countries around the world to confront their own challenges in ensuring a smooth transition to clean energy. For example, the energy crisis in China in October 2021 stemmed from the fact that more than 60% of the country's electricity generation relied on coal. When key manufacturing countries, such as Australia and Indonesia, faced production limitations in their coal mines, and China's coal mines were also unable to manufacture enough coal to meet increasing demand, the price of coal rose significantly globally and in China.

Moreover, requirements for coal-fired power plants to peg electricity prices to coal are preventing these plants from passing on higher fuel costs to the electricity price, therefore they do not have the incentive to generate more electricity input in the system. The result is that not enough electricity is being generated to meet demand, making it necessary to ration power use and request plants to halt operations – with potential implications on economic expansion. Mitigation measures must be urgently implemented to allow more fuel costs to be transferred to the final price by increasing the difference between coal-generated electricity prices to higher than ±20% of the reference fuel price – without increasing electricity prices for residential housing and industry consumers, and by requiring all coal power plants to enter the retail power market.

The European Union is also confronting an energy price crisis caused by the rising cost of natural gas. This is partly due to rising electricity demand – as renewable electricity generation output is lower than anticipated, there has been greater reliance on generation from gas power plants. Europe depends on up to 70% of natural gas imports. Over 45% of the natural gas that is used in the European Union comes from Russia, therefore there is the risk of supply disruption caused by international conflicts. For example, when Ukraine and Russia were in dispute over a gas pricing agreement in January 2009, Russia halted gas flows for 13 days and as a result, many countries in the European Union faced a gas shortage.

For this reason, Europe has recently been relying more on LNG. But the LNG market is a global one. As LNG demand increases around the world to respond to the speed of economic activity, this could lead to a surge in spot LNG prices and a shortage of LNG.

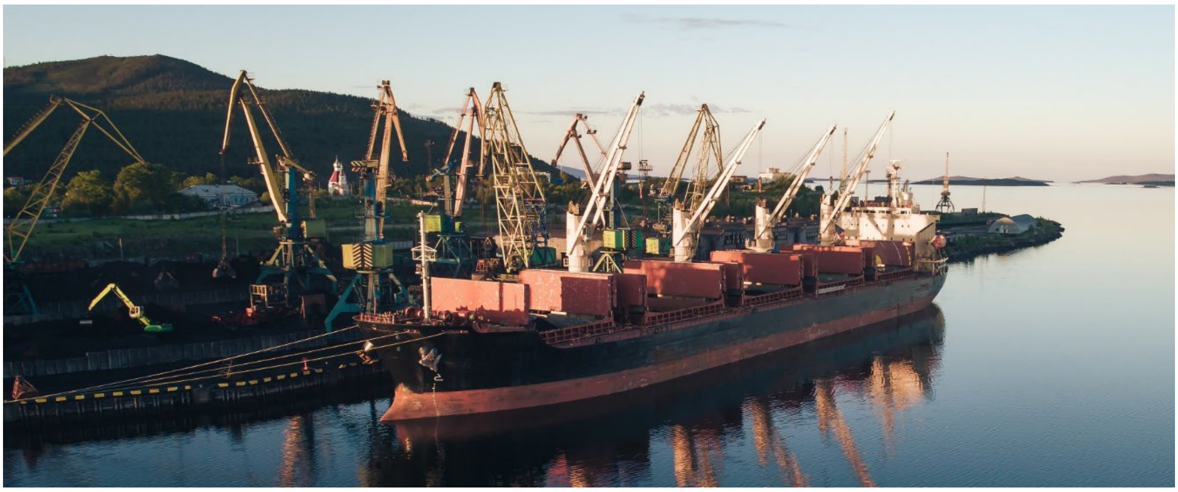
The U.S. similarly faces its unique challenges. The majority of the country's electricity transmission system has been through long periods of use, and there are difficulties in accessing locations with renewable power potential. Given this, it is necessary to expand and upgrade transmission lines. This has been proposed in the draft USD 1.2 trillion Infrastructure Bill, which allocated a budget for investments in infrastructure improvements – including in energy and research. The investment budget in the draft Bill was proposed to the U.S. Congress on 5th November 2021, which led to speculation that there would be investments in the energy sector to develop pilots for new energy technologies such as energy storage, to build a hydrogen hub, provide support for technologies relating to efficiency improvements and climate resilience, as well as smart grids. Nevertheless, there was limited budget available for investments in inter-state electricity transmission lines that would link renewable power sources to the main power transmission grid, as project areas would have to cover multiple states and require a sharing of cost burdens. Developing an interconnection project is therefore highly complex, and demonstrates that each country faces its own challenges. Accordingly, they will need to adopt management and mitigation measures that are most suited to their contexts.

> “These examples from different countries demonstrate that each is grappling with its own energy issue.The energy transition is making these issues more evident, for example for countries whose economies have long relied on fossil fuels; how political will is required to push through cleantech adoption, and the risk of an overliance on only one type of fuel source.”

These examples from different countries demonstrate that each is grappling with its own energy issue. There are therefore different policy approaches that they could use to address them and maintain a balance in energy security, affordability, as well as minimize environmental impact. Moreover, the energy transition has made certain issues more evident, for instance, countries whose economies have long relied on fossil fuels for electricity generation; the necessity of political will or policy commitments to invest in infrastructure development for cleantech adoption, and shifting perspectives on relying on only one source of fuel for energy. For example, it is no longer reliable to use natural gas as a main fuel source due to its fluctuating costs and dependence on specific transport systems. Doing so has caused risks around gas processing and distribution to consumers, price risks, and procurement risks to ensure a sufficient and prompt supply.

Transitional risks concerning policy and regulatory changes on environmental issues and greenhouse gas emissions mean that investments in fossil fuel-based power plants will no longer be low-risk. The costs of financing fossil fuel power plants, particularly coal, are increasing due to higher climate risks. In turn, financial institutions are increasing their loan interests for fossil fuel-powered projects as well. In May

2021, G7 countries agreed to end international financing for coal power plants that do not capture carbon by the end of 2021. Similarly, many commercial banks around the world such as ANZ, Barclays, HSBC, JPMorgan, Maybank, MUFG, Mizuho and UOB, have divested from coal-powered projects and/or will not invest in new coal-powered projects. In Asia, the Asian Development Bank announced that it would no longer provide loans for fossil fuel exploration projects. Although ADB did not announce that it would stop issuing loans to fossil fuel-based power plants, this still sends an important signal that new power plant projects, particularly coal-powered, will encounter greater financing challenges in the capital market.



Natural gas power plants are also facing challenges. The cost of generating renewable power has declined rapidly such that the marginal cost of constructing new renewable power plants is now lower than the cost of producing from an existing natural gas power plant – because these plants have additional fuel costs. Solar and wind power plants are two such examples that have zero marginal costs. In addition, clean technologies such as vehicle-to-grid[6] and demand response can be integrated into the power system to replace gas power plants in the form of a 'peaking plant'[7] or 'intermediate load power plant'[8], and will emit much lower amounts of greenhouse gases. Consequently, natural gas power plants, although seen as a transitional fossil fuel in the shift towards renewable power, also risk becoming stranded assets – where they will no longer be operational and do not generate returns. Gas power plant owners, particularly in the EU, are also planning to stop investing in the construction of new gas power plants, or are requesting to shorten their operational lifetimes to mitigate the risk that they would still be holding on to a fossil fuel-based asset as the power industry works to replace generation capacity with renewable energy.

[6] Vehicle-to-Grid (V2G) technologies allow electric vehicles to store energy and receive and discharge power into the transmission system.

[7] Power plants that generate power to support peak demand

[8] Power plants that generate power to cover demand between base load and peak load (therefore covering the 'intermediate' load).

The Thai power sector is facing an issue of oversupply and holds stranded assets and infrastructures that are not flexible enough to respond to the rapid expansion of cleantech.

The Thai power sector is currently facing an oversupply of power generation. Even under business-as-usual conditions, without an economic crisis, the real demand for power in Thailand grew by less than 3% per year between 2012-2019. The volume of actual electricity use was lower than the system demand forecast outlined in the Power Development Plan (PDP). In 2019, the actual demand for electricity in Thailand was around 190,000 GWh, lower than the PDP forecast of 210,000 GWh, or a difference of around 9%. When COVID-19 impacted the Thai economy, actual electricity demand was even lower than the forecast.

As for Thailand's peak demand, the highest demand (including peak demand from Independent Power Supply (IPS)) during the hot season in 2019 was 37,312 MW, while the country's generation capacity was 56,034 MW. This difference is enough to support another 15% increase in peak demand beyond the actual use volume in 2019, with 13,000 MW generation capacity remaining.

These circumstances, along with the ongoing impacts of COVID-19 on economic expansion, have resulted in lower electricity demand than under business-as-usual conditions. A resolution issued by the Committee of Energy Policy Administration (CEPA) on Thailand's energy use in mid-2020 specified that the Thai power industry had a reserve margin[9] as high as 37-40%. An CEPA Resolution from 14 May 2021[10] provided a newer assessment, and specified that the reserve margin in 2020 was "around 10% higher than estimates in the PDP2018 Rev.1." **All of these factors are pointing to an oversupply crisis in the Thai power sector.**

> "Private IPP power plants that will not operate in 2021-2027 have a total generation capacity of **3,534** MW."

The resolution further noted that several plants, including those belonging to EGAT and privately-owned, will not be operational. These include two EGAT-owned power plants that will not be operational in 2021-2025, as these are relatively old and have high generation costs. As a result, 1,152 MW of generation capacity will be decommissioned from service. There also remain many other older power plants with high generation costs that are on standby. Meanwhile, private IPP[11] power plants that will not be operational in 2021-2027 have a total generation capacity of 3,534 MW. The fact that there are power plants that have been invested in but are not operational **is an indicator that Thailand's power sector is already facing the problem of stranded assets.**

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[9] Reserve Margin refers to the generation capacity that is reserved for use when the system experiences a sudden surge in demand. Generally, the standard reserve margin is 15% higher than the historic peak demand.

[10] Energy Policy Management Committee Resolution 5/2021 (27th session) on 14 May B.E. 2564

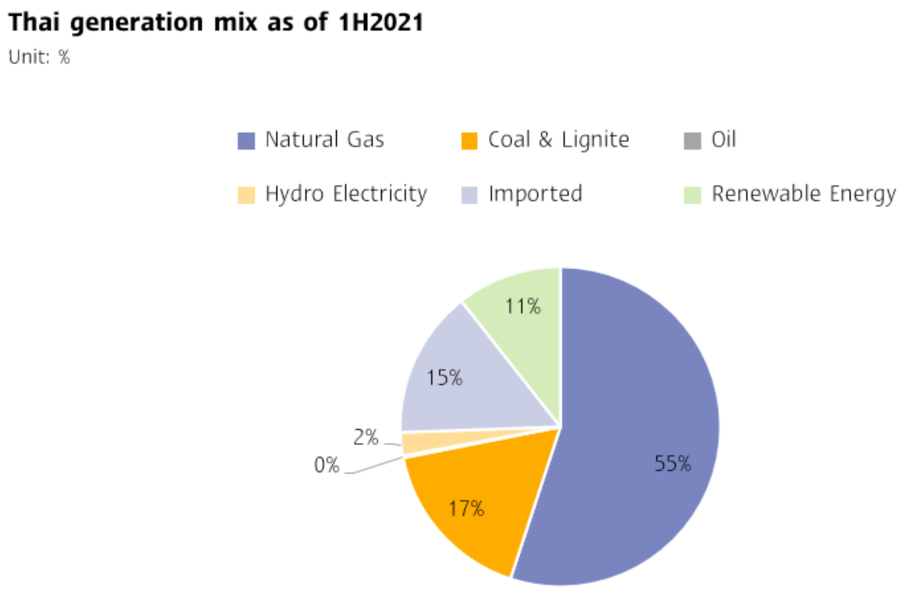
[11] Independent Power Producers (IPPs) are large-scale producers with very high generation capacity. IPPs are private producers that use commercial energy (not including nuclear) in electricity generation, such as natural gas and coal (domestic and imported), and have a generation capacity of over 90 MW.

The CEPA's resolution also specified that, if contracts with private power plants are cancelled in 2022, "*this will cost around 17,899 million baht, which is a difference of around 11,656 million baht compared to the cost of paying for the agreed contracts*." Even though cancelling the contracts of non-operational power plants before their expiration may help to reduce the public sector's spending on electricity purchases, these costs will ultimately be reflected in the end consumer's electricity prices. This would be the case no matter if power plant contracts are cancelled, or are not cancelled but left as non-operational until their contracts expire. This is because these costs derive from the revenue structure of long-term binding electricity purchase contracts with power plants. Such contracts had previously been designed with energy security in mind, to meet electricity demand that, in the past, had been expanding rapidly. **But, now that the nature of the Thai power sector is changing, it is time to design new structures to reflect these changes.**

The structure of Thailand's electricity purchase contracts and existing infrastructure are currently not flexible enough to support the rapid expansion of cleantech. This is because the trading of electricity and natural gas operates on the premise of 'take-or-pay', which is a binding condition where the buyer agrees with the seller to buy and receive a certain volume of electricity or gas. If the buyer is unable to receive the electricity or gas in the volume or within the timeframe that was previously agreed, they will have to pay for the value of the electricity or gas that they did not receive. The buyer must then compensate in the following year by receiving the volume of electricity or gas according to the value that had already been paid for. In addition, electricity purchase contracts are long-term contracts. For example, natural gas power plants run by IPPs agree on contracts based on project lifetimes of 25 years. That means that amending the contract after signing is difficult and costly. Changing the terms of a contract afterwards will also directly impact how profitable the project was to be when it was initially conceived.

Furthermore, as over 50% of Thailand's real power generation capacity comes from natural gas, the country faces risks from volatile natural gas prices, such as LNG, which is imported from overseas. Similarly, there are risks associated with procurement and supply disruptions, for instance, delayed deliveries and natural disasters that may negatively affect the volume of gas produced. Therefore, once Thailand's energy consumption landscape shifts due to changing electricity demand – caused by external pressures such as stricter environmental policies imposed by key partners, such as the European Union's Carbon Border Adjustment Mechanism (CBAM), and the demand for cleaner electricity from the private sector, especially those with linkages to the global supply chain – the power sector must adjust its procurement accordingly. However, at this stage, Thailand's electricity procurement is not responding quickly enough. This is because of the aforementioned factor concerning long-term binding conditions in purchase contracts with power plants, as they limit the sector's ability to respond to demand for cleaner energy without affecting the reliability of the power system or creating additional cost burdens on electricity users too quickly. Not only that, the infrastructure of the electricity transmission system is centrally controlled to enable national-level system governance, therefore it is not possible to view and control the volume of electricity entering and exiting the system at the node level. [12]

Figure 7: Proportion of Thailand's power generation, with over half of the generation from natural gas.



Source: EPPO

Carbon Border Adjustment Mechanism (CBAM) of the EU: A carbon tax applied to imported products that originate from countries with lower standards of GHG emissions reduction than the EU. The objective of the tax is to prevent manufacturing bases from being moved from the EU to countries with lower carbon standards to avoid the EU's stricter environmental measures and then exporting those products back into the EU, creating a carbon leakage. This measure will help to create equal competition for businesses in terms of environmental standards. Because of this, manufacturing costs for Thai products exported to the EU will increase due to carbon adjustments.

The Thai power industry may not be able to avoid the energy transition from fossil fuels to cleaner energy sources.

The adoption of cleantech will undoubtedly become widespread across the Thai power industry. When solar cell technology first arrived in the Thai power sector over the previous ten years, its costs were extremely high, and this prompted the government to issue a policy of purchasing the electricity generated from solar power to stimulate investments in new renewable generation capacity. Today, however, the costs of solar power have dropped significantly enough to allow consumers to invest in

[12] Nodes that have at least 2 branches of t&D line.

installing their own rooftop solar panels and to use the electricity generated from their systems to reduce electricity prices. This has subsequently led to a change in the behavior of consumers, who have become "prosumers," fundamentally shifted Thailand's overall daily load profile, as well as prompted a change in how electricity generation is managed.

The establishment of Thailand's National Energy Plan is a sign from policymakers that it is time for the country's power industry to change. According to the Prime Minister's announcement at COP26 of the UNFCCC in Glasgow, U.K. on 1 November 2021, the Plan states that Thailand will become carbon neutral[13] by 2050 and net-zero by 2065, and further includes the target to strengthen the country's competitiveness and investments in the low-carbon economy. However, Thailand's ambition for net-zero by 2065 is relatively slow compared to those of other countries, such as the U.S., Japan and the EU's 2050 target, and China's 2060 target. Interested energy policymakers, therefore, regard Thailand's target as being insufficient. This could impact the country's competitiveness over the long term if partner countries decide to apply a carbon adjustment policy that makes the cost of Thailand's product exports uncompetitive.

Table 1: Definitions of GHG emissions reduction targets

	Net zero / climate neutral	Carbon neutral	Carbon negative/positive	Climate positive	Zero carbon	Zero emissions
Carbon Dioxide (CO_2)	✓	✓	✓	✓	✓	✓
Other greenhouse gas emissions (CH_2, N_2O, Fluorinated gases, etc.)	✓	✗	✗	✓	✗	✓
Emission offsets	✓	✓	✓	✓	✗	✗

Source: EIC analysis based on data from BNEF and company information

[13] Carbon neutrality refers to the release of net-zero carbon emissions.

The National Energy Plan's policy directions to promote green energy investments in the energy sector, as outlined in the resolution of the National Energy Policy Committee meeting on 2/2021, are as follows:

- Increase the portion of new power generation from renewable energy to at least 50%, in alignment with much lower renewable energy costs, while also considering the costs of long-term energy storage systems and ensuring that the cost of electricity generation does not increase in the long term.
- Shift to green energy use in the transport sector by using electric vehicle technology under the 30@30 policy. This will support the achievement of greenhouse gas reduction targets, increase efficiency in energy use in the transport sector, and address the issue of PM2.5 pollution. To date, the National EV Policy Committee has established a policy to increase the use of EVs to more than 30% by 2030, which already aligns with the 30@30 Policy. If it is possible to speed up these efforts, the proportion of overall EV use will increase even further going forward.
- Increase energy efficiency by more than 30%, which is one of the first measures that must be implemented to reduce greenhouse gas emissions. This can be achieved by promoting the adoption of modern energy management technologies and innovation to increase energy management efficiency. In turn, this will help to achieve greenhouse gas emissions reduction targets in the energy sector much faster.
- Restructure energy businesses to support the energy transition by using the 4D1E approach, consisting of Decarbonization in the energy sector, Digitalization of energy management systems, Decentralization, Deregulation to support more modern energy policies, and Electrification.

"Competition to meet net-zero targets will further increase demand for clean electricity. Meanwhile, the costs of energy technology will decline even further due to improved efficiency and greater expertise in manufacturing and installing these technologies, leading to more widespread adoption of cleantech."

Competition to achieve net-zero targets at both the national and organizational level, particularly in the private sector globally and in Thailand, will cause an even greater demand for clean electricity. Meanwhile, the costs of energy technology will decline even further due to improved technology efficiency and greater expertise in manufacturing and installing such technologies. This will lead to more widespread cleantech applications. Indeed, the use of cleantech will not only be limited to Distributed Energy Resources (DERs), which refer to a distributed electricity manufacturing and storage system, but will also become more diverse based on needs, and more complex as the equipment is becoming more digitalized.

Thailand's electricity generation capacity, while higher than real demand and therefore a cost burden on users, could be used to protect against the risk that the country would have a gap in electricity generation as consumption behaviors shift during the power sector's energy transition.

The process of transitioning to clean energy to replace fossil fuels will occur gradually, as the new power purchase agreements that are developed based on various PDPs will have long-term binding conditions. Furthermore, investments in new cleantech infrastructure, such as transmission lines, will also require time. As a result, **the invested generation capacity of large-scale power plants, whose power purchase agreements have yet to expire, can be useful. Having a generation capacity that is higher than demand will help to minimize the risks from change in consumer behaviorfor many years.** In this way, it will not be necessary to construct new large-scale fossil fuel power plants to ensure power reliability while the Thai power sector is on the energy transition pathway.

While the Thai power industry has high power generation stability, it is necessary to focus on:

- **Investments to expand and improve the coverage of transmission lines and upgrade them to smart grids;**
- **Revisions to relevant energy policies, including:**
  1) **Electricity procurement, to reduce the grid emission factor,**
  2) **Creating market measures to transfer costs transparently, and**
  3) **Promoting efficient electricity use, and from renewable origins.**

Ramping up investments to upgrade transmission lines into smart grids is essential to ensuring readiness for clean electricity demand and to managing operational risks within the power industry. This is because **the transmission line system is critical to the security, reliability, and affordability of the power system throughout the duration of the energy transition.** Moreover, having a sufficient transmission line system, as well as good data collection and communications systems, will decrease the risk of the power system being damaged by system faults or climate risks, the latter which could lead to more extreme weather events such as more severe and frequent storms[14] that could damage the system.

[14] ADB: Climate Risk and Adaptation in the Electric Power Sector

Revisions to the power purchase policy should focus on reducing the long-term grid emission factor from electricity generation, to support the conditions of the power industry and distribute risks from relying on only one type of technology.

Electricity procurement should not be focused on increasing renewable generation capacity whilst there is an oversupply, as consumers are already bearing the costs of this oversupply. Instead, plans should focus on securing electricity from cleantech without relying too much on one type of technology and designing market mechanisms to trade power services for the system's needs in terms of volume, quality, and fuel source. Furthermore, the conditions for power purchase agreements with new power plants should be revised for both fossil fuel and renewable energy plants, to be more flexible in responding to changing power consumption needs and the market mechanisms of a power industry that will no longer be limited only to electricity trading.

In the future, power purchase agreements should include lower Availability Payments and Capacity Payments for power plants with the Firm contracts.

These power plants can input electricity into the system continuously and stably. Current power purchase agreements have an agreement structure that stipulates that this specific group of power plants generate income by providing generation capacity when SOs require electricity to be dispatched into the system. These are referred to as availability payments and capacity payments. However, because the current generation capacity is at an oversupply, the majority of generation capacity in Thailand's power system, such as natural gas and hydropower plants, can be increased or decreased its generation ouput quickly enough to match power generation from solar and wind power. A report by the IEA[15], which assessed the flexibility of Thailand's power system, has specified that the system is flexible enough to support more renewable energy than it is currently[16]. Indeed, if solar and wind energy constitutes 15% of total power consumption by 2030, the Thai power system will become flexible enough by using generation from large hydropower plants and CCGT[17] natural gas power plants to support electricity demand.

[15] IEA: Thailand Power System Flexibility Study

[16] According to the EPPO, the proportion of renewable energy, including biomass, from January to August 2021, constituted 10.5% of total electricity generation from various fuels, totaling 141,412 kWh.

[17] Combined Cycle Gas Turbines

Planning for the adoption of other cleantech in the power system will help to distribute the risks of overly relying on one type of technology, and fulfill the system's needs both in terms of electricity volume and quality. The current use of hydropower and natural gas power generation comes with its limitations. For example, the volume of water fluctuates according to season, and the costs of natural gas could increase with Thailand relying more on natural gas imports. By using other technologies, such as different types of energy storage systems, the sector can spread risks and ensure that the technologies complement each other. Examples include battery technologies that can immediately dispatch stored energy into the transmission system; Flywheel energy storage (FES) technology, which addresses the issue of frequency in the power system; or hydrogen technology, which can store more energy when scaled up as a large project and for a longer duration, with minimal energy loss.

Furthermore, transmission systems that have been upgraded with smart grid technology will be able to connect and communicate with any generator or energy storage unit, no matter the technology or unit size. When integrated with the capabilities to visualize system demand at the node level, solar or wind power generation can be increased according to the level of readiness at each node of the smart grid system. Consequently, there would be no need to specify conditions that limit generation capacity, for example, MEA's requirement that rooftop solar panels, which are linked to MEA's distribution transformers, must have a generation capacity that is lower than 15% of distribution transformer rating.[18] Fundamentally, this will help with the efficient management of transmission systems and reduce the long-term costs of transmission system management. And, aside from supporting energy technologies that are more likely to enter the system in the future, this will help to encourage the growth of a new power business model that is not only limited to purchasing units of electricity, but also open the market to power trading solutions, such as grid ancillary services, as well.

The creation of a power trading market is a measure that will encourage competition and transparency in electricity pricing.

As the costs of each type of power plant will vary depending on their technology, and demand on the system varies by period, a good power trading market will serve as a mechanism for revealing market conditions through the price per unit of electricity, demonstrating:

1) The highest per-unit cost of production that is necessary to maintain the supply and balance of the electricity system.
2) The price that users are willing to pay for their electricity needs.
3) The readiness of the transmission line in each area, or at each node.

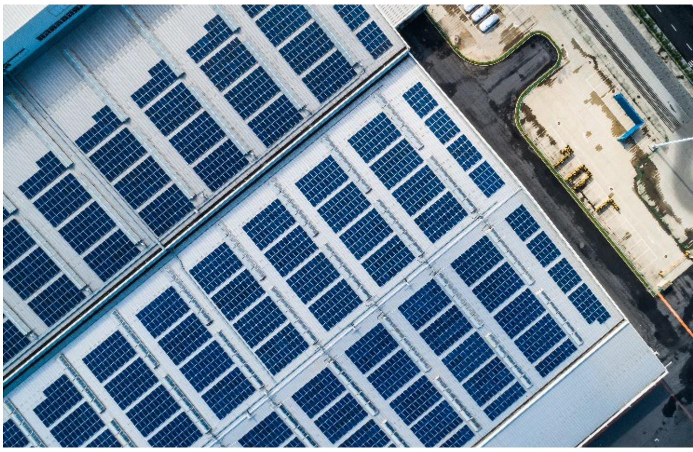
Determining costs in this way will also encourage efficiency improvements among power producers, to allow them to compete with other players using energy payments based on market conditions. Meanwhile, transmission system operators are also regularly improving the efficiency of their

[18] The Metropolitan Electricity Authority (MEA)'s regulations on electricity grids, Section 2, Limitations on Solar PV Rooftop systems.

transmission lines in order to reduce management costs and avoid creating cost burdens on electricity users. This will be a benefit for users, who will be able to purchase power at a cheaper cost due to improved efficiency, and with prices that are transparently disclosed by market mechanisms.

In addition, there are other necessary conditions in designing a power industry to support the ongoing energy transition. This includes improving market choices for consumers to purchase power and services according to their needs. For example, providing the opportunity for prosumers with excess electricity to participate in the market by becoming a 'virtual power plant'[19]; offering consumers the choice to purchase clean electricity from the market or directly from clean electricity producers to meet their organization's net-zero target without physical area limitations, or to become limited pilot projects.

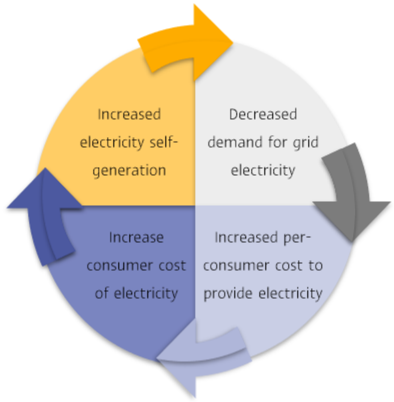
Power purchase policies should proactively support efficient electricity use and electricity purchases from clean energy sources.



Policies to enforce efficiency improvements in energy consumption are fundamental across all sectors, as well as policies to promote electrification. In terms of the structure for retail electricity prices, aside from having to reflect production costs, all groups of electricity consumers must be engaged with using technology and transparent information, to provide them with clear communications on why price increases, such as wheeling charges, are necessary, and what the increase will be used for. This will encourage consumers, particularly those in the prosumers group, which is expected to keep growing, to remain within the structure of the power industry and avoid the 'death spiral' that occurs when one group of power users breaks away from the main power system to turn to other power sources, such as off-grid systems and DERs. If this occurs, there will be a decrease in the number of consumers in the system, higher system costs per user, and overall higher electricity prices – which is why more electricity users are moving away from the main power system. Technologies such as smart meters and information management should therefore be used to help increase the management efficiency of power businesses, and DERs, which are linked to the system, should assume a role in more flexible power system management.

[19] Collating the generation capacity from DERs (Distributed energy production and storage systems) to sell on the power market in the same way as a large power plant.

Figure 8: The "Death Spiral" that occurs when one group of power users breaks away from the main system to rely on another source of energy.



Source: EIC analysis

Overall, there should be an application of market mechanisms that promote the use of cleantech or electricity from renewables. Examples include regulatory adjustments to allow Off-site Direct PPAs to be possible, and a carbon offset market with certification processes in line with international standards, to provide consumers with choices of measures to reduce their greenhouse gas emissions, particularly in hard-to-abate sectors such as steel, cement, and chemical manufacturing.

Three key factors will determine the energy transition direction in Thailand's power sector: technology, market and policy.

Although cleantech is now competitive, its applications remain limited. There is both a lack of market support due to unsupportive industry infrastructure and limited openness to pilot cleantech, which will make it difficult to meet the government's objective of reducing greenhouse gas emissions by replacing fossil fuel-based energy with renewable energy. Relying on generation from natural gas, while considered a relatively lower greenhouse gas-emitting fossil fuel compared to other fossil fuels, may ultimately not help Thailand achieve its net-zero target.

Over the next decade, optimal policies, market mechanisms, and the adoption of cleantech will be the keys to achieving net-zero in the power sector and Thailand. The focus should not only be on reducing the costs of electricity, but also providing reliable power using zero-emission energy sources, and ramping up electrification in other sectors such as industry and transportation. All of these measures will result in positive environmental impacts as well as enhance Thailand's competitiveness.

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