CFNT
Climate Finance Network Thailand

Briefings

A Better Path is Possible:

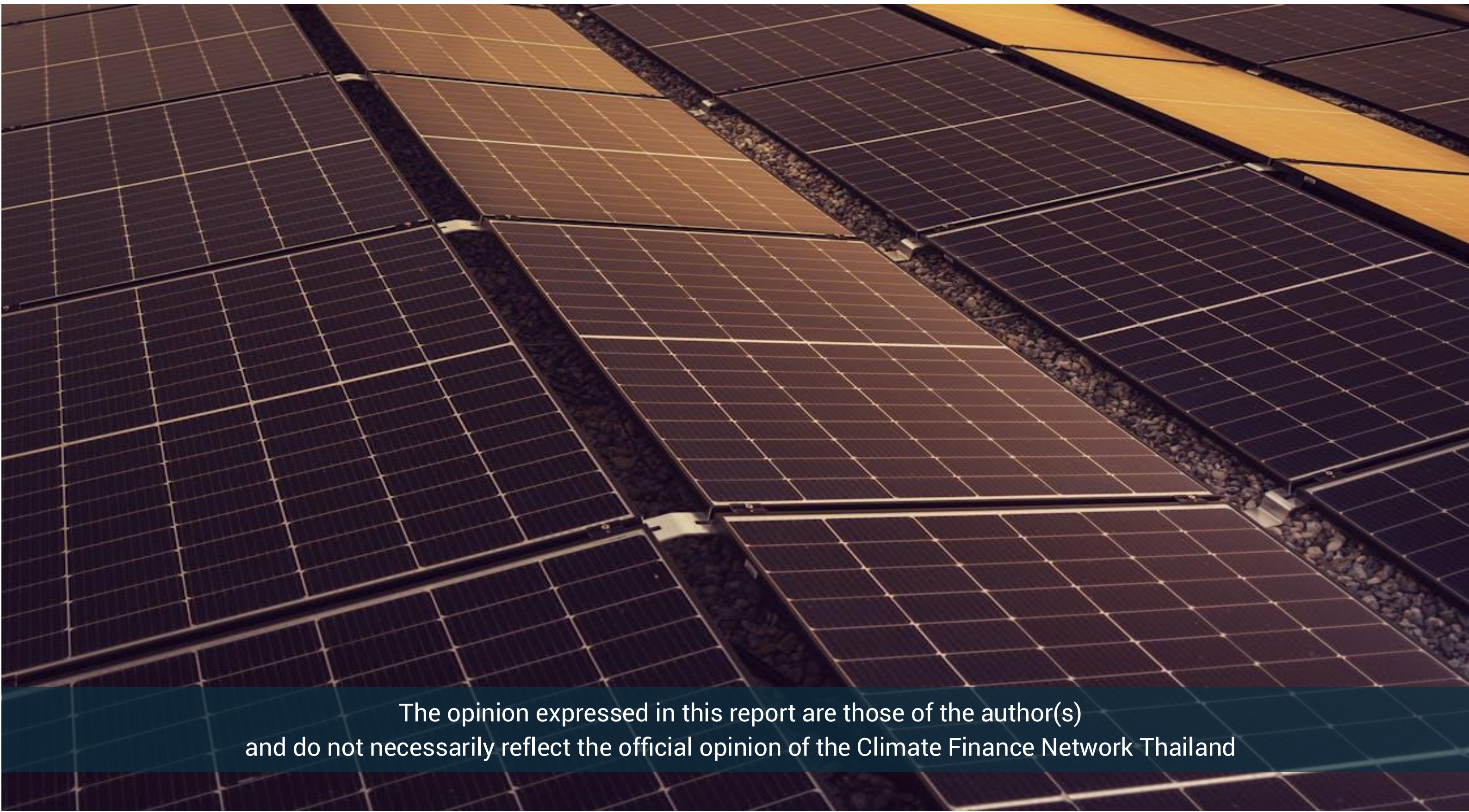
Critique and Suggestions to Draft PDP2024

July 2024

by

Rapeepat Ingkasit

Nawaphat Junkrajang



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Abbreviations

CCS	Carbon Capture and Storage
CO_2	Carbon dioxide
DAC	Direct Air Capture
GHG	Greenhouse gas
EPP	Energy Pool Price
EPPO	Energy Policy and Planning Office
ERIA	Economic Research Institute for ASEAN and East Asia
ETS	Emission Trading System
FiT	Feed-in-Tariff
GgCO2 eq	Gigagram carbon dioxide equivalent
IEA	International Energy Agency
IEEFA	Institute for Energy Economics and Financial Analysis
IRA	Inflation Reduction Act
IPCC	Intergovernmental Panel on Climate Change
kWh	Kilowatt-hour
PDP	Power Development Plan
MMV	Measurement, Monitoring, and Verification
$MtCO_2$	Megatonnes of carbon dioxide
MTPA	Million Tonnes per Annum
MW	Megawatt
MWh	Megawatt hour
NDC	Nationally Determined Contribution
LCOE	Levelized Cost of Electricity
LT-LEDS	Long-term Low Greenhouse Gas Emission Development Strategy
LNG	Liquefied Natural Gas
LOLE	Loss of Load Expectation
SMRs	Small Modular Reactors
T&S	Transport and Storage

About Us

Climate Finance Network Thailand (CFNT) is a think tank and network of like-minded individuals headquartered in Bangkok, devoted to propelling sustainable financial practices and assisting in Thailand's transition toward a low-carbon economy in line with 1.5°C climate target. CFNT's primary objective is to help catalyze impactful climate finance through solution-based research, stakeholder engagement, and network building. Our goal is to assist Thailand's financial sector to be more responsive to the challenges of climate change. By uniting forces with like-minded partners, CFNT endeavors to help shape a financial landscape that aligns with global sustainability goals and fosters a resilient, green, and inclusive economy.

Website: https://climatefinancethai.com
Email: info@climatefinancethai.com

Authors Contact

Rapeepat Ingkasit
Email: rapeepat@climatefinancethai.com

Nawaphat Junkrajang
Email: nawaphat@climatefinancethai.com

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Key Takeaways

- Draft PDP2024 prioritizes fossil fuels, particularly natural gas, with 6,300 MW of new gas plants scheduled for installation between 2027 and 2037. This will constitute 41% of the energy mix in 2037, despite the high volatility of LNG prices and Thailand's commitment to achieving carbon neutrality by 2050.
- Draft PDP2024 does not include the high costs associated with carbon emissions, including those from a forthcoming carbon pricing mechanism under the draft Climate Change Act and carbon capture and storage (CCS) initiatives to be implemented from 2040 to 2050. Consequently, the plan does not specify who will bear these additional costs.
- Despite Thailand's significant solar potential and decreasing costs of solar energy, draft PDP2024 does not prioritize solar energy development. Instead, it focuses on unproven technologies like Small Modular Reactors (SMRs) and hydrogen blending and relies on socially and ecologically disruptive imports from large hydropower projects, which may not be as cost-effective or reliable as in the past.

Introduction

Thailand's draft Power Development Plan 2024 (draft PDP2024), which underwent a rushed public hearing process in June 2024, ostensibly marks significant progress towards reducing carbon emissions in the Thai energy sector. The plan aims for an energy mix comprising 51% renewable sources, an improvement from the 36% target in PDP2018 Revision 1, the most recent plan. Draft PDP2024 claims that it is aligned with Thailand's Long-term Low Greenhouse Gas Emission Development Strategy (LT-LEDS)[1] and surpasses the country's second Nationally Determined Contribution (NDC)[2]. The plan is said to provide three main benefits: security, with a Loss of Load Expectation (LOLE) of less than 0.7 per year; economic efficiency through appropriate electricity rates; and sustainability with carbon emissions aligned with NDC and LT-LEDS.

At first glance, it seems Thailand is ramping up its low carbon ambitions after losing its position as the renewable energy champion in ASEAN to Vietnam. Nevertheless, the details reveal a different story. Despite the headline figure of increasing renewable energy share to 51%, draft PDP2024 continues with nearly all the new gas plant projects proposed in PDP2018 Revision 1. Specifically, 6,300 MW of new gas plants are slated for installation between 2027 and 2037, a slight decrease from the 7,700 MW planned in PDP2018 Revision 1. On a positive note, the government has abandoned plans for an additional 2,000 MW of coal-fired power plants, which would have jeopardized Thailand's carbon neutrality target for 2050 and net zero target for 2065.

Our recent research[3] on potential stranded asset costs in the gas and coal power plant sectors, using PDP2018 Revision 1 as a baseline, revealed that aligning emissions with the current NDC would result in stranded costs of approximately THB 360 billion. An updated estimation based on draft PDP2024 shows a minimal reduction in stranded costs to THB 330 billion, or around 9%. This

[1] MNRE (2022) Thailand LT-LEDS (Revised Version)_08Nov2022.pdf (unfccc.int)
[2] ONEP (2020) Thailand Updated NDC.pdf (unfccc.int)
[3] CFNT (2024) Fossil Reckoning: Valuation of Coal and Gas Stranded Assets in Thailand - CFNT (climatefinancethai.com)

indicates that pursuing the pathway outlined in draft PDP2024 still expose Thailand to significant transition risks in a low carbon world.

Draft PDP2024 claims an average electricity cost of THB 3.87 per unit, arguing this is economically viable despite private sector concerns that it remains uncompetitive compared to Vietnam and Malaysia[4]. Notably, this figure excludes additional costs from the carbon pricing mechanism planned to be introduced in the draft Climate Change Act, the costs from Carbon Capture and Storage (CCS) set for implementation from 2040 onwards per LT-LEDS and does not account for the high volatility of LNG (Liquefied Natural Gas) prices. As Thailand's gas resources in the Gulf of Thailand are depleting, the country will need to rely on approximately 40% of gas imports, or more if additional 'potential gas' in the Gulf of Thailand does not materialize.

Draft PDP2024's choices for low carbon emission energy sources are also debatable. Thailand has significant potential for solar PV, with the second-lowest levelized cost of electricity (LCOE) for solar in ASEAN. However, solar power is projected to account for only 17% of the energy mix in 2037, while the controversial imported electricity from new hydropower project in the Mekong River constitutes 15% of the energy mix. The plan also includes unproven and expensive technologies such as 600 MW of Small Modular Reactors (SMR) and the blending of 5% hydrogen into on-grid gas power plants starting from 2030.

Additionally, the emissions pathway outlined in draft PDP2024 appears overly optimistic. It claims alignment with LT-LEDS despite the renewable sources making up only 51% of the energy mix by 2037. LT-LEDS clearly states that to achieve carbon neutrality by 2050, renewable electricity should account for 68% of total generation by 2040 and 74% by 2050. This would require a substantial and unlikely addition of 17% in renewable energy within the energy mix in only 3 years, between 2038 and 2040, which seems unrealistic.

Thailand's energy sector is the most carbon-intensive sector, with total direct GHG emissions from the energy sector in 2018 estimated at 257,340.89 $GgCO_2$ eq, accounting for 69.06% of the country's total GHG emissions. The majority of GHG emissions in the energy sector is generated by fuel combustion, mostly from energy industries at around 103,055.20 $GgCO_2$ eq[5]. Therefore, the power development plan is central to transitioning Thailand to a low carbon economy. Achieving a low emission grid with higher electrification penetration will enable Thailand to contribute more significantly to global efforts to tackle climate change.

In this CFNT Briefing, we will dive deep into the additional costs such as carbon pricing and carbon capture and storage (CCS) which are not included in draft PDP2024 and how they affect the electricity rate. We will also explore the three low carbon sources including imported hydroelectricity, SMR, and blended hydrogen, which seem to be false solutions rather than viable alternatives. Lastly, we propose an alternative energy pathway that emphasizes aggressive solar power expansion.

[4] ENERGY NEWS CENTER (2024) เอกชน แห่ร่วมแสดงความเห็นแผน PDP 2024 จี้ลดค่าไฟฟ้า พลังงานแจงสัดส่วนไฟฟ้า กฟผ. ปลายแผนฯ เหลือ 17% | Energy News Center
[5] MNRE (2022) Thailand LT-LEDS (Revised Version)_08Nov2022.pdf (unfccc.int)

Hidden Costs

Carbon Pricing Mechanism

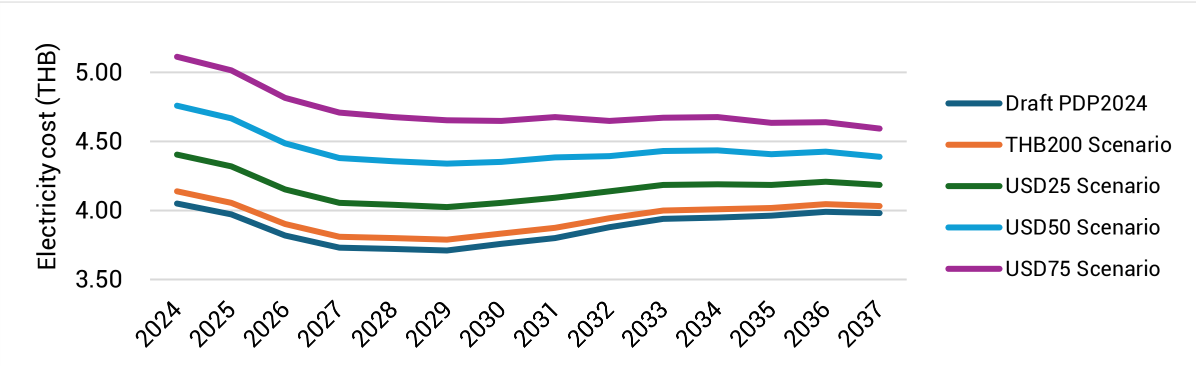
Thailand has made significant progress with the draft Climate Change Act ("draft CCA"), which as of 1 July 2024 consists of 14 chapters and establishes various carbon pricing instruments, including an Emission Trading System (ETS), carbon tax, and carbon credits. This draft recently underwent comprehensive public hearings from February to March 2024 and is expected to be submitted to the parliament this year, with implementation potentially starting in a few years. This will inevitably impact electricity prices.

It is currently unclear whether the legal requirements in draft CCA that affect the power generation sector will involve a carbon tax, where the government sets the carbon price, an ETS, where the market determines the price, or a combination of both, given the carbon-intensive nature of power generation. In either case, this sector is likely to be a primary target for carbon pricing mechanisms due to its outsized greenhouse gas emitter status[6].

Prior to the enactment of the draft CCA, Thailand's Excise Department has proposed a carbon tax of THB 200 per ton of CO_2 equivalent, primarily on oil products, which it is expects to implement by the end of 2024[7]. For analysis purposes, we use this rate of THB 200 per ton of CO_2 equivalent as a baseline carbon tax. Additionally, we consider three other scenarios based on the suggested floor prices proposed by the International Carbon Price Floor Agreement[8]: USD 25 for low-income countries, USD 50 for middle-income countries, and USD 75 for high-income countries.

The calculation involves adding carbon tax burden to the electricity price presented in draft PDP2024, while the carbon emissions are calculated based on draft PDP2024 energy generation by sources. The emissions of selected electricity supply technologies are based on the IPCC Technology-specific Cost and Performance Parameters[9], which reports that the median life cycle emissions of electricity generated by coal and gas are 820 and 490 gCO_2eq/kWh, respectively. The results of each scenario are presented in Figure 1 below.

Figure 1 Estimated electricity cost under different scenarios (THB)



Sources: Calculations by the authors based on publicly disclosed information.

[6] Kasikorn Research Center (2024) https://www.kasikornresearch.com/th/analysis/k-social-media/Pages/cis3490-Climate-Change-FB-09-05-2024.aspx
[7] The Standard (2024) https://thestandard.co/thai-carbon-tax/
[8] IMF (2022) Why Countries Must Cooperate on Carbon Prices (imf.org)
[9] IPCC (2018) ipcc_wg3_ar5_annex-iii.pdf

In the THB 200 scenario, the average electricity cost increases by approximately 1.8%. In the USD 25, USD 50, and USD 75 scenarios, the average electricity cost increases by 7.3%, 14.6%, and 21.9%, respectively. The challenge lies in determining who will bear the cost. Due to the current pass-through mechanism, electricity generators are likely to pass all costs to consumers. Given the centralized nature of Thailand's utilities market, there is no competition or viable alternative for consumers who buy electricity from the grid. They have no choice but to accept the prices or produce electricity themselves. Therefore, if the power development plan does not adequately address the transition to a lower carbon energy mix, the government should at least liberalize the market to allow both household and corporate consumers to make their own decisions.

Costs of Carbon Capture and Storage

To enhance decarbonization efforts, draft PDP2024 outlines CO_2 emission reduction targets for the electricity generation sector by incorporating Carbon Capture and Storage (CCS) as a negative emission technology to absorb 18.9 $MtCO_2$ of carbon emissions by 2045 and 34.2 $MtCO_2$ by 2050. While CCS is not a novel concept and is included in the LT-LEDS as a key component for low emissions by 2040 and net-zero emissions by 2050[10], its implementation comes with substantial costs that are not accounted for in draft PDP2024.

According to Global CCS Institute, CCS refers to a technology that prevents CO_2 released from point sources, such as industrial plants, coal and natural gas-fired power plants, and oil refineries, from entering the atmosphere or captures it directly from the atmosphere.[11] The same institute projects that CCS technology can capture over 90% of CO_2 emissions from point sources through different engineering techniques[12].

In Thailand, PTT Group has spearheaded CCS development with two notable initiatives. The first is the Arthit upstream CCS Project, which demonstrates Thailand's CCS capability and storage potential. The second initiative is the Eastern Thailand CCS Hub Project, aimed at implementing large-scale CCS along the east coast. Under the CCS hub model, CO_2 emissions from industrial sources are consolidated at a central terminal and subsequently transported offshore for storage in the Gulf of Thailand. This model aims to optimize economic efficiency by facilitating the shared use of a single Transportation & Storage (T&S) facility among multiple emitters[13].

The deployment of CCS demands considerable investment, encompassing three processes: capture, transport, and storage, which involve capturing CO_2 from emission sources, compressing it for transport, and injecting it into secure geological storage sites[14].

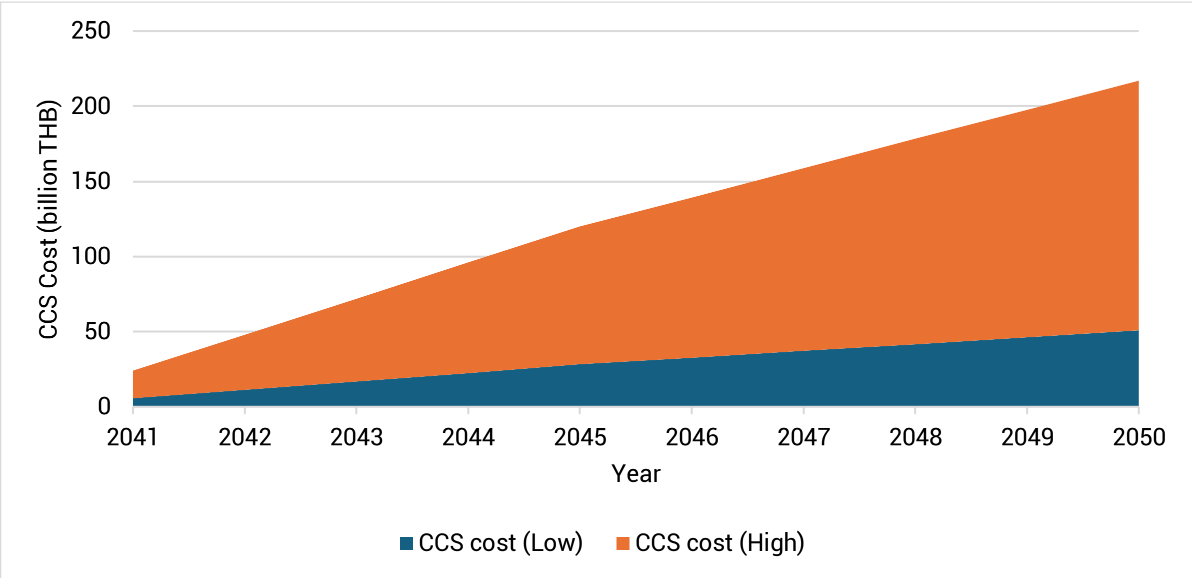
According to International Energy Agency (IEA), the levelized cost of CO_2 capture varies by sector and initial CO_2 concentration, ranging from USD 15 to 120 per tonne of CO_2 (approximately THB 55 to 4,412 per tonne of CO_2), excluding Direct Air Capture (DAC) and Compression only[15]. Given this variability, the initial phase of the T&S project for Thailand CCS hub requires an estimated investment ranging from USD 2 to 3 billion. Consequently, the projected T&S fee is anticipated to range from USD

[10] MNRE (2022) Thailand LT-LEDS (Revised Version)_08Nov2022.pdf (unfccc.int)
[11] GCCSI (2022) Factsheet_CCS-Explained_The-Basics.pdf (globalccsinstitute.com)
[12] GCCSI (2024) CCS Explained: Capture - Global CCS Institute
[13] PTTEP (2023) Carbon Capture and Storage Lights Decarbonization Pathway to Carbon Neutrality | PTTEP
[14] GCCSI (2024) CCS Explained: Capture - Global CCS Institute
[15] IEA (2019) Levelised cost of CO2 capture by sector and initial CO2 concentration, 2019 – Charts – Data & Statistics - IEA

40 to 60 per tonne of CO_2 (approximately THB 1,470 to 2,206 per tonne of CO_2), with potential for further reductions through additional government subsidies[16].

When all costs are combined, the estimated CCS cost for the CCS hub project could range from USD 55 to 180 per tonne of CO_2 (approximately THB 2,000 to 6,600 per tonne of CO_2)[17]. The estimated high and low annual cost for CCS from 2041 to 2050 is presented in Figure 2. If draft PDP2024 is implemented, the cost of CCS is projected to be approximately THB 30.85 to 100.95 billion per year on average during this period. It is noteworthy that this hub project operates on seaboard or offshore sites. However, the T&S cost of CO_2 for onshore may vary due to the differing distances between these sources and the storage sites, as well as other factors such as reservoir depth. It has been found that offshore injection sites are more expensive than onshore sites due to higher transportation and storage costs, particularly for storage[18].

Figure 2 Estimated CCS costs (THB billion)



Sources: Calculations by the authors based on publicly disclosed information (see Appendix for details).

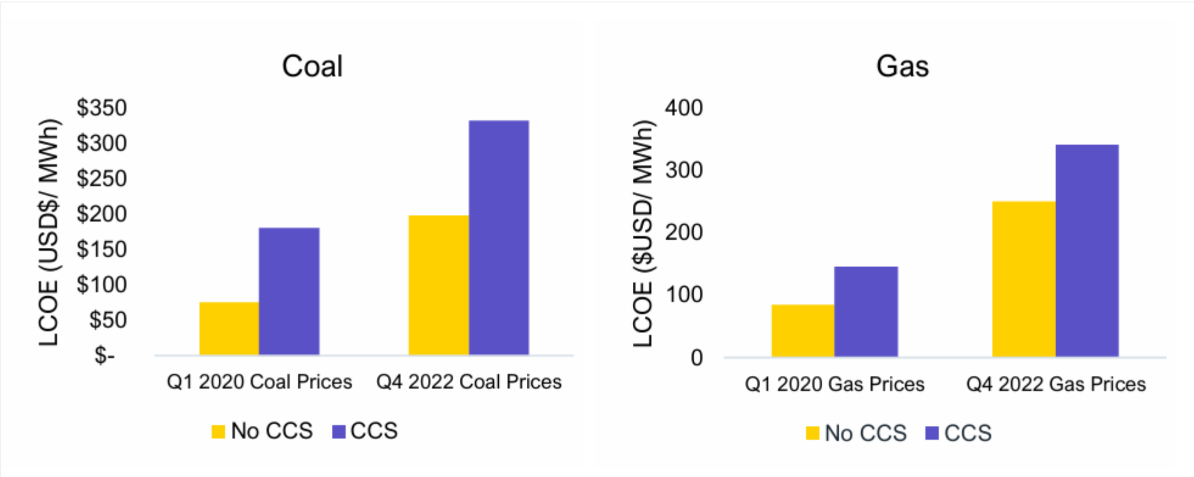
However, the cost of CCS extends beyond capture and T&S to include additional expenses such as Measurement, Monitoring, and Verification (MMV)[19]. The Institute for Energy Economics and Financial Analysis (IEEFA) analysis underscores the uncertainty surrounding CCS's actual cost and cost trajectory. To manage these costs, the analysis mentions that governments may consider subsidizing CCS or integrating it into electricity pricing mechanisms. It also indicates that integrating CCS into the power sector is likely to substantially increase the current cost of energy production, potentially leading to higher electricity prices[20].

According to IEEFA's analysis, implementing CCS in Australia's thermal resources could increase the weighted average wholesale prices by AUD 100 to AUD 130 per MWh (approximately

[16] Sutabutr, T. (2024) Carbon-Capture-Storage-and-Utilisation-CCUS-Development-in-Thailand.pdf (eria.org)
[17] The cost estimates exhibit a broad range, influenced by factors including sector, CO_2 concentration, process type, engineering techniques, and storage site.
18 ERIA (2022) 11_Chapter-2-A-Model-Case-Study_CCUS-Cost-Estimation_ed.pdf (eria.org)
[19] ดร.วรรณี อินศิริกุล และสวทช. (2024) สิ่งที่แนบมาด้วย1_รายงานฉบับสมบูรณ์_CCUS TRM_V15_27012024.pdf
[20] IEEFA (2023) IEEFA Report - CCS for power yet to stack up against alternatives_March2023.pdf

2,463 to 3,201 AUD/ MWh), compared to 2023 spot prices, which average between AUD 75 and AUD 95 per MWh (approximately 1,847 to 2,339 AUD/ MWh)—an increase of 95% to 175%. These additional costs are expected to be passed on to energy consumers through higher electricity bills. However, if resulting electricity prices from CCS implementation become unaffordable for consumers, CCS may not prove economically viable[21]. Figure 3 highlights the substantial cost gap between CCS and non-CCS generators in Australia.

Figure 3 The differences in LCOE between historical and current 2022 prices for coal and gas facilities with and without CCS in Australia (USD/MWh)



Source: IEEFA analysis

LNG Price Volatility

Thailand's heavy reliance on LNG (Liquefied Natural Gas) for electricity generation poses significant challenges due to the high volatility of LNG prices, which is becoming the new normal. Historically, natural gas has been the backbone of Thailand's energy sector, driving economic growth and the development of a robust petrochemical industry. Currently, natural gas accounts for approximately 60% of Thailand's energy mix, with draft PDP2024 projecting that gas power plants will still constitute 41% of the generation mix by 2037.

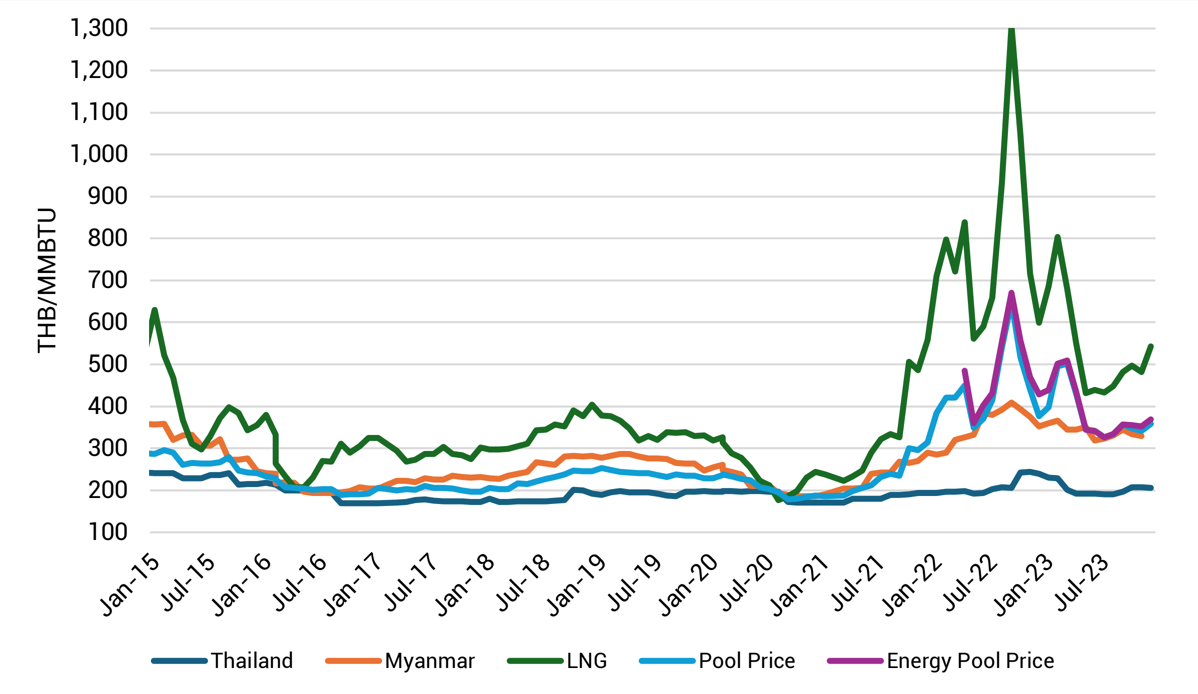
Since 2011, as domestic gas reserves deplete, Thailand has increasingly relied on imported LNG, which now constitutes approximately 31% of the total gas supply. According to the draft Gas Plan 2024, Thailand will need to rely on imported LNG for at least 40% of its gas supply from 2030 onwards, with an additional 10% dependence if potential gas in the Gulf of Thailand does not materialize.

The volatile nature of LNG prices was starkly evident during the period from 2020 to 2022, with prices plummeting during the COVID-19 pandemic and soaring during the Russo-Ukrainian War[22]. Despite having domestic gas resources, high-quality gas is primarily allocated to the petrochemical industry. Consequently, consumer electricity bills are based on the Energy Pool Price (EPP), which

[21] IEEFA (2023) IEEFA Report - CCS for power yet to stack up against alternatives_March2023.pdf
[22] ERIA (2024) Mitigating-Extreme-Volatility-of-LNG-Prices-in-ASEAN.pdf (eria.org)

includes a weighted average of stable domestic gas prices, imported gas prices from Myanmar, and highly volatile LNG spot prices. Figure 4 illustrates LNG prices compared to other energy prices.

Figure 4 Estimated gas pool price in Thailand from 2015 to 2023 (THB/MMBTU)



Sources: EPPO

Although LNG spot prices have recently declined, the possibility of price hikes remains, given the volatile nature of global markets[23]. According to the IEEFA[24], three key factors contribute to LNG price volatility in Asia:

- **Demand-Supply Imbalances**: Supply shocks, such as the Russo-Ukrainian war, and demand shocks, such as Japan's increased LNG imports after the Fukushima disaster, contribute to price volatility. High prices incentivize the construction of new supply facilities, leading to oversupply and subsequent price drops, causing continuous imbalances in the LNG market.
- **Trade Flows**: A significant percentage of gas is traded on the spot market. In 2022, about 35% of global gas trade occurred on the spot market, making LNG prices more dynamic and susceptible to global market fluctuations. Currently, Thailand requires approximately 20% of its total domestic gas demand from the spot market. This portion is projected to increase to 38% by 2037 if Thailand cannot secure additional long-term contracts, which could result in volatile electricity generation costs.
- **Seasonality**: Extreme weather events, such as harsh winters or unexpected heat waves, drastically alter demand patterns. For instance, a mild winter in Europe can reduce demand and lower prices, while extreme heat can increase demand for cooling, driving prices up. This seasonality introduces another layer of unpredictability to LNG prices.

[23] Zero Carbon Analytics (2024) Bullish Asian gas demand forecasts eroded by renewable surge - Zero Carbon Analytics (zerocarbon-analytics.org)
[24] IEEFA (2024) Volatile global LNG market: Impact on India | IEEFA

Thailand risks a fossil-fuel lock-in due to the rapid expansion of gas infrastructure, including pipelines and LNG import terminals with an 18 mtpa capacity currently in operation and an additional 5 mtpa capacity (LNG Map Ta Phut terminal 3 phase 1) under construction[25]. As the world moves towards net zero, this new infrastructure could lock in Thailand to an over-reliance on LNG, a highly volatile energy source, potentially slowing down the transition to more sustainable and low-cost energy alternatives.

While natural gas has historically supported Thailand's economic growth, increasing reliance on LNG could introduce significant risks due to market volatility. Thus, this reliance does not ensure long-term energy security and economic stability but rather introduces volatility to Thailand's economy.

False Solutions

Small Modular Reactors

Thailand's draft PDP2024 includes the commissioning of two 300 MW Small Modular Reactors (SMRs) by 2037. The concept of nuclear energy in Thailand dates back to 2007, with plans for nuclear power plants appearing in several PDP revisions until they were removed in PDP2018 to prioritize gas and renewable energy[26]. Draft PDP2024 reintroduces nuclear energy with SMRs.

SMRs refer to an advanced nuclear technology that is smaller in size compared to traditional nuclear power plants. They are designed to address common issues such as budget overruns and project delays that often affect large-scale nuclear projects[27], while also being safer to operate[28]. Despite their potential, SMRs are still in the development stage and are expected to incur high costs.

Transitioning to net zero requires critical reliance on renewable energy sources like wind and solar. However, due to their intermittent nature, they necessitate backup from baseload power plants capable of supplying uninterrupted electricity 24/7[29]. SMRs present a carbon-free energy option and show promise in addressing this intermittency by providing a reliable baseload power source, thereby enhancing grid stability[30]. They are also designed to be inherently safer than traditional nuclear reactors, addressing safety concerns from past nuclear disasters.

Nevertheless, SMRs face significant challenges. Leading SMR companies[31] have encountered higher-than-expected costs, causing their flagship construction projects to stall due to excessive expenses. These increased costs were attributed to higher construction material costs, increased labor expenses, elevated interest rates, and supply chain problems[32]. As construction costs escalate, so do power costs. In 2024, SMRs-generated power is estimated to cost USD 119 per MWh (approximately THB 4,351 per MWh) without the Inflation Reduction Act (IRA) subsidy and USD 89 per

[25] CFNT (2024) Thailand's Fossil Lock-In: Stranded Risk of Midstream Oil & Gas Infrastructure - CFNT (climatefinancethai.com)
[26] Prachathi (2024) โรงไฟฟ้านิวเคลียร์ในไทย มีแผนมาตั้งแต่เมื่อไร ทั่วโลกใครใช้บ้าง | ประชาไท Prachatai.com
[27] IEEFA (2024) SMRs Still Too Expensive Too Slow Too Risky_May 2024.pdf (ieefa.org)
[28] MIT Technology Review (2023) We were promised smaller nuclear reactors. Where are they? | MIT Technology Review
[29] Harris, M (2023) 2023 Climate Tech Companies to Watch: NuScale and its modular nuclear reactors (technologyreview.com)
[30] MIT Technology Review (2023) We were promised smaller nuclear reactors. Where are they? | MIT Technology Review
[31] The three market leaders in the SMRs field are NuScale, X-Energy, and GE-HITACHI Nuclear Energy
[32] MIT Technology Review (2023) We were promised smaller nuclear reactors. Where are they? | MIT Technology Review

MWh (approximately THB 3,254 per MWh) with the IRA subsidy – significantly higher than solar PV + storage, estimated at USD 50 per MWh (approximately THB 1,828 per MWh)[33].

In addition to cost issues, SMRs construction faces potential delays. Projects in Russia and China were prolonged beyond expectations, requiring 12-13 years before becoming operational. Similarly, many other projects are anticipated to experience setbacks of approximately 5 to 10 years. These delays are due to their complexity, regulatory requirements, and prioritization of safety. Despite limited experience with nuclear power plants, the Thai government remains optimistic about SMRs, possibly overlooking the country's abundant solar resources[34].

Hydrogen

Thailand's draft PDP2024 includes the introduction of blending 5% hydrogen into on-grid gas power plants starting from 2030. This initiative aims to reduce CO_2 emissions from gas power plants and supplement the depleting domestic gas supply, which increasingly relies on expensive and volatile LNG imports. This plan aligns with Thailand's vision of integrating commercial hydrogen use into the energy sector by 2030, as emphasized by Energy Policy and Planning Office, which endorses hydrogen as an "energy of the future"[35].

Hydrogen is widely regarded as a promising low-carbon energy source. Currently, it is primarily utilized in industrial processes such as refining oil and producing ammonia for fertilizers. However, this hydrogen is typically produced using fossil gas, resulting in high carbon intensity. The global energy transition aims to replace existing hydrogen sources with "green" or "renewable" hydrogen, produced using clean electricity and water, instead of climate-warming methane gas. This transition not only targets current hydrogen applications but also seeks to decarbonize other high emission industries.

Hydrogen is seen by many as a potential replacement for fossil gas in the future, hoping to utilize existing gas infrastructure for hydrogen transport and avoid stranded costs. However, the chemical properties of hydrogen pose challenges. Hydrogen is the smallest molecule, which can lead to "embrittlement" of steel pipelines and increase the likelihood of leaks. Blending hydrogen with natural gas is a potential solution, but even then, only low concentrations are considered safe. For example, California allows up to 5% hydrogen blending, while France permits up to 6%[36].

Blending hydrogen with natural gas can reduce greenhouse gas emissions only marginally, as hydrogen has a lower energy density than methane. For example, blending 20% green hydrogen into Europe's distribution networks would cut greenhouse gases by just 6-7% while increasing end-user costs by 10-40% [37]. Current power plants can handle hydrogen blends of 20-40%, but higher levels would require significant upgrades or replacements of existing facilities[38].

In summary, while hydrogen presents an opportunity to reduce emissions and enhance energy security, its integration into Thailand's energy mix must be carefully managed due to high production costs, infrastructure challenges, and efficiency issues. Hydrogen can play a crucial role in hard-to-abate industrial sectors such as steel, ammonia, refineries, and chemical plants, where alternative

[33] IEEFA (2024) SMRs Still Too Expensive Too Slow Too Risky_May 2024.pdf (ieefa.org)
[34] IEEFA (2024) SMRs Still Too Expensive Too Slow Too Risky_May 2024.pdf (ieefa.org)
[35] DEDE (2024) ไฮโดรเจน พลังงานทางเลือกใหม่ ขับเคลื่อนไทยสู่เป้าหมาย Carbon Neutrality (dede.go.th)
[36] IEA (2019) Current limits on hydrogen blending in natural gas networks and gas demand per capita in selected locations – Charts – Data & Statistics - IEA
[37] RECHARGE NEWS (2022) 'Expensive, wasteful, limited CO2 reduction: Blending hydrogen into gas grid should be avoided' | Recharge (rechargenews.com)
[38] Climate Portal (2023) Can we use the pipelines and power plants we have now to transport and burn hydrogen, or do we need new infrastructure? | MIT Climate Portal

decarbonization options are limited[39]. However, the pathway of hydrogen blending in power generation appears to be a less effective and more expensive solution compared to other renewable energy options. Perhaps most significantly is the fact that draft PDP2024 does not mention which type of hydrogen Thailand will use in the 5% target, despite a vast difference between "gray", "blue", and "green" hydrogen.

Hydroelectricity Import

In addition to domestic electricity generation, Thailand supplements its energy supply by purchasing electricity from hydropower projects in the Lower Mekong River, including large projects in Laos such as Xayaburi Hydroelectric Power Project. The Xayaburi project is developed by CK Power, a major construction company in Thailand. The primary aim of this project is to generate electricity from Xayaburi Dam, with Thailand committed to purchasing 95% of the dam's output. Valued at approximately THB 134,876 million, the project has received financial support from several Thai financial institutions[40].

In draft PDP2024, Thailand plans to increase imported hydroelectricity to 15%, up from 9% in PDP2018, which translate to 3,500 MW[41] of new projects between 2035 and 2037. While hydroelectric imports have historically offered relative price stability, they now raise concerns due to significant social and environmental impacts on neighboring countries as well as Thai populace that rely on the Mekong River for their livelihood. These imports also face new challenges such as unreliable electricity generation caused by more drastically fluctuating water levels due to China's dam management in the Upper Mekong River and climate change, alongside higher construction costs in an increasingly resource-constrained world.

The construction of dams in the Lower Mekong has been shown to cause severe disruptions to local ecosystems. The Stimson Center's Mekong Dam Monitor (2022-2023) summarizes the profound impact of hydroelectric power on the altered water flow dynamics, which is especially notable during dry seasons. The operation of hydroelectric plants not only profoundly affects river ecosystems, but also poses serious socio-economic threats to millions of people who reside in and rely on the Lower Mekong Basin.

Furthermore, the IEA notes that the impacts from climate change could reduce the capacity factor of hydroelectric plants in Laos and Thailand by 7% to 8% between 2060 and 2099 under scenarios of less than 2 degrees Celsius global temperature rise. This reduction could escalate to 11% under scenarios of over 4 degrees Celsius. This indicates that hydroelectric power becomes less reliable over time and raises doubt as to its viability as a sustainable long-term energy solution.

The production of hydroelectricity is also associated with high costs. The electricity tariff agreed for newly approved hydropower projects in Laos[42] were recorded at THB 2.84 per unit for one project and THB 2.92 per unit for another. These prices notably exceed the Feed-in-Tariff (FiT) for solar projects equipped with energy storage systems (batteries) at THB 2.83 per unit. This disparity

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[39] Agora (2021) No-regret hydrogen (agora-energiewende.org)
[40] The standard (2019) สะท้อนมุมมองทั้งสองด้านของ 'เขื่อนไซยะบุรี' แหล่งพลังงานสำคัญแห่งใหม่หรือศัตรูร้ายแห่งลุ่มแม่น้ำโขง – THE STANDARD
[41] The breakdown of 3,500 MW is 1,400 MW in 2578, 1,400 MW in 2579, and 700 MW in 2580.
[42] ENERGY NEWS CENTER (2022) กพช.อนุมัติอัตราค่าไฟทั้งโครงการหลวงพระบาง และ ปากแบง ของ สปป.ลาว | Energy News Center

highlights the diminishing cost competitiveness of hydroelectric power, particularly in comparison to the increasingly economically viable solar energy solutions that incorporate storage capabilities[43].

Sun is the Solution

In 2018, Thailand was the leader in Southeast Asia's solar energy sector with an installed capacity of approximately 3,000 MW. However, the growth of solar has stagnated since 2019. Vietnam has since surpassed Thailand, achieving more than six times its solar capacity. According to draft PDP2024, it will take Thailand nearly one decade to achieve what Vietnam has accomplished in less than five years.

A recent article in *The Economist* describes the current era as the "dawn of the solar age," highlighting the rapid global expansion of solar power as the world is expected to install a gigawatt of solar power capacity per day, a significant increase from a gigawatt per year in 2004. IEA notes that purchasing and installing solar panels is currently the largest category of investment in electricity generation[44]. The installed capacity of solar power consistently exceeds expert forecasts, driven not only by environmental concerns but also by the rapidly decreasing costs per megawatt.

The drastic price drop in solar energy is primarily due to the raw material used — sand, made of quartz, a crystalline form of oxidized silicon. The process involves heating silicon foundries to 1,900°C in electric-arc furnaces with carbon, forming molten polysilicon. This polysilicon is then cooled, crushed, and processed into trichlorosilane, which is repeatedly distilled to remove impurities[45]. Initially, the solar-cell industry relied on offcuts from the computer industry's silicon wafers. However, rising demand for photovoltaics in the mid-2000s, driven by subsidies, led to the establishment of dedicated polysilicon foundries, particularly in Asia. By 2023, Chinese firms produce 93% of the world's polysilicon for solar cells.

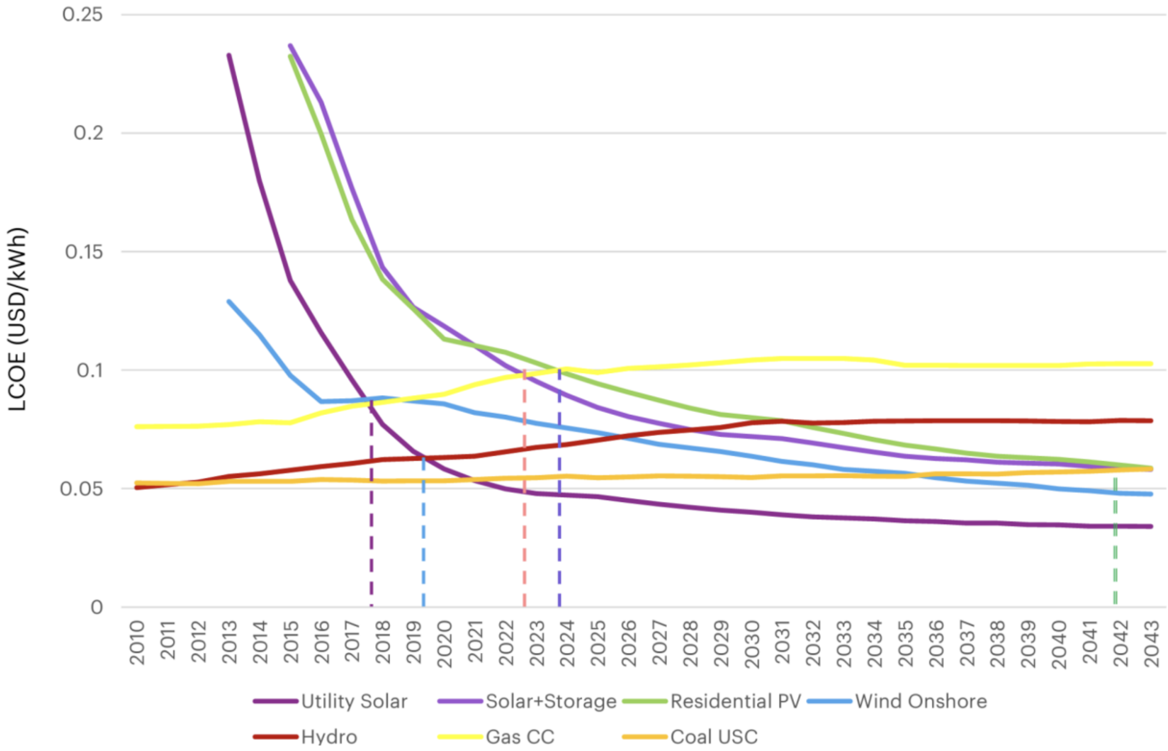
Solar photovoltaic (PV) cells, which are standardized products without moving parts, compete mainly on cost. Manufacturers strive to produce cells that generate more electricity from a given amount of sunlight or reduce production costs. In 2015, BloombergNEF (BNEF)[46] estimated the global LCOE for solar at USD 122 per MWh, compared to USD 83 per MWh for onshore wind, USD 85 to 93 per MWh for gas, and USD 50 to 75 per MWh for coal in regions without carbon pricing. Today, both solar and onshore wind LCOEs are in the low USD 40, while gas and coal remain much the same.

Thailand is well-endowed with sunlight year-round, yielding approximately 4.06 to 5 kWh/m² per day on global horizontal irradiation. A report[47] by Accenture suggests that utility-scale solar LCOE in Thailand is already at grid parity with natural gas and is expected to reach parity with coal very soon, as illustrated in the Figure 5 that shows the trends in LCOE for Thailand's primary energy sources from 2010 to 2037. This trend was accelerated by spot market fuel price spikes in 2021 compared to 2020. The long-term trend of solar PV's cost advantage over coal is expected to continue. Solar PV with storage is projected to achieve price parity with gas by 2023 and with coal by 2042. Currently,

[43] The MOMENTUM (2024) โรงไฟฟ้าพลังน้ำกับความหมกเม็ดของ 'พลังงานสะอาด' ในร่างแผน PDP2024 (themomentum.co)
[44] IEA (2024) Massive expansion of renewable power opens door to achieving global tripling goal set at COP28 - News - IEA
[45] PV-Manufacturing (2024) PV-Manufacturing.org
[46] BloombergNEF (2015) Wind and solar boost cost-competitiveness versus fossil fuels | BloombergNEF (bnef.com)
[47] Accenture (2022) APAC System Value Analysis Thailand

Thailand's utility-scale solar LCOE is the second lowest in ASEAN, making it a strong contender for becoming a solar powerhouse in the region.

Figure 5 LCOE evolution of main energy sources for Thailand from 2010 to 2037 (USD/kWh)



Sources: Accenture

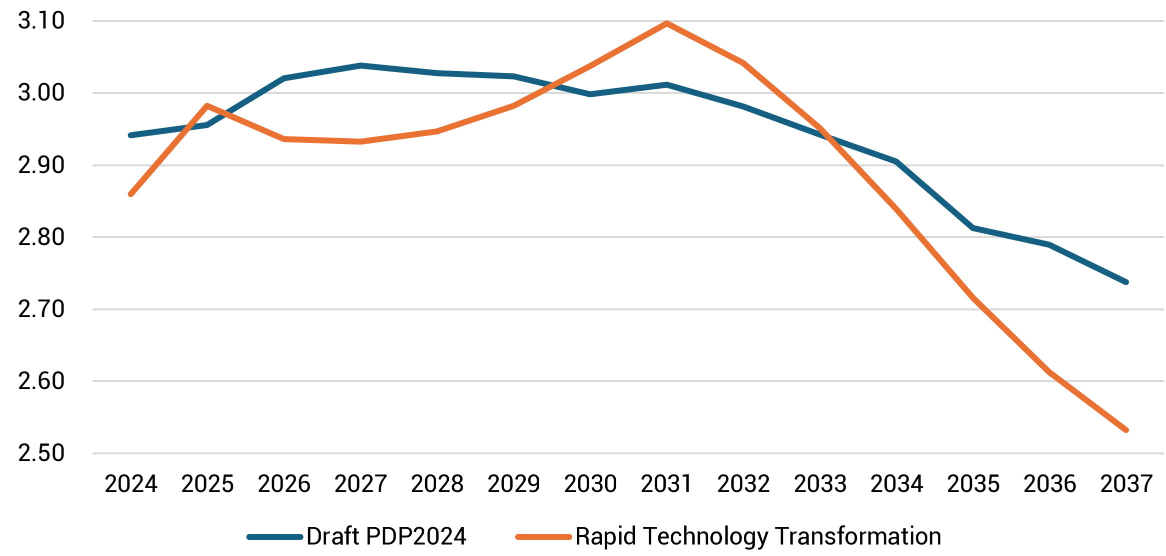
However, according to draft PDP2024, Thailand is not fully leveraging this solar potential and low costs. Instead, the plan relies heavily on expensive and volatile fossil gas, expensive unproven technologies such as hydrogen blending and SMRs, and socially and ecologically disruptive hydroelectric imports that are becoming less reliable.

We consider alternative energy development scenarios based on the report titled "National Energy Plan for the People," [48] authored by The Institute of Industrial Energy and the Clean Energy for People Foundation. This report presents a scenario called Rapid Technology Transformation, which closely aligns with Thailand's NDC and implements similar stability criteria, such as LOLE < 0.7 day per year, which is the same as draft PDP2024. According to this plan, Thailand will rapidly phase out coal by 2030, with no new gas plants except those already commissioned, and prepare to phase out gas power plants from 2030 onward, replacing them with utility solar PV and storage systems. By 2037, the last year of draft PDP2024, Thailand's energy mix is projected to be primarily from solar PV and storage systems (40%), gas power plants (27%), and wind (19%).

[48] RE 100 (2022) แผน PDP ภาคประชาชน (National Energy Plan-NEP) - สมาคมพลังงานหมุนเวียนไทย (อาร์อี 100) Thai Renewable energy (RE100) association (re100th.org) /

We utilized the projected cost of each energy generation technology presented above to recalculate the weighted LCOE based on energy generation from the Rapid Technology Transformation scenario and compared it to draft PDP2024. The results are presented below.

Figure 6 Weighted average LCOE between draft PDP2024 and Rapid Technology Transformation scenario (THB/kWh)



Sources: Draft PDP2024 and calculations by the authors

Notably, the Rapid Technology Transformation scenario shows a significant drop in generation costs from 2033 onwards due to the rapid deployment of solar PV plus storage systems and the beginning of gas phase-out. The average weighted LCOE for draft PDP2024 is THB 2.94 per kWh, while the Rapid Technology Transformation scenario is THB 2.89 per kWh. Although this difference may seem minor, the weighted LCOE does not account for availability payments, which are a significant cost in Thailand's generation due to the high reserve margin. The Rapid Technology Transformation scenario avoids new power plants, resulting in higher utilization rates and lower costs, reflecting greater efficiency and a more realistic electricity demand projection.

Naturally, integrating renewable energy sources such as solar PV to constitute more than 15% of the total electricity mix raises integration issues. However, current technologies and new management mechanisms are available to address these challenges. For example, remote inverter control and volt-VAR optimization can help manage the variability of solar energy production. Autonomous inverter settings and load control technologies further enhance the efficiency of integrating distributed generation into the grid effectively[49]. Moreover, utility-scale batteries and pumped hydro storage are becoming more cost-effective[50], offering essential backup to ensure a stable power supply during periods when solar energy is unavailable. By integrating these storage solutions with solar PV, it becomes possible to balance supply and demand, minimize the necessity for new fossil fuel power plants, and improve the overall reliability of the electricity grid.

[49] NREL (2024) Solar Integration Cost | Grid Modernization | NREL
[50] IEA (2024) Rapid expansion of batteries will be crucial to meet climate and energy security goals set at COP28 - News - IEA

Conclusion

Thailand stands at a critical juncture in its energy development journey. The June 2024 draft of the Power Development Plan 2024 (PDP2024) proposes a path heavily reliant on fossil fuels, particularly natural gas, which poses significant economic and environmental risks. The volatility of LNG prices and substantial costs associated with carbon emissions and carbon capture technologies, which are not accounted for in the plan, further complicate this approach.

The alternative is clear and promising: a proactive expansion of domestic renewable energy sources, particularly solar power. With its abundant sunlight, Thailand has the potential to reclaim its leadership in solar energy. The Rapid Technology Transformation scenario demonstrates that prioritizing solar PV and storage systems can reduce energy costs, enhance energy security, and align with global climate goals.

By choosing to invest in domestic renewable energy, Thailand can mitigate financial, social and environmental risks that rise from fossil fuel dependency, comply with upcoming international carbon regulations, and meet the demands of national and multinational companies that have set net-zero targets. Moreover, this transition will support the development of a resilient, sustainable, and competitive economy.

The Thai government must overcome the inertia of sunk cost bias and commit to a forward-thinking energy strategy. Embracing renewable energy technologies will not only secure Thailand's energy future but also position the country as a leader in the global fight against climate change. It is imperative that Thailand makes this bold shift now to build a climate-resilient economy for the future.

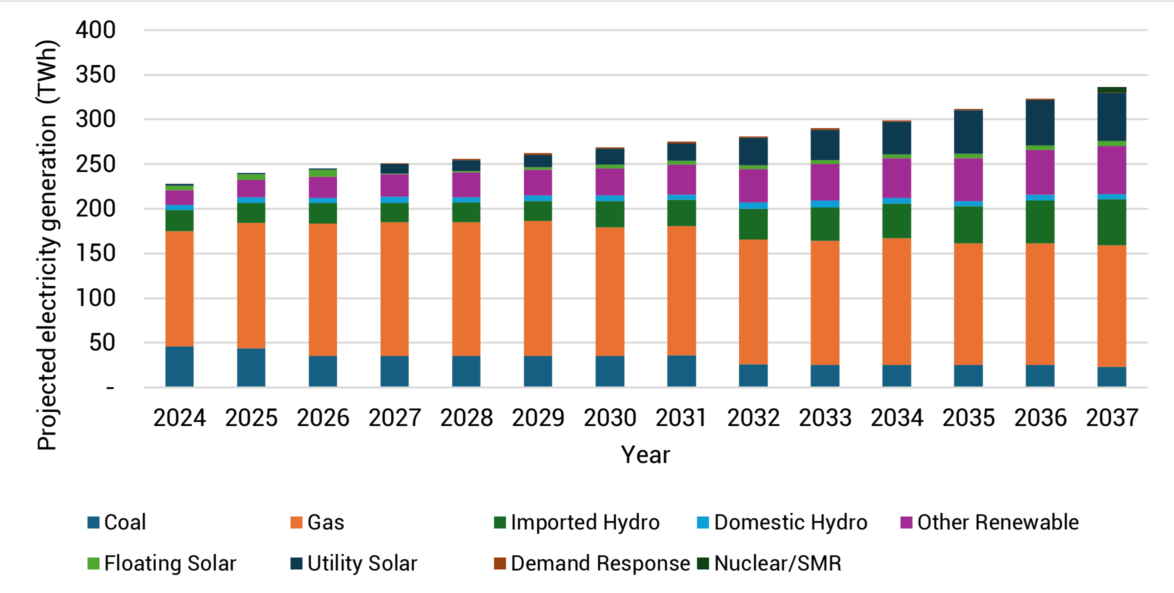
Appendix

A. Calculation Methodology

A.1 Carbon Pricing Mechanism

The additional cost of carbon emissions is based on the electricity generated from the projected energy mix in draft PDP2024 (Figure 7). We calculate the emissions by multiplying the electricity generated from fossil fuels by the median life cycle emissions for coal and gas, which are 820 gCO_2eq/kWh and 490 gCO_2eq/kWh, respectively. We use a baseline carbon tax of THB 200 per tonne for our calculations. Additionally, we consider three other scenarios based on the suggested floor prices proposed by the International Carbon Price Floor Agreement: USD 25 for low-income countries, USD 50 for middle-income countries, and USD 75 for high-income countries.

Figure 7 Projected electricity generation by sources from 2024 to 2037 (TWh)

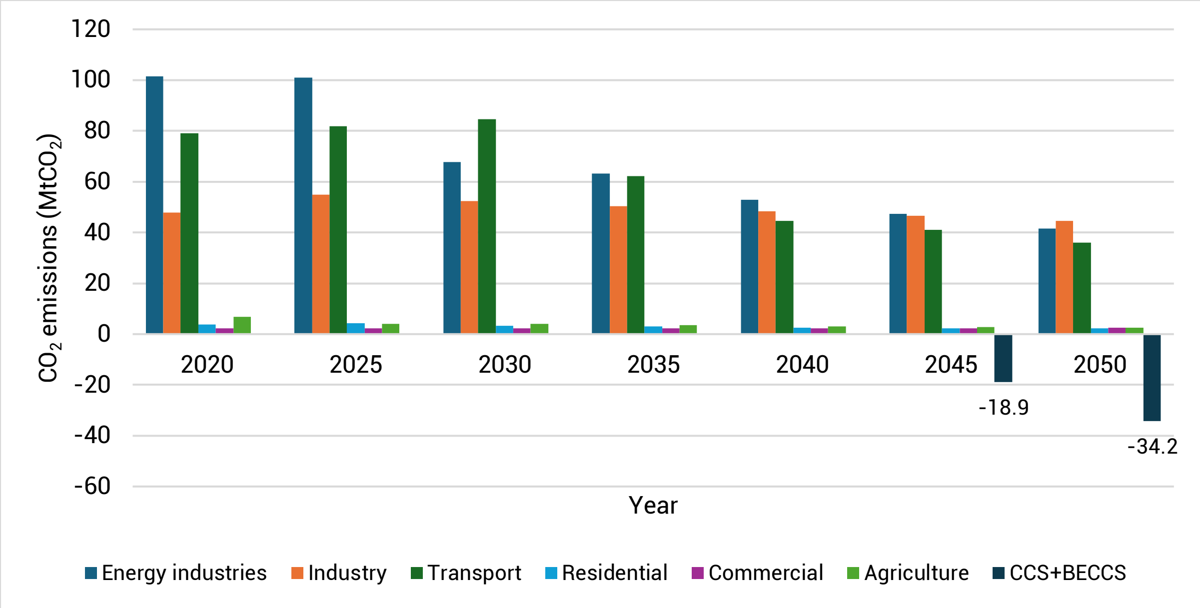


Sources: Draft PDP2024

A.2 Upcoming CCS Costs

We have estimated the costs associated with abating CO_2 emissions through CCS technology based on the CO_2 emission targets in the electricity generation sector from draft PDP2024 (Figure 8), which are -18.9 in 2045 and -34.2 in 2050, respectively. We assume a linear increase in CCS emission reduction from 2040, which aligns with the LT-LEDS's initiation of CCS in 2040 and its aim for carbon neutrality by 2050.The estimated costs of CCS in Thailand are derived from reliable published sources, including the IEA and ERIA. The costs of CCS consist of three main components: capture, transport, and storage. In this analysis, we represent Transportation & Storage (T&S) as a unified cost, in conjunction with T&S facilities under PTT's CCS hub. However, there is no single cost for CCS, as it can vary depending on factors such as the source of CO_2 and the CO_2 concentration. Consequently, the costs span a wide range from low to high.

Figure 8 CO_2 emission targets in the electricity generation sector from 2020 to 2050 ($MtCO_2$)



Source: Adapted from Draft PDP2024

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