APEC Oil and Gas Security Exercise in Thailand

5th APEC Oil and Gas Security Exercise

Bangkok, Thailand | 6-7 September 2023

APEC Energy Working Group

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Asia-Pacific
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Produced by

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DISCLAIMER

The Thaioil refinery and Thappline pipeline incidents described in the scenarios are purely hypothetical and used solely for the Exercise.

The incidents described in the QATARGAS scenario are purely hypothetical and used solely for the Exercise. A true *force majeure* incident in Qatargas happened in January 2009, when a breakdown in the supply of cooling seawater to the plant occurred that lasted for three weeks.
Details: REUTERS

Preface

Given the increasing concerns about energy security, the Energy Ministers during the 10th APEC Energy Ministerial Meeting in June 2012 in St. Petersburg, Russia instructed the Asia Pacific Economic Cooperation- Energy Working Group (APEC- EWG) and the Asia Pacific Energy Research Centre (APERC) to pursue regional cooperation on supply emergency response. In compliance with the directives, the Oil and Gas Security Initiative (OGSI) was proposed and has been a continuing activity being undertaken by APERC. Following this, APERC has conducted workshops and exercises, such as the Oil and Gas Security Exercise (OGSE), to assist economies in improving response measures, policies and institutional frameworks in dealing with threats and risks resulting in supply disruptions while considering the economy's domestic circumstances.

Recent developments have made APEC more vulnerable to disruptions. While the pandemic brought an initial reprieve to oil and gas buyers, it also brought demand uncertainty and, together with a Saudi-Russia oil price war, supply destruction. A muted supply response during the pandemic recovery suggests that we could be returning to a boom-bust energy market cycle. Lastly, the global restructuring of energy supplies in response to the Russia-Ukraine war is leading to higher energy price levels and volatility. As a result of these events, the economic costs of supply disruptions are at the highest levels in recent history. This is no secret to Thailand, which has recently relied on a high share of expensive spot LNG imports to fulfil its gas requirements.

Amidst this backdrop, this OGSE in Thailand is more important than ever. We truly appreciate that the Thai government's interest in revitalising this activity was sustained even after its postponement in February 2020 during the onset of the COVID-19 pandemic.

This OGSE in Thailand is the fifth emergency exercise conducted under the OGSI. As in the past, the "blind" scenario-type approach was undertaken, in which participants were provided with simulated oil and gas supply emergency scenarios without prior information. To make these emergency scenarios realistic, APERC used actual name of oil/gas suppliers, but **accidents/incidents which trigger emergency situations are purely hypothetical.** Experts from the International Energy Agency (IEA), the ASEAN Centre for Energy (ACE), the Economic Research Institute for ASEAN and East Asia (ERIA), Japan Organization for Metals and Energy Security (JOGMEC), the Department of Energy of the United States (US-DOE) and Thailand's very own experts from Petroleum Institute and Chulalongkorn University provided insightful comments and suggestions on the responses of Thailand.

This report provides the outcome of the exercise, which details Thailand's responses to the hypothetical oil and gas emergency scenarios formulated by APERC, including the comments and recommendations from the Expert Review Team. The report aims to strengthen Thailand's emergency response measures, policies, plans, procedures and communication strategies to better face supply emergencies.

Through this activity, APERC envisions that economies will conduct similar exercises to test how their emergency preparedness system, plans, policies and procedures, including communication strategies, can handle and mitigate the impacts of supply disruptions.

Regularly conducting energy security exercises can strengthen the response measures and make the system more resilient to supply shortfall emergencies.

Finally, the Expert Review Team and APERC wish to thank all the participants and delegates, representing the key energy stakeholders in Thailand, who professionally and seriously undertook the exercise. We especially wish to thank the Ministry of Energy of Thailand, in particular, the organising team led by Ms. Krittiya Petsee for without their support, this exercise would not have been possible.

APERC is committed to carrying out this activity and respectfully encourages other APEC member economies to consider holding it to strengthen their policies, institutional arrangements and mechanisms, and response measures on supply disruption.

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Abbreviations and acronyms

Abbreviations

bcf/d	Billion cubic feet per day
kb/d	Thousand barrels per day
ktoe	Thousand tonnes of oil equivalent
Ml/D	Million liters per day
MMscfd	Million standard cubic feet per day
Mtpa	Million tonnes per annum

Acronyms

ACE	ASEAN Centre for Energy
APEC	Asia-Pacific Economic Cooperation
APERC	Asia Pacific Energy Research Centre
APSA	ASEAN Petroleum Security Agreement
ASEAN	Association of Southeast Asian Nations
DMF	Department of Mineral Fuels
US-DOE	United States Department of Energy
DOEB	Department of Energy Business
DSM	Demand Side Management
EGAT	Electricity Generating Authority of Thailand
EPPO	Energy Policy and Planning Office
ERC	Energy Regulatory Commission of Thailand
ERI	Energy Research Institute, Chulalongkorn University
ERIA	Economic Research Institute for ASEAN and East Asia
EWG	Energy Working Group
GDP	Gross Domestic Product
GIIGNL	International Group of Liquefied Natural Gas Importers
GPSC	Global Power Synergy Public Company Limited
IEA	International Energy Agency
IMF	International Monetary Fund
JOGMEC	Japan Organization for Metals and Energy Security
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
MOE	Ministry of Energy
MTJDA	Malaysia-Thailand Joint Development Area
NESDB	National Economic and Social Development Board
PTIT	Petroleum Institute of Thailand
PTT	PTT Public Company Limited
PTTEP	PTT Exploration and Production Public Company Limited
PTTGC	PTT Global Chemical Public Company Limited

Executive summary

The 5th APEC OGSE was conducted by APERC in Bangkok during 6-7 September 2023. The exercise was hosted by the Ministry of Energy of Thailand. APERC deployed a team of experts from international organisations to participate and contribute to the exercise. Details of expert team are available in **Annex III.** There were a total 51 participants in the exercise from relevant government and private sectors involved in emergency responses. The list of participants is included in **Annex II**. Emergency response exercise for oil was conducted on 6 September and gas on 7 September.

The oil emergency scenario aims to highlight responses to severe disruptions in petroleum product supply and distribution. The scenario was divided into two stages. The first stage involved a situation where a major fire incident occurred at Thailand's second-largest oil refinery, while the largest refinery was on its maintenance shutdown, resulting in a 45% combined loss of the economy's total refining capacity. The second stage involved an escalated severity of fuel product supply distribution, where the first-stage fire incident had caused severe damage to the petroleum product pipeline facilities adjacent to the refinery complex, rendering the main pipeline completely unable to transport petroleum products from the connected four refineries to demand concentration areas in Bangkok and other demand areas. Details of the two stages are available in Section 2.1.

Similarly, the gas scenario aims to highlight responses to severe disruptions in the supply of natural gas production from the Gulf of Thailand and the imported LNG, which accounted for 62% and 22% of Thailand's total gas supply in 2022, respectively. The scenario was divided into three stages. The first stage involved a forced majeure by Qatargas due to a fire incident, a major supplier of LNG to Thailand under a long-term contract. The incident resulted in the loss of 36% of total LNG supply to Thailand for about a month. In stage two, the gas disruption was further escalated due to Typhoon Zigzag passing through the main gas production areas in the Gulf of Thailand, causing the evacuation of staff and the shutdown of the total gas production system. Stage two impacted almost 35% of gas production from the Gulf and further impeded another 26% of LNG import rate due to unattained incoming LNG cargo. Stage 3 of the gas scenario involved an incident of the failure of an offshore pipeline during the production restart after the storm had passed, resulting in a 30% loss of normal gas supply from the Gulf. Details of scenarios are available in Section 3.1.

APERC's team presented to Thai stakeholders the oil scenario and gas scenario on the first day and second day of the exercise, respectively. Mocked up television news reports, the *APERC Breaking News*, were also presented to the audiences to make the scenario real. After scenario presentation of each day, the Thai stakeholders gathered and discussed for response measures, and presented the measures to APERC's expert team. Toward the end, the experts provided their observations and recommendations to the measures, followed by an active session for questions and answers and exchange of opinions by all participants.

The responses to oil emergency scenarios from Thai stakeholders were divided into two stages according to the incidents. For stage 1, action plans for mitigation specifically to each petroleum product were analysed and presented, both supply and demand measures. The countermeasures to increase supply of fuel products included temporary ban of petroleum product export and increase product imports, increasing crude-run and adjusting product yields for the remaining refineries, adjusting product specifications to accommodate product imports, and increasing biofuel blend rates for bio-gasoline and biodiesel to minimize

consumption of petroleum fuels. The demand-side measures included communication strategies to seek cooperation from public to consume less fuel and use more public transportation, incentivising higher use of biofuels, and preparation to rationale products for each sector if necessary. For stage 2, the action plans to counter disruption in pipeline transportation included switching of distribution mode from the affected pipeline to alternative modes, which included oil trucks, marine vessels, and trains. Other action plans included relaxation of banned hours of heavy trucks and oil trucks into inner cities to increase flexibility of oil trucks to deliver products, incentivising higher use of regional oil depots to supply to regional fuel stations in order to convert oil trucks from other regions to increase transportation capability. Details of responses to oil emergency scenarios are available in Section 2.2.

The responses to gas emergency scenario were divided into three stages and were presented. For stage 1, the LNG storage was analysed and anticipated to be sufficient to supply for 36 days, thereby eliminating any immediate demand-related concerns. Consequently, there is no necessity for implementing demand-side measures at this stage. In the second stage, Thai stakeholders identified potential shortage of 0.08 bcf/d in gas supply. The action plans included managing LNG capacity and optimisation of regasification capabilities, increasing LNG imports, reducing LNG send-out rate, and relaxing gas specifications, all aiming to manage the current demand-supply dynamics effectively. On demand side, the plans included switching power generation from gas to diesel to secure additional supply sources to replenish and sustain the oil stock. For stage 3, several supply-side measures have been proposed. These included sourcing spot LNG cargoes to cover short-term gas demand, reducing the LNG send-out rate until the arrival of the first imported cargo, relaxing gas specifications, and fostering cooperation among gas suppliers and buyers. On the demand side, measures were proposed to curtail consumption through prioritisation. This involved managing the power generation system to enhance efficiency and reducing gas supply to the petrochemical sector. Additionally, maximising the utilisation of alternative fuels such as diesel and coal for power plants was suggested as a backup to meet power demand. Details of responses to gas emergency scenarios are available in Section 3.2.

Toward the end of the exercise, expert team made valuable contributions by providing observations and recommendations from their experiences to the Thai stakeholders. These observations and recommendations touched upon the areas of institutional and communication strategies, supply measures, demand measures, data collection and data management for decision making, and regional cooperations. After the expert session, all participants actively and constructively discussed and exchanged opinions regarding further improvement of emergency response capabilities in Thailand. More details are available in Section 4.

In conclusion, the 5th APEC Oil and Gas Security Exercise in Bangkok, Thailand, during 6-7 September 2023, was considered very successful and was highly appreciated by the participating Thai stakeholders and the Ministry of Energy of Thailand.

1. Background and energy situation in Thailand

1.1. Demographic and economic background

Thailand is located in the centre of APEC Southeast Asia. It is surrounded by Myanmar to the west, the Lao People's Democratic Republic (Lao PDR) and Cambodia to the north and east, and Malaysia to the south (Figure 1). Covering an area of 513 120 square kilometres, Thailand is home to a population of 66 million people (NESDB, n.d.). In 2022, its GDP surged to USD450 billion (constant 2015 USD), marking a 2.6% increase from the previous year (World Bank, 2022). The growth was attributed to the post-pandemic recovery of the export and tourism industries. Thailand earned recognition from the World Bank as one of the great development success stories. This achievement is credited to intelligent economic policies, elevating Thailand to the status of an upper middle-income economy and driving progress towards achieving the Sustainable Development Goals.

Figure 1: Map of Thailand

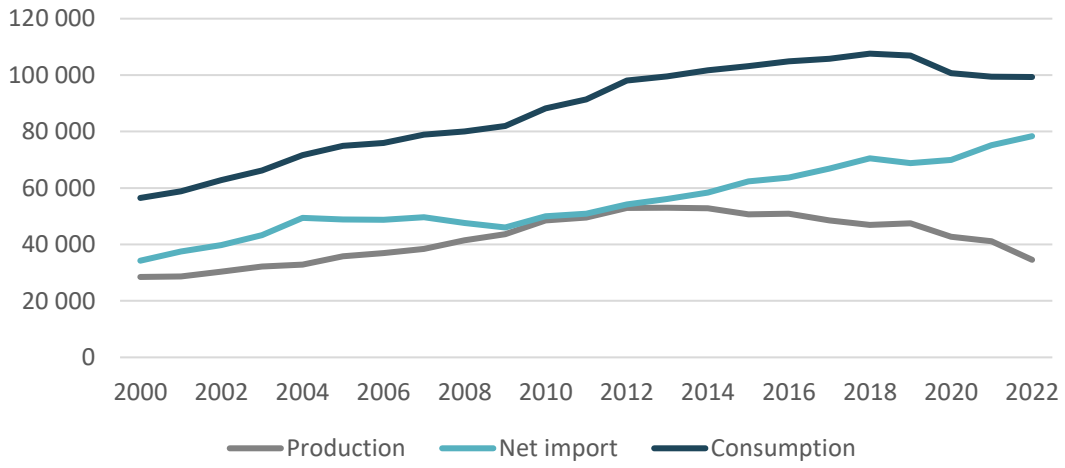
Source: (UN Cartographic Section)

Thailand possesses limited energy resources but has a significant endowment of natural gas. As of 2022, the proven reserves of natural gas and oil are estimated to be 3 445 bcf and 95 million barrels, respectively (EPPO, 2023). Natural gas production is on the decline due to the depletion of reserves. In 2022, the total natural gas production was 2 648 million standard cubic feet per day (MMscfd), marking a 17% decrease from the previous year and a 34% decrease from the levels recorded in 2012.

Thailand is net energy importer. Of the total 99 317 thousand tonnes of oil equivalent (ktoe) primary energy consumption in 2022, Thailand's net imported energy was 78 361 ktoe,

equivalent to nearly 80% of primary energy consumption (Figure 2) Crude oil import accounted for 57%, followed by LNG import at 19% and coal import at 17% of total net import, respectively. Notably, the shift to natural gas in power generation led to an 11% decrease in coal imports compared to the previous year.

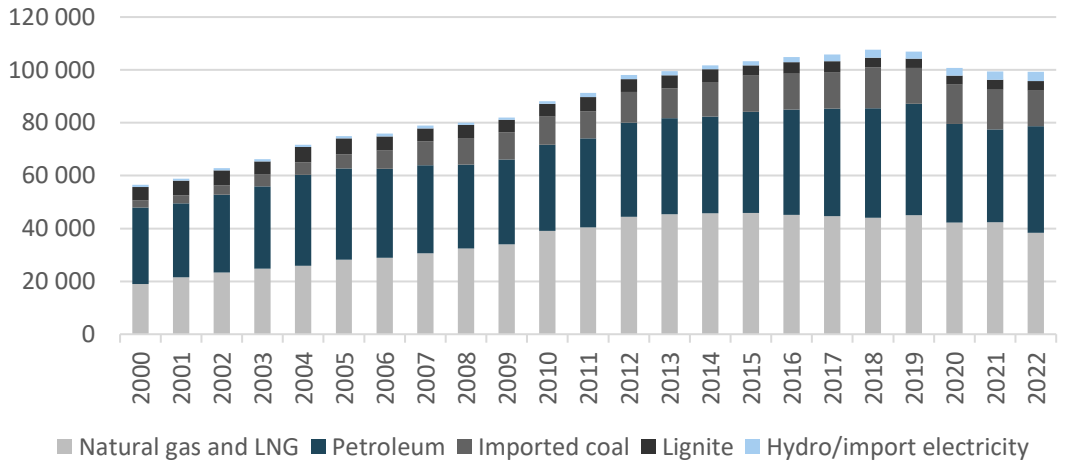
Figure 2: Primary commercial energy production, consumption, and net import (ktoe)



Source: (EPPO, 2023)

In 2022, there was a slight decrease of 0.1% in primary commercial energy consumption, compared the previous year (Figure 3). The rise in petroleum products and electricity consumption was a result of economic recovery and the easing of COVID-19 restrictions. However, the conflict between Russia and Ukraine led to a substantial increase in gas prices, prompting a decline in consumption for power generation and industrial purposes. This decrease aimed to stabilise production costs and maintain stable prices, minimising the impact on consumers.

Figure 3: Primary commercial energy consumption by fuel (ktoe)

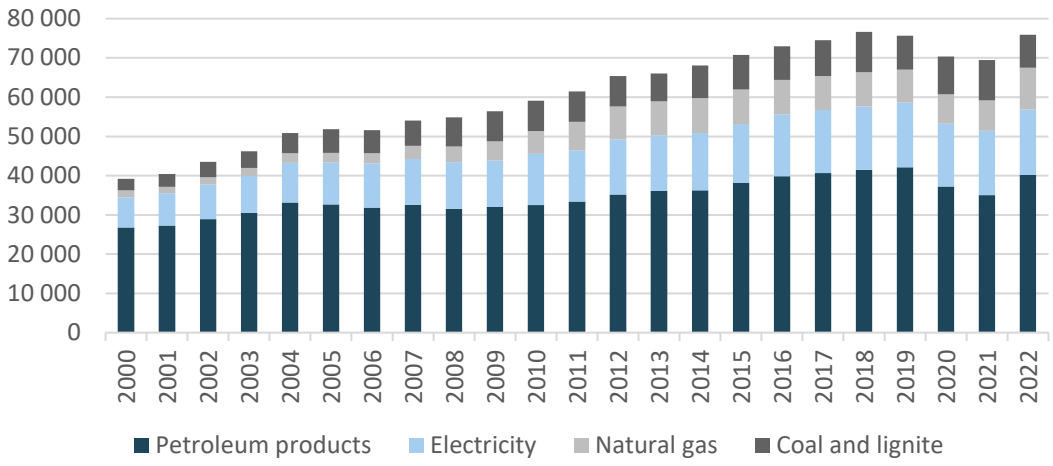


Source: (EPPO, 2023)

In terms of final energy consumption, Thailand consumed roughly 40 000 ktoe of petroleum products in 2022, an increase of 15% from the 2021 due to economic activity resurgence

(Figure 4). The final energy consumption mix comprised 53% oil, 22% electricity, 14% natural gas, and 11% coal. Among the sectors, the industrial sector accounted for 39% of consumption, followed closely by the transport sector at 38%, and commercial and residential sectors at 20%.

Figure 4: Final energy consumption (ktoe)



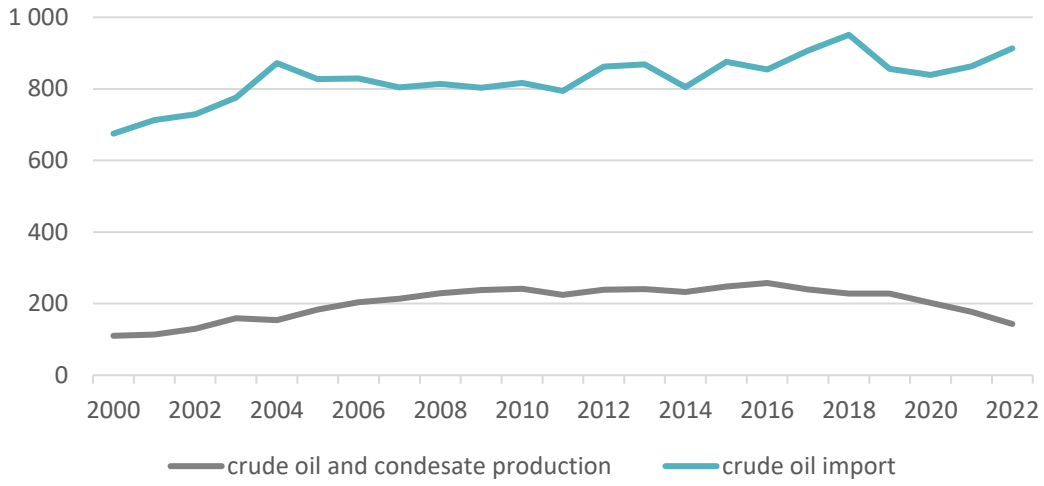
Source: (EPPO, 2023)

1.2. Oil supply and demand

Crude oil

Thailand possesses limited crude oil resources. In 2022, the economy imported 913 thousand barrels per day (kb/d) of crude oil, constituting 92% of the total crude oil supply, which amounted to 992 kb/d (Figure 5). Much of this supply, 62%, came from the Middle East, followed by 13% from the Far East, and 25% from other sources. The overall crude oil supply in 2022 saw a significant 32% increase from the previous year, driven by the resurgence of economic activities, especially in the transport sector, due to the rise in tourism activities. This is partly due to the continual fall of domestic production, which at 143 kb/d is around 45% lower than its 2016 peak.

Figure 5: Crude oil production and import (kb/d)

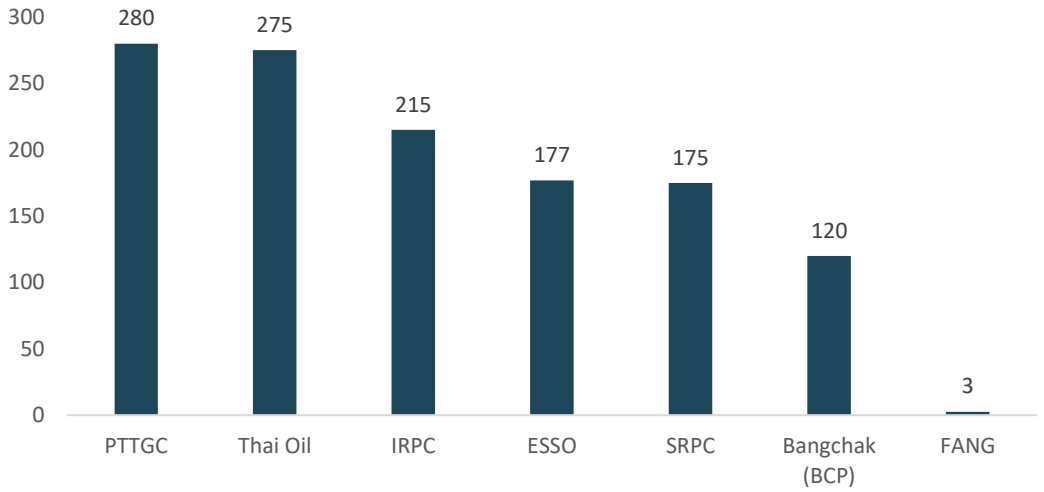


Source: (EPPO, 2023)

Oil refinery

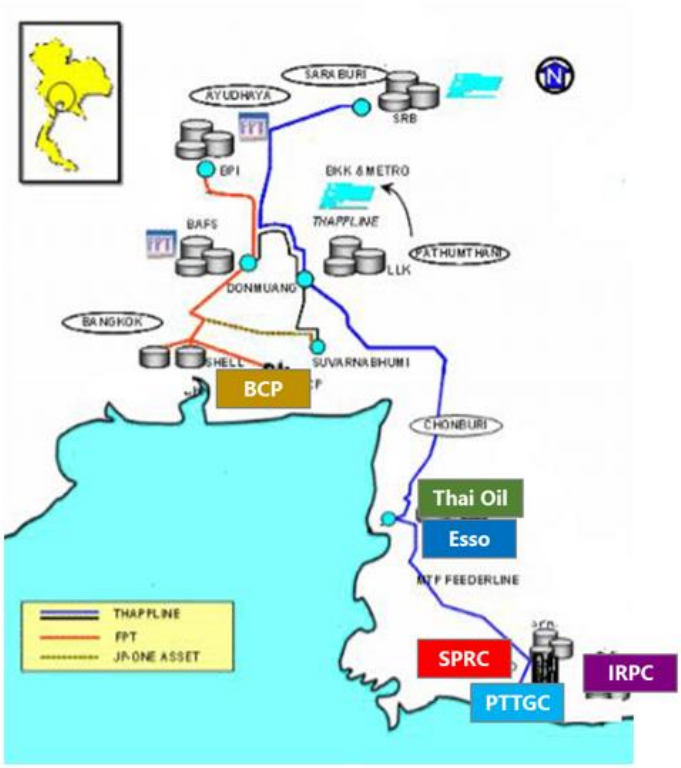
Thailand has seven oil refineries with a combined crude oil distillation capacity of 1 245 kb/d, including 2.5 kb/d of Fang refinery owned by the Royal Thai Army for military purpose (Figure 6). Except Bangchak refinery (BCP) in Bangkok and Fang refinery in Chiang Mai province, all refineries are situated in the eastern part of Thailand and are interconnected through an oil product pipeline (Figure 7).

Figure 6: Crude oil refinery capacity by refinery in 2022 (kb/d)



Source: (PTIT, 2021)

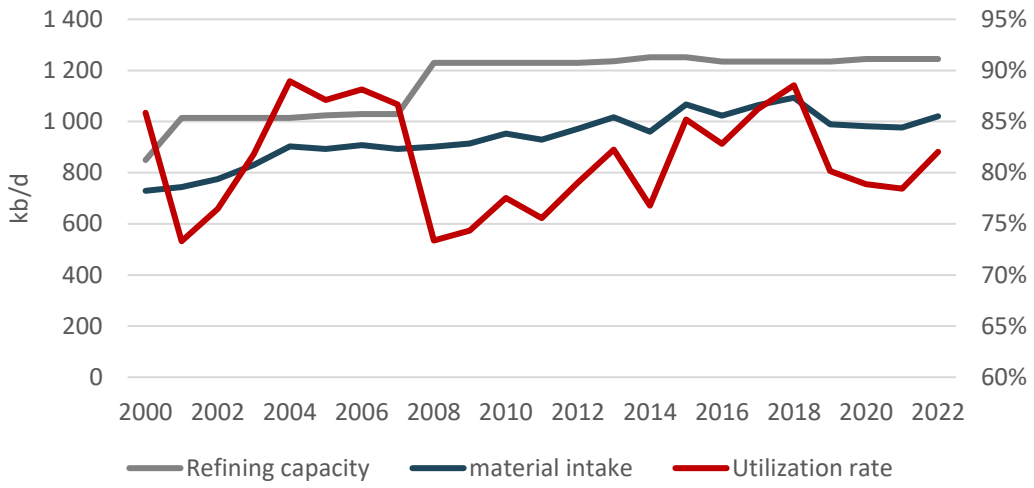
Figure 7: Location of oil refineries



Source: (PTIT, 2009)

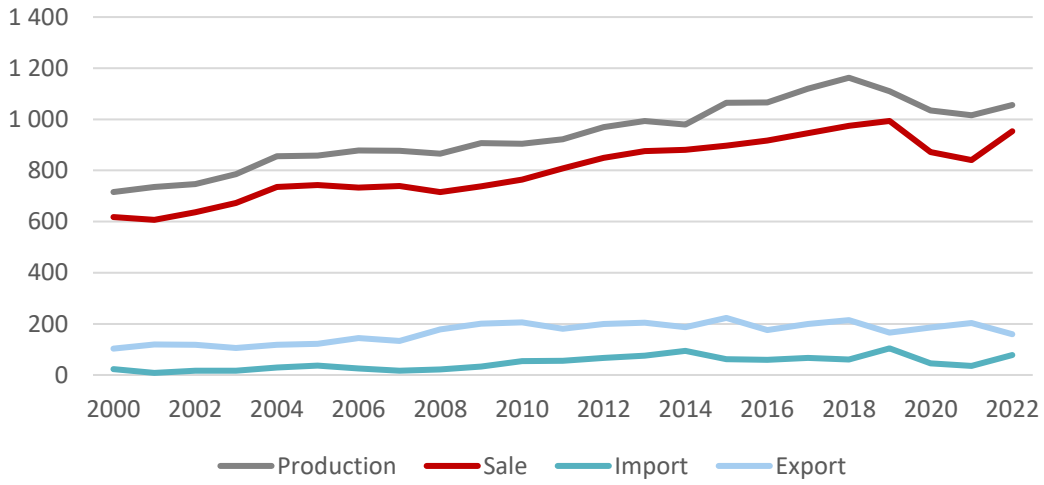
In 2022, Thai refineries processed a total of 1 021 kb/d of crude oil, indicating an 82% utilisation rate of their total capacity (Figure 8). Oil refineries in Thailand are modern and complex and have consistently maintained high utilisation rates, meeting the demand for petroleum products. Thailand is self-sufficient in production of petroleum products; the output from all refineries is adequate to fulfill domestic consumption needs (Figure 9). Surplus petroleum products are exported to neighbouring economies through long-term supply contracts and spot markets. Occasionally, minimal oil product imports are required for blending with domestic production or biofuels to meet specific product requirements.

Figure 8: Refining capacity, material intake, and utilisation rate (kb/d and %)



Source: (EPPO, 2023)

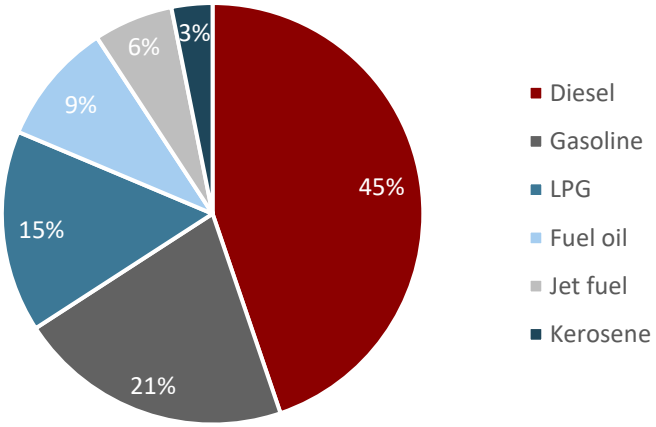
Figure 9: Petroleum product production, sale, import, and export (kb/d)



Source: (EPPO, 2023)

In terms of oil product yields from the refinery in 2022, diesel oil accounted for 45% of total oil product yield, gasoline 21%, LPG 15%, fuel oils 9%, and jet fuel at 6%, respectively (Figure 10).

Figure 10: Petroleum product yield mix from Thai refineries in 2022

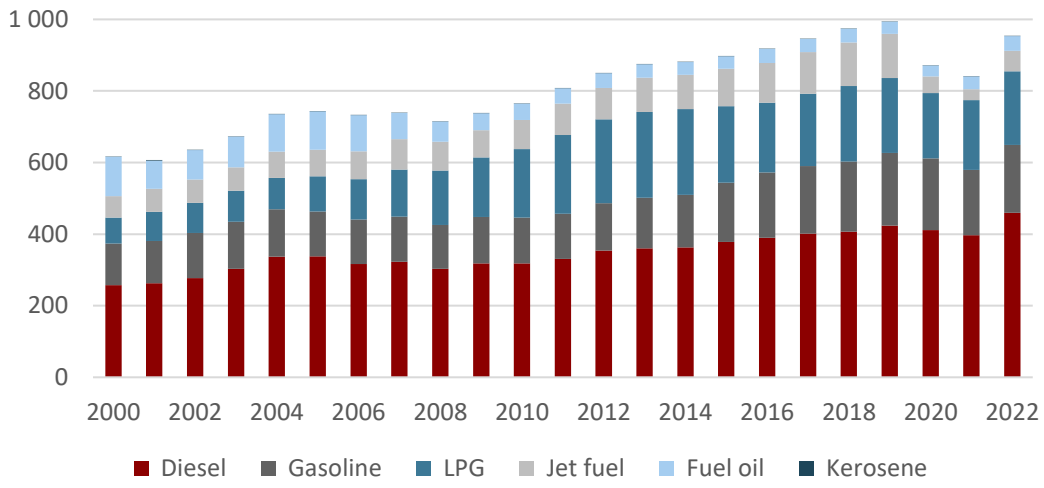


Source: (EPPO, 2023)

Consumption of petroleum products

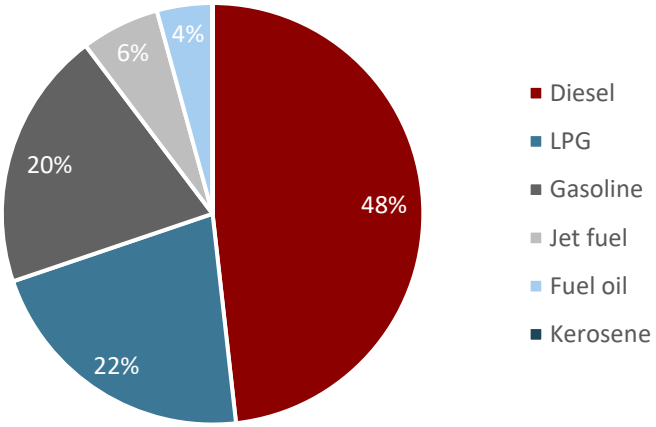
Total domestic consumption of petroleum products in 2022 was 953 kb/d (Figure 11). Of the total domestic consumption, diesel oil accounted for 48%, LPG 22%, gasoline 20%, jet fuel 6%, and fuel oils 4% (Figure 12). Diesel, gasoline, and jet fuel were primarily used in the transport sector, whereas fuel oils found applications in the industrial sector. Since 2008, Thailand has been a net importer of LPG, with imported LPG making up 23% of the total LPG supply in 2022. The petrochemical industry predominantly consumed LPG as feedstock, accounting for 43% of the total LPG usage. Household cooking represented 32% of consumption, with the transport sector, mainly public taxis, contributing 13%, and the industrial sector accounting for 11%.

Figure 11: Petroleum product consumption (kb/d)



Source: (EPPO, 2023)

Figure 12: Petroleum product consumption mix in 2022

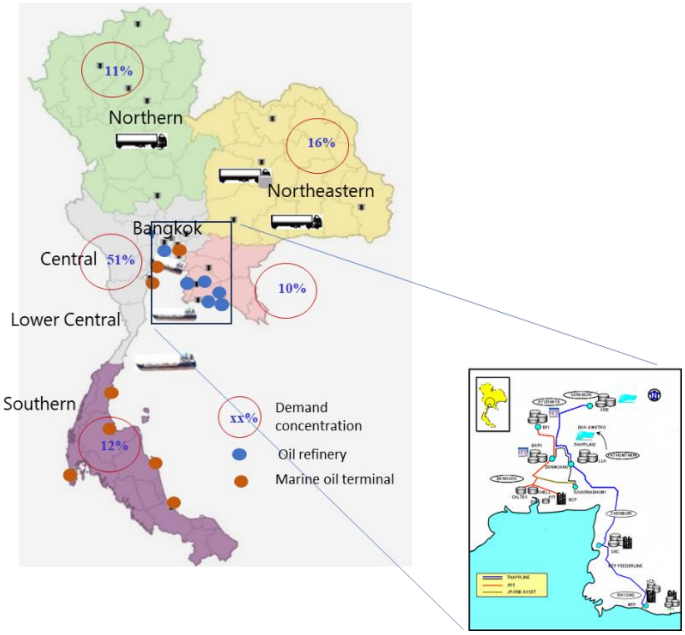


Source: (EPPO, 2023)

Distribution of petroleum products

Thailand is geographically divided into five regions: Central, Northeastern, Northern, Southern, and Eastern. Petroleum products from the Eastern region's five refineries were distributed to meet the demand in each region (Figure 13). Diesel, gasoline, and jet fuel were transported to the Central area through petroleum product pipelines, then redistributed via oil trucks to serve the needs of Bangkok and the Central regions. In the Northeastern and Northern regions, the products were transported to regional oil depots mostly by oil trucks, and subsequently by small-sized oil trucks to deliver to gas stations. The Southern region, located by the Gulf of Thailand, is distinctive, in that petroleum products are mainly transported by marine vessels to domestic marine depots before being redistributed to gas stations in the area.

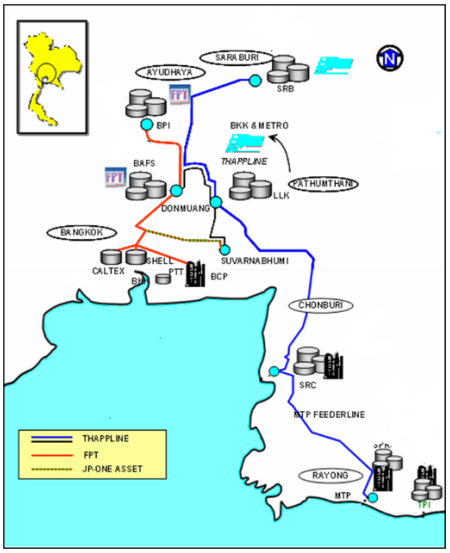
Figure 13: Distribution of petroleum products and demand concentration



Source: (PTIT, 2009)

Petroleum product pipelines have been expanded from the Central area to meet the growing demand in the Northeastern and Northern regions. The extension to the Northern region has recently been completed, while the Northeastern extension is expected to be completed by 2025. The primary pipeline system, Thappline, boasts a higher pipeline capacity and is presently operating at around 75% of its total capacity (Figure 14). Thappline can receive petroleum products from five major refineries located in the Eastern area. Additionally, the FPT pipeline, with a lower capacity, can directly receive petroleum products from the Bangchak refinery in Bangkok, and from eastern refineries via marine vessels. Currently, FPT is operating at approximately 60% of its pipeline capacity.

Figure 14: Petroleum product pipeline systems and capacity



THAPPLINE = 360 Km

Route	Dia.(inch)	Length(Km)	Cap.(m3/hr)
MTP-SRC	14	67	1,250
SRC-LLK	24	134	3,060
LLK-SRB	18	92	1,700
LLK-DM	10	29	450
LLK-SBA	18	38	1,600

FPT + JP One Asset = 99 Km.

Route	Dia.(inch)	Length(Km)	Cap.(m3/hr)
BCP-Shell	14	7	1,390
CTL-Shell	14	2	1,390
Shell-DM	14	25	1,390
DM-BPI	14	34	1,390
MKS-SBA	14	31	1,390

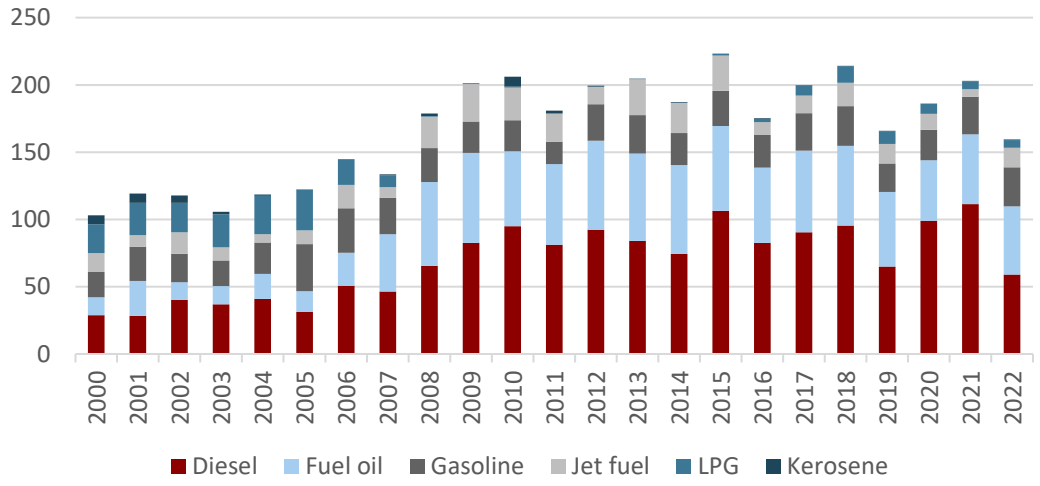
Source: PTIT Industry Survey (as of June 2021)

Source: (PTIT, 2009)

Petroleum product exports

In 2022, Thailand exported petroleum products at a rate of 159 kb/d in the forms of supply contracts and cargo spot sales (Figure 15). Among the exported products, 37% were diesel, 32% were fuel oils, 18% were jet fuel. Thailand's strategic geographic location enabled efficient inland transportation to cater to neighbouring economies' demands and facilitated exports to Singapore through marine vessels.

Figure 15: Petroleum product exports (kb/d)



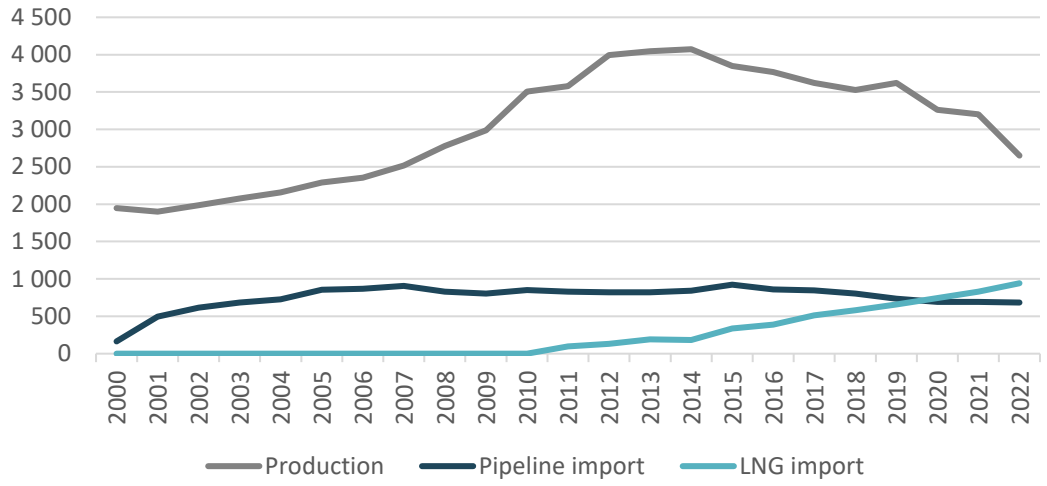
Source: (EPPO, 2023)

1.3. Gas supply and demand

Production and import of natural gas

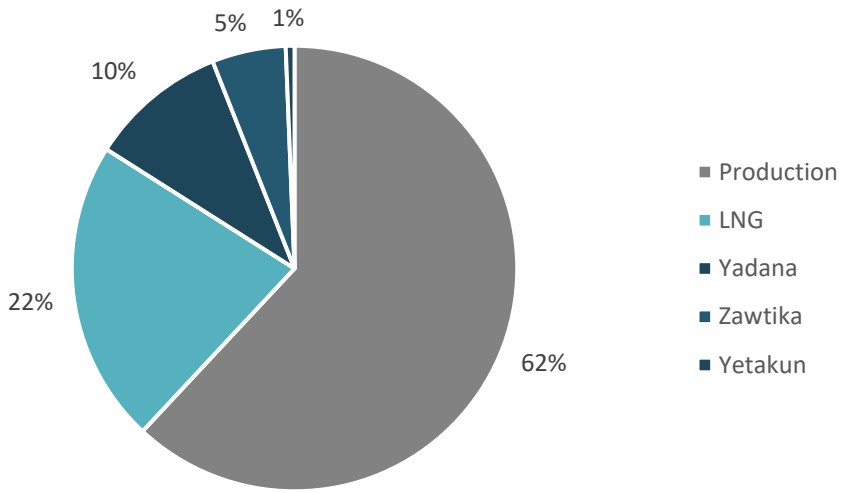
Historically, Thailand possessed a significant reserve of natural gas, enabling it to meet domestic consumption demands. However, with the depletion of these reserves and a surge in consumption, Thailand has increasingly relied on natural gas imports (Figure 16). In 2022, Thailand produced 2 648 MMscfd of natural gas from the Gulf of Thailand, constituting 62% of the total supply of 4 274 MMscfd. Domestic production steeply declined in recent years due to reduced investment and disruption caused by legal dispute between Chevron and PTT over Erawan gas field decommissioning costs. Natural gas imports accounted for 1 626 MMscfd, equivalent to 38% of the total supply. This import comprised 22% from pipeline gas import from Myanmar and 16% from LNG import (Figure 17).

Figure 16: Production and import of natural gas (MMscfd)



Source: (EPPO, 2023)

Figure 17: Share of natural gas production and import in 2022



Source: (EPPO, 2023)

PTT currently holds long-term LNG supply contract with four sellers, totalling 5.2 million tonnes per annum (Mtpa) (Cedigaz, 2023) (Table 1). Qatari contracts make up a large share (38%) of the current contract slate, making Thailand very vulnerable to potential disruptions from this economy. The rest of the contracts are with portfolio players, which means their supply sourcing could emanate from anywhere, including Qatar. However, with the Qatargas contract due to expire within this decade, there is an urgency for Thailand to secure new contracts. To address this, PTT has successfully negotiated three new LNG supply agreement, totalling 2.8 Mtpa, which are set to commence in 2026. Additionally, PTTGL is a Thai portfolio seller that procures the quantity from Corpus Christi, United States. Despite Thailand's active effort in seeking additional contracted volumes, the economy is still expected to heavily depend on the spot LNG market. This reliance persists due to the growing number of third-party LNG players.

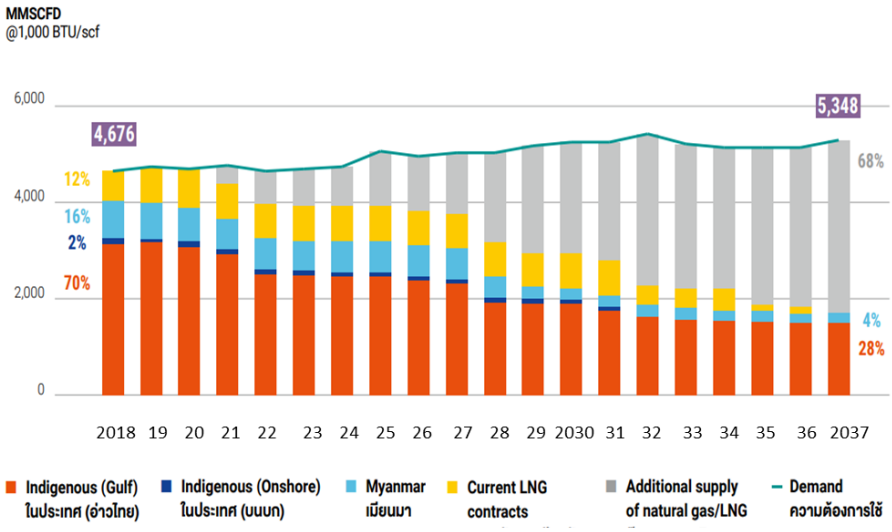
Table 1: LNG supply contracts (Mtpa)

Seller	Start year	End year	Volume (Mtpa)
Qatargas	2015-06-30	2029-06-30	2.00
BP	2017-06-30	2037-06-30	1.00
Petronas	2017-06-30	2032-06-30	1.20
Shell	2017-06-30	2032-06-30	1.00
Cheniere Energy	2026-01-01	2046-01-01	1.00
Oman LNG	2026-01-01	2035-01-01	0.80
PTTGL	2026-01-01	2040-12-31	1.00

Source: (Cedigaz, 2023)

Ensuring the security of Thailand's natural gas supply has become increasingly crucial. Thailand's Gas Plan 2018-2037 underscores the necessity for additional sources of natural gas, whether imported as LNG or through pipelines, or discovered domestically. With depleting domestic gas reserves and the expiration of existing long-term LNG contracts, the Gas Plan projects that new sources of gas, including LNG imports and new domestic discoveries, will account for approximately 68% of the total gas supply by 2037. This highlights the importance of diversifying and securing the economy's gas supply for the future (Figure 18).

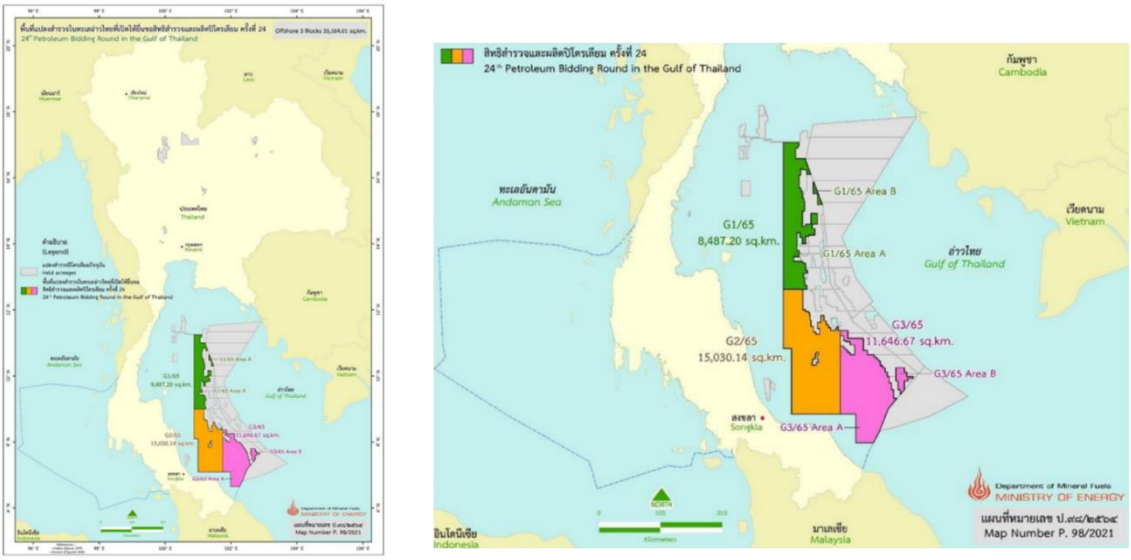
Figure 18: Future supply and demand of natural gas (MMscfd)



Source: (EPPO, 2020)

As the natural gas reserves in the Gulf of Thailand are diminishing, leading to a 17% decrease in domestic gas production in 2022 compared to 2021, Thailand is taking proactive steps to address the situation. In 2021, the economy awarded two concessions to PTTEP and Chevron Exploration, signalling its commitment to exploring new natural gas reserves in the Gulf (Figure 19).

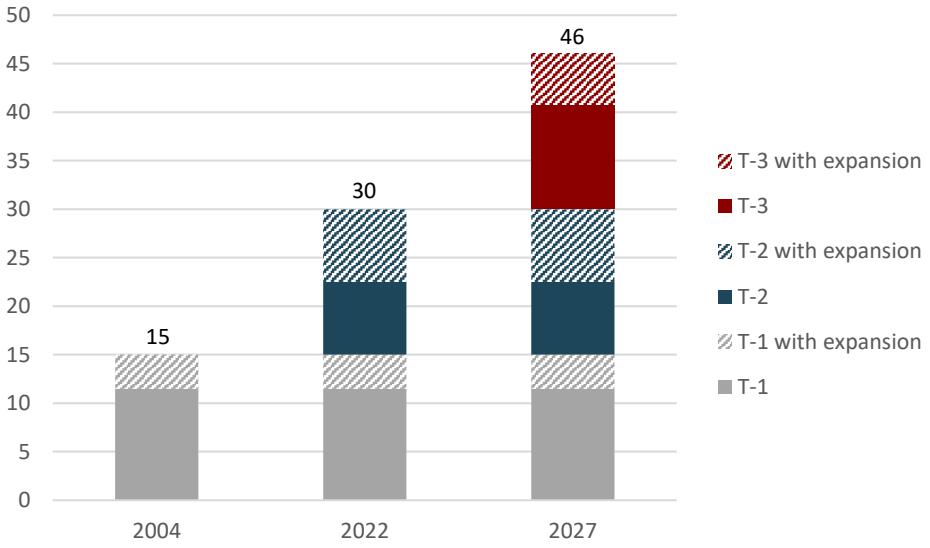
Figure 19: New oil and gas concession blocks in the Gulf of Thailand



Source: (DMF, 2021)

In May 2011, Thailand initiated LNG imports and currently operates two LNG import terminals in the Eastern region: Map Ta Phut 1 (T-1) and Map Ta Phut 2 (T-2). These terminals have a combined receiving capacity of 22.5 Mtpa, expandable to a maximum of 30 Mtpa (Figure 20). A third LNG receiving terminal, located nearby, is set to be completed by 2027, raising Thailand's total LNG receiving capacity to 40.8 Mtpa, with the potential for expansion to 46 Mtpa. This increase in capacity is crucial for ensuring the security of the natural gas supply, given the decline in domestic gas production.

Figure 20: Capacity of LNG import terminals (Mtpa)

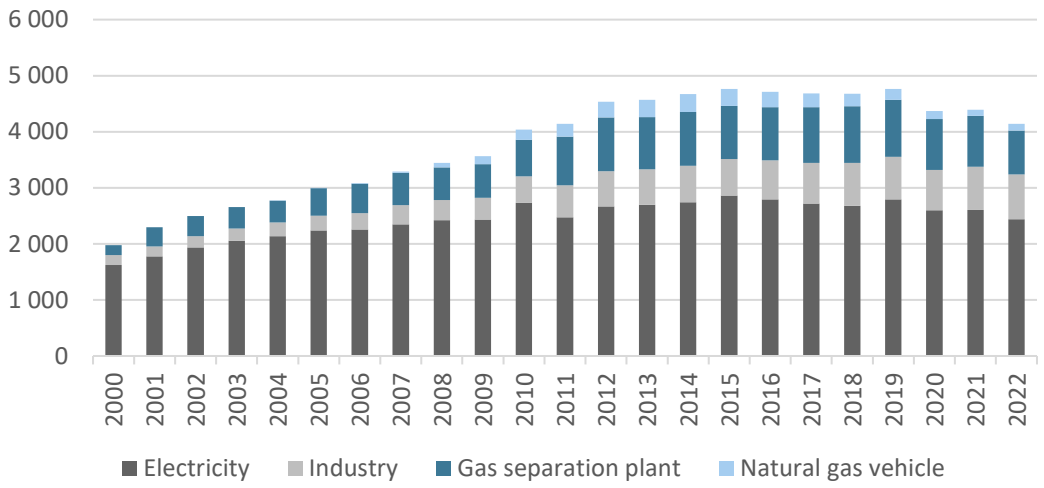


Source: APERC Analysis

Consumption of natural gas

In 2022, natural gas consumption in Thailand reached 4 143 MMscfd, marking a 5.7% decrease from the previous year (Figure 21). The power sector remained the largest consumer, accounting for 59% of the total consumption, followed by the industry sector at 19% and gas separation plants for the petrochemical industry, also at 19%. The recent fall in gas use is partly due to the higher cost of gas supply.

Figure 21: Consumption of natural gas by sector (MMscfd)



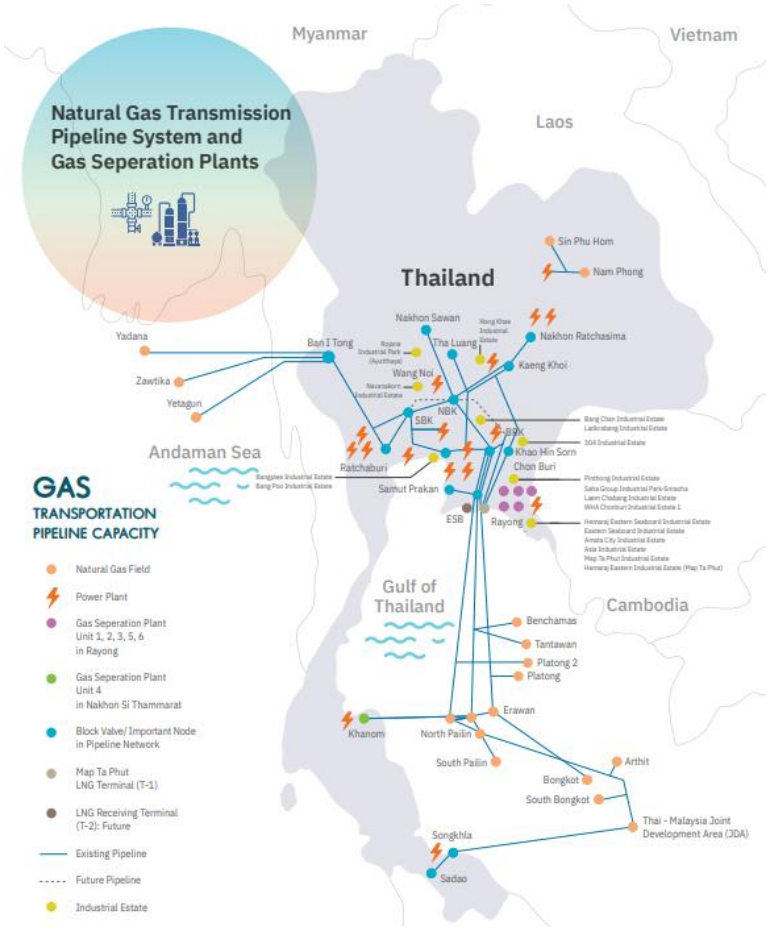
Source: (EPPO, 2023)

Natural gas grid and distribution of natural gas

Thailand boasts a sophisticated natural gas grid (Figure 22). Domestic natural gas extracted from 13 major production platforms in the Gulf of Thailand is transported through a network of subsea pipelines. These pipelines primarily supply gas separation plants in the Eastern region, with a portion also reaching gas separation facilities in the Southern region. Following the separation process, the gas is blended with imported LNG post-regasification. This mixed gas is then distributed to power plants and industrial gas consumers across the Eastern, Central, and Northeastern regions through an inland gas grid.

Furthermore, Thailand's gas grid is linked to imported pipe gas originating from Myanmar's gas production platforms to the west. In addition, there is a smaller gas grid in the upper Northeastern region, connecting onshore gas production to local power plants. Additionally, a gas grid in the Southern region receives offshore gas from the MTJDA and supplies it to both Southern gas separation plants and regional power facilities.

Figure 22: Natural gas grid



Source: (PTT, 2023)

2. Oil supply emergency exercise

2.1. Oil emergency scenario: stages 1 and 2

Background

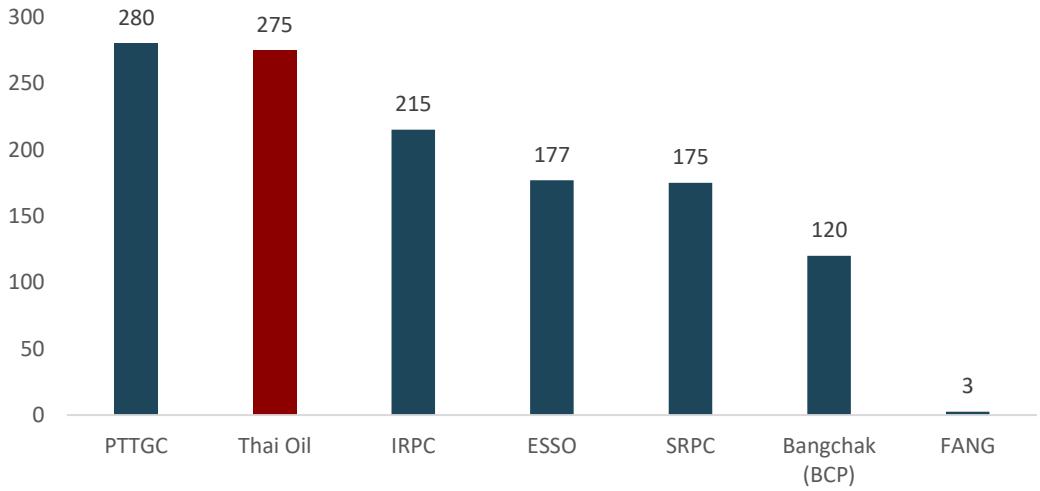
Thailand has limited crude oil production and hence is highly dependent on crude oil imports. In 2022, 92% of total crude oil supply was imported, mostly from the Middle East. Nevertheless, in terms of emergency response Thailand has proven to be resilient to crude oil supply disruptions, considering the past events such as geopolitical crises in the Middle East and an outage at a major crude oil receiving facility in the Eastern region. Since the first APEC Oil and Gas Security Exercise in Thailand in 2013, Thailand has committed to strengthening expertise in this area by conducting a comprehensive annual oil supply emergency exercise.

In this 5th APEC Oil and Gas Security Exercise, the oil emergency scenario stage 1 and stage 2 are aimed to highlight the response measures to the disruption of petroleum product supply and distribution. In scenario 1, it is assumed that the two largest oil refineries of Thailand are not able to supply petroleum products to the system. These two refineries account for 45% of total Thailand's refinery capacity in 2022, providing a vital source of supply of petroleum products. Thailand has never assumed any scenario at this level of severity in their past exercises. In scenario 2, the severity is further escalated by assuming a disruption in oil product pipeline, which is the main distribution system of transportation fuels, accounting for approximately 60% of product distribution. Even though Thailand has a sophisticated multi-modal distribution system for petroleum products, Thailand has never assumed the major disruption in pipeline system in their past exercises.

Stage 1 of the oil supply emergency scenario: Thai Oil refinery fire incident

The first stage of oil supply emergency scenario aimed to evaluate the response measure in the event of **a major disruption to petroleum product supply** from oil refineries. The scenario revolved around a significant fire incident at the Thai Oil refinery, the second-largest refinery in Thailand with a crude oil capacity of 275 kb/d (
Figure 23). The fire occurred in the crude oil distillation unit, a crucial part of the refinery, and was caused by a vapor leak igniting due to an unidentified source. The incident occurred in the early morning of 6 September but was eventually brought under control after several hours of intensive firefighting efforts.

Figure 23: Oil refinery capacity in 2022 (kb/d)



Source: (EPPO, 2023)

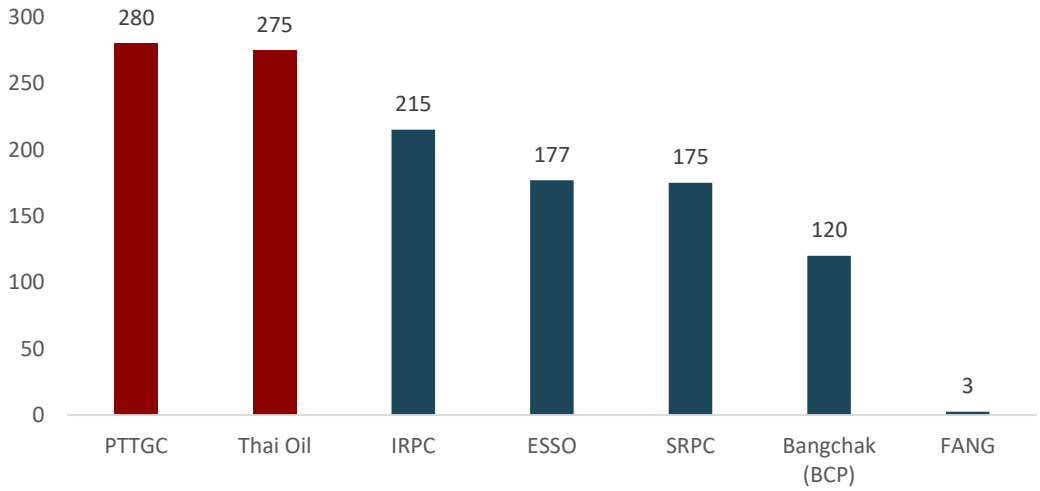
Despite the fire being contained, the intense flames severely damaged key operational units, including hydrocracking units, thermal cracking units, and platformer units. Consequently, the Thai Oil refinery had to completely cease its operations, shutting down oil refining activities and associated facilities involved in loading/unloading oil products into tank trucks, as well as all crude oil and oil product storage tanks. It was important to note that the operations of receiving and loading oil products at the marine terminal remained unaffected.

During the oil supply emergency exercise, a simulated news report called *APERC Breaking News* was created and presented to the audience to enhance the realism of the scenarios (Figure 24). According to this mock news report, the Thai Oil refinery was quoted to have to be shut down for a minimum of 60 days for a major repair due to the incident. Moreover, the 6 September fire incident at Thai Oil occurred at a time when Thailand's largest refinery, PTTGC, with a refining capacity of 280 kb/d, was already amid a scheduled shutdown for routine major maintenance (
Figure 25). Consequently, PTTGC couldn't supply any petroleum products to the market for the next two weeks or 14 days (Figure 26). Both Thai Oil refinery and PTTGC refinery are in the Eastern region of Thailand and are connected through the Thappline oil product pipeline.

Figure 24: APERC Breaking News

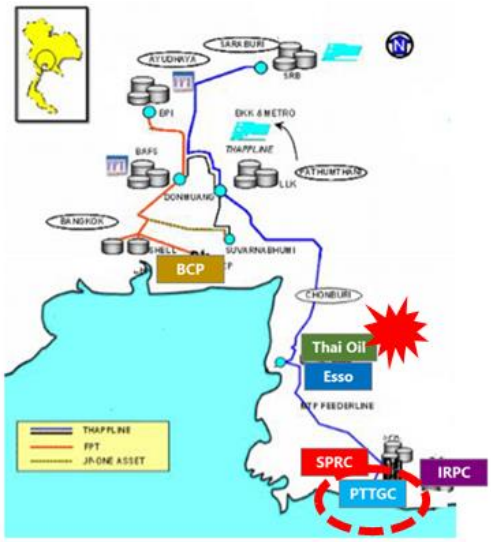
Source: APERC, 2023 (NP)

Figure 25: Refining capacity of PTTGC and Thai Oil refineries



Source: (EPPO, 2023)

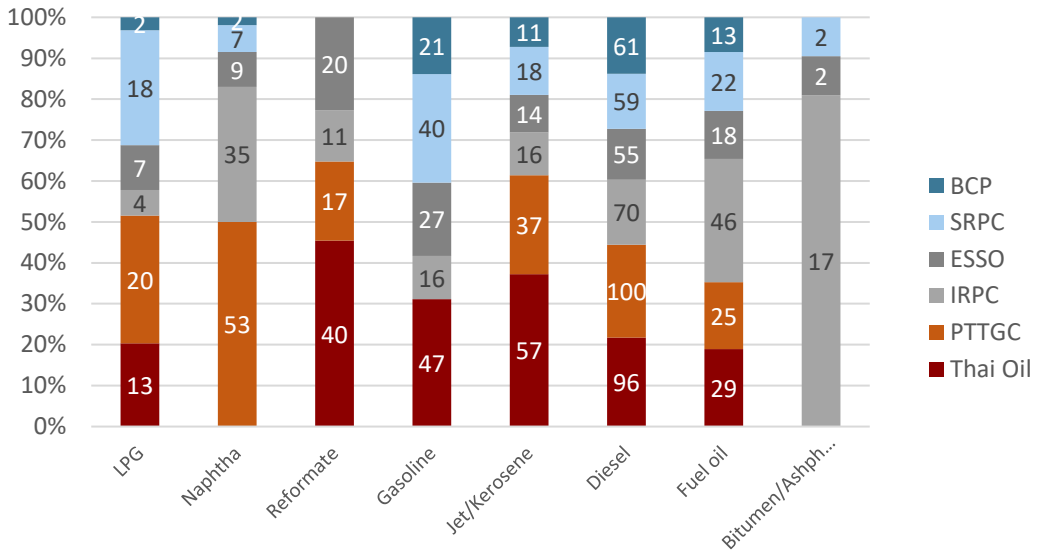
Figure 26: Location of Thai Oil and PTTGC refineries



Source: (PTIT, 2009)

The two major refineries have a combined refining capacity of 555 kb/d, almost half (44.5%) of Thailand's total oil refinery capacity. Consequently, the disruption in petroleum product supply from the two refineries was anticipated to cause severe product shortage to the Thai oil market. For example, the combined production of LPG from PTTGC and Thai Oil refineries in 2020, as seen in Figure 27, was 33 kb/d, which accounted for half of total LPG production from all refineries. Similarly, the production of diesel and gasoline from the two disrupted refineries were 196 kb/d and 47 kb/d, which accounts for 45% and 31% of total production in 2020, respectively. The situation was especially critical for jet fuel, vital for the tourism industry, as the combined supply disruption from the two refineries amounted to 94 kb/d, equivalent to 61% of the total production.

Figure 27: Share and total refinery capacity by petroleum products in 2020 (% and kb/d)



Source: (PTIT, 2021)

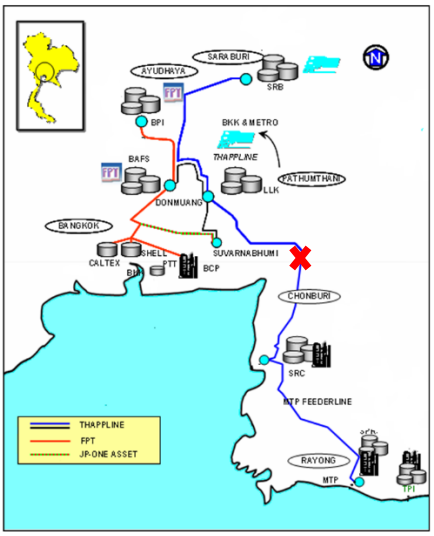
In summary, the first emergency scenario was expected to illustrate one of the most severe possibilities that could happen in the oil product supply in Thailand. Consequently, the response of the Thai stakeholders to counter this scenario was expected to be valuable.

Stage 2 of the oil supply emergency scenario: Thai Oil fire damaged Thappline

The second stage of oil supply emergency scenario was designed to assess the robustness of response measures in dealing with the disruption in Thailand's petroleum product distribution system. This stage assumed that the propagation of the fire during the incident at Thai Oil refinery also caused severe damage to the operation of the nearby Thappline petroleum product pipeline.

All five major refineries in the Eastern region of Thailand, which collectively possess a refining capacity of 1 122 kb/d (90% of total refining capacity), are connected to the Thappline product pipeline. As of 2020, the refineries in the Eastern transported their oil products through Thappline due to the competitive transport tariffs as compared with other transportation modes. Thappline typically operated at 60% of its maximum pipeline capacity of 1 250 cubic meters per hour (Figure 28). Oil transportation into Bangkok, Saraburi, and Suvarnabhumi airport is mainly by Thappline. The shutdown significantly impacted the entire oil transportation system in the Eastern area, affecting facilities such as Thai Oil Refinery, Esso Sriracha Refinery, PTT Oil Terminal, and Cholburi Terminal Co. Ltd. Moreover, oil transportation from PTTGC and SPRC through Sriracha to Bangkok via Thappline became impossible.

Figure 28: Petroleum product pipeline capacity



THAPPLINE = 360 Km

Route	Dia.(inch)	Length(Km)	Cap.(m3/hr)
MTP-SRC	14	67	1,250
SRC-LLK	24	134	3,060
LLK-SRB	18	92	1,700
LLK-DM	10	29	450
LLK-SBA	18	38	1,600

FPT + JP One Asset = 99 Km.

Route	Dia.(inch)	Length(Km)	Cap.(m3/hr)
BCP-Shell	14	7	1,390
CTL-Shell	14	2	1,390
Shell-DM	14	25	1,390
DM-BPI	14	34	1,390
MKS-SBA	14	31	1,390

Source: PTIT Industry Survey (as of June 2021)

Source: (PTIT, 2009)

Due to the Thappline disruption, refineries would likely resort to using oil trucks and marine tankers for oil product transfers to Bangkok, leading to heavy traffic congestion and increased diesel consumption. However, the FPT product pipeline had the capability to receive oil products by barge and redistribute them to two other inland oil terminals and the two international airports in Bangkok, albeit with limited capacity. Marine product transfer options were also restricted.

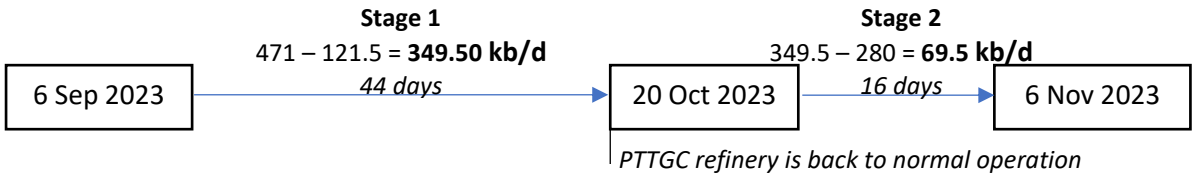
The repair of the Thappline system was assumed to take a minimum of three weeks, exacerbating the challenges faced by the affected oil transportation network.

2.2. The response

After the oil scenario presentation, there was a specific inquiry from a Thai stakeholder about the assumption regarding petroleum product imports, as relying on imports could potentially incur significant costs. In response to this concern, APERC decided to grant Thai stakeholders the flexibility to freely assume any level of imports in their assessments. This approach acknowledges the importance of addressing potential financial implications and empowers the Thai stakeholders to make informed decisions based on their specific needs and circumstance.

Figure 29 illustrates the chronological progression of the oil scenario during Stage 1 and Stage 2. Stage 1 spans from 6 September to 20 October 2023, encompassing a duration of 44 days. Subsequently, Stage 2 extends until 6 November 2023, spanning 16 days. The numerical values in the figure represent the extent of supply loss. Thai stakeholders have presented their strategic responses to address the situation systematically, aligning with the stages mentioned.

Figure 29: Timeline of oil scenarios



2.2.1. Response on oil scenario: stage 1

A. Government's response

The initial reaction of the Thai stakeholders was to activate the Emergency Response Center. This comprised officials from relevant departments and divisions of MOE including International Affairs Division, Strategy and Planning division, DMF, EPPO, DOEB, and other relevant organizations including EGAT, ERC, and PTT, each has its own responsibilities in case of oil supply emergency.

The Thai stakeholders also indicated to referring on their own Oil Emergency Response Plan. The Oil Response Plan contains response measures for light-, medium- and heavy-handed emergencies.

B. Assessment of impact

In the response, Thai stakeholders provided an estimation of the impact on caused by the refinery outage. The estimated loss of refinery production capacity was calculated at 349.5 kb/d. This was derived from the gross total loss of refinery capacity due to Thai Oil outage of 275 kb/d, plus the loss of 70% of 280 kb/d refining capacity from maintenance of PTTGC. Total refining capacity loss would thus be 471 kb/d (275 kb/d + 70% of 280 kb/d). The 70% comes from the fact that Thai regulations require refineries to stock at least 30% of its refining capacity throughout the duration of a maintenance shutdown.

To estimate net capacity and volume loss, Thai stakeholders further assumed that the government would impose a ban to oil product export of 121.5 kb/d. Therefore, the net refinery production capacity loss was 349.5 kb/d (471 kb/d less 121.5 kb/d), which was equivalent to a product volume loss of 2 445 million liters for the 44-day period. This loss of refinery production capacity was used to estimate the volume loss and specific countermeasures throughout the supply chain of each petroleum product to alleviate the disruption and to minimize the impact from crisis.

C. Basic stance of the government

- ❖ Supply measures

The Thai stakeholders outlined a detailed plan of action specific to various fuel types. In the case of LPG, the strategies involve curtailing consumption within the petrochemical industry, enhancing LPG import capabilities, transitioning owned-use fuel sources from LPG to natural

gas in refineries, and restricting LPG exports. All measures are aimed to bring more LPG supply to help alleviate supply disruption from the LPG.

Regarding gasoline and diesel, the timeline analysis from the Thai stakeholders indicated that there were 21 days of supply left for gasoline and 18 days for diesel at the time of the incident. This reflects legal reserves, working stock and the production of the remaining refineries at normal operations. To address this impending shortage, an emergency response center was activated. Measures to be implemented by the center included increasing gasoline and diesel imports; limiting petroleum product exports; exploring available supply reserves; incentivising higher biofuel blend rates; urging refineries to maximise capacity; and facilitating the transfer of crude oil from Thai Oil to other refineries, although adjustments in product formulations might be necessary. Additionally, the fuel specifications of gasoline imports were relaxed to widen the product eligibility to respond to the shortage.

As for jet fuel, taking legal reserves and working stock into account, Thailand has 6 days of the fuel in storage. This was because the two refineries were major supply sources of jet fuel, producing more than 60% of total jet fuel production capacity. To address this issue, Thai stakeholders proposed optimising distillated portions to increase jet fuel production, thereby reducing domestic diesel production. Given Thailand's available diesel import capacity, this reduction in diesel supply can be compensated for by increasing imports. Thailand also planned to increase its jet fuel imports while enforcing international standard quality control and implementing restrictions on jet fuel exports.

- Demand measures

A DSM strategy was outlined from 6 September to 20 October 2023, spanning 44 days. This plan involves promoting fuel consumption awareness, providing incentives to fuel users to reduce their consumption, and encouraging the use of public transportation.

Recognising the severity of the situation, international cooperation efforts were emphasised, highlighting the need for collaborative measures with neighbouring governments and global partners to secure essential energy supplies and maintain stability in the region. These comprehensive strategies and collaborative initiatives were crucial in mitigating the impact of the refinery outage and ensuring a coordinated response among stakeholders.

In summary, the Thai stakeholders deemed that the above response measures, on both the supply and demand sides, should be sufficient to handle the oil supply disruption crisis in scenario 1.

2.2.1. Response on oil scenario: stage 2

A. Government’s response

Aside from activating the Emergency Response Center, one of the responses also suggested to establish a mechanism that will involve international collaboration such as seeking guidance from neighbouring economies within the region e.g., ASEAN or APEC. The Emergency Decree on Remedy and Prevention of Shortage Fuel Oil also needs to be activated.

B. Assessment of impact

Thai stakeholders highlighted the impact of the Thappline outage on their product distribution system. Lum Looka's Thappline, a vital component of the fuel supply chain, was unable to deliver fuels to the north and northeast regions, resulting in a loss of approximately 25.8 million liters per day (Ml/D). Although the FPT pipeline, connected to Bangchak refinery and serving locations like Ayudhaya, Phitsanulok, Kampaengpetch, and Lampang, is still operational, its limited capacity of 4 Ml/D leaves a critical deficit of 21.8 Ml/D that urgently needs resolution. The central challenge lies in framing a solution to replace the lost 21.8 Ml/D of products, necessitating the exploration of alternative transportation methods and strategies to ensure the stability and reliability of fuel supply.

C. Basic stance of the government

- ❖ Supply measures

To address the pressing issue of the Thappline outage, several supply-side measures (oil product distribution modes) have been proposed. Firstly, regulations governing heavy vehicle transportation, the so called “banned hours”, will be relaxed. This will allow more time for oil trucks to deliver products to the high demand concentration in Bangkok, previously accommodated by Thappline. Theoretically, all the deliveries of oil trucks will need rerouting to optimise the utilisation of the available oil trucks, and to ensure the efficiency of fuel supplies. Moreover, alternative modes of transport, including marine vessels, rail systems, additional oil trucks from other provinces, and additional use of oil depots, will be actively explored and deployed to bridge the gap on petroleum product supply caused by the pipeline issue. These measures aim to improve efficiency of available transportation infrastructures, ensuring a stable fuel supply to affected regions.

- ❖ Demand measures

On the demand side, proactive measures have been initiated to alleviate the Thappline outage impact. Requests to other agencies have been made to streamline processes and enhance coordination. Public communication measures have been identified to keep stakeholders informed in a transparent manner to prevent panic of the public.

Additionally, the implementation of the Emergency Decree on Remedy and Prevention of Shortage Fuel Oil will be activated, which includes oil rationing strategies to ensure a fair allocation of fuel products to various service sectors according to the pre-determined priority lists. These demand-side initiatives collectively aim to manage the crisis, minimise disruptions and maintain stability in the fuel supply chain.

In summary, the Thai stakeholders deemed that the countermeasures as presented should be sufficient to manage the crisis from the disruption of oil product distribution system in scenario 2.

D. Challenges for the improvement of response measures

The Thai stakeholders highlighted that more data and information about the distribution system of oil products need to be collected and analysed to ensure effectiveness of the response measures. These include, for example, the number of available oil trucks and marine vessels, the storage level and tankage capacity of regional oil depots, and the current oil product distribution.

2.3. Observations and recommendations from the expert team

For this exercise, APERC assembled a group of seven oil and gas (energy) security specialists. The details of these experts are available in **Annex III**. Considering the unique features of the Thai energy sector, the expert team examined Thai stakeholders' response measures to the two stages of oil emergency situations and offered the subsequent recommendations.

Institutional arrangements and communication strategy

1. As the response measures will involve various stakeholders (e.g. energy, food and climate/environment), it is crucial to ensure to coordinate inter-ministerial collaboration at different levels based on crisis severity. This adaptive strategy ensures a unified and effective emergency response. Emphasising seamless cooperation enhances authorities' preparedness, reinforcing resilience in emergency situations.
2. Documenting emergency response policy and procedures for both oil and gas responses is important and highly recommended by the expert team. The document should clearly address roles and responsibilities of each person in the response team, as well as the delegation of authorities in activating each level of response measures.
3. Having backup personnel is worth considering. The backup personnel serve as a safety net, ready to step in if the original emergency response team is unable to respond immediately. Their presence ensures that there is always a contingency plan in place.
4. Institutional memory. It is important that all emergency response documents, old or new, are properly endorsed to the succeeding staff and officials to preserve the efforts made in the past.
5. The emergency response team should consider including APERC's scenarios in the OGSE into the annual exercise.

Supply measures

6. An expedited refinery maintenance process could be considered to bring the operation of PTTGC back to normal ahead of schedule. The commissioning of PTTGC will significantly alleviate the supply disruption of oil products.
7. The imposition of restrictions on LPG exports should be carefully considered, as this could create a ripple effect across ASEAN economies reliant on Thailand for LPG supply.

Additionally, substituting LPG with natural gas should be evaluated carefully as it can inadvertently transfer the issue to the power sector by disrupting gas supply.

8. The potential negative repercussions on Thailand's economy due to limitations on jet fuel exports require a comprehensive reassessment. This reevaluation is imperative, considering the intricate connections between economic stability, trade relationships, and domestic energy markets.

9. Response measures targeting refinery processes could be considered, especially in cracker units, to manage both yields and slate to optimise jet fuel and diesel production from the remaining active refineries. Crude processing deals and arrangements between refineries should also be evaluated in advance as different crude oil inventory in the affected refinery may need to be transferred to be processed in other refineries. This will help enhance the product supply capability during an emergency.

10. Increasing the consumption of biofuels by incentivising E20 vehicles to switch to use the E20 gasoline instead of E10 or normal gasoline is suggested by the experts. This increase in the use of biofuels should displace some gasoline consumption. Simultaneously, a temporary relaxation of gasoline grade specifications and streamlining two types of gasoline components (G-base 1 and G-base 2) into a single G-base grades is also recommended to optimize the gasoline blending system.

11. Legal reserves are underscored as a fundamental pillar of energy security, surpassing commercial interests. The experts emphasise that legal reserve should be used as the last resort for domestic security. In emergency situations, measures that acquire additional supply and elicit demand responses should take precedence, ensuring a delicate balance between safeguarding domestic security and maintaining economic stability. Additionally, because the reserve cost is directly transferred into the fuel costs, it is important that the government should exercise caution in determining the appropriate amount of compulsory reserve to be legalized.

12. Solving logistical problems should begin with exercising a combination of different alternative modes of transporting oil products before resorting to heavy-hand measures such as demand rationing or trade restriction. Therefore, it is essential for the response team to fully study and understand the logistical capacity and have access to transport system data to assess the potential for switching transport modes. Furthermore, the process should include a review and re-evaluation of the countermeasures in each mode at appropriate time intervals, such as annually or twice a year.

13. Consider increasing the use of the newly operating TPN pipeline in the Northeastern region as it has idle capacity of transporting more products to the region, thus can help redirect trucks from the Northeastern area to the affected regions, aiding in extra transportation capability during emergency.

14. To mitigate logistical hurdles, imposing access to inventory data requirements at gas stations is recommended. Thai stakeholders discussed regulating digital measures of gas stations' stockpiles. They also recognised the potential benefits the government can get from accessing inventory data during emergencies.

15. Switching to supply sources closer to demand concentration through 'product delivery swapping concept' is suggested. Implementing regional stock supply can future enhance logistical efficiency. A possibility is, for example, the remaining refineries or regional oil depots to supply to the nearby demand regardless of normal supply contract. This will

greatly reduce the traveling distance of oil trucks from the normal contracted supply sources, thereby increasing availability of oil trucks to substitute the pipeline disruption.

Demand measures

16. If possible, a priority list and implementation process for petroleum products rationing should be agreed upon by involving agencies/authorities in advance and endorsed by the highest authorities. In Thailand's context, public health, public transport, and private vehicles are prioritised, respectively. Moreover, a course of action to enforce the merit order of the priority list is determined by subcommittees from various ministries.

17. In exercising oil product rationing, it is necessary that the response team of the Ministry of Energy seek acknowledgment from involving authorities and to monitor for the impact of the measure in order to make any necessary adjustments.

Data management and accessibility

18. The critical role of accurate and up-to-date data is emphasised in making informed decisions. Thai stakeholders delve into an existing regulation known as Article 7, which governs fuel traders. However, concerns have been raised regarding the timeliness of real sales data, indicating a one-month lag. Moreover, Thai stakeholders stress the importance of daily updates for fuel stocks, underscoring the crucial need for timely information for effective decision-making processes.

19. The establishment of a dedicated data center is strongly encouraged. This center would serve as the hub for real-time information during emergencies, facilitating prompt and well-informed decision-making processes. The commanding central data center also facilitates rapid and non-disclosed exchange of information between agencies, without the need for authorization processes under the mandate authority.

Regional cooperation

20. Thai stakeholders seek the expert team’s opinion on the feasibility of the ASEAN Joint Stockpiling mechanism. While ASEAN member states have initiated the APSA, the slow implementation and lack of legal binding make bilateral initiative preferable. Additionally, the APEC framework should foster cooperation in oil stockpiles within the region.

General recommendations

21. Relevant publications by the IEA regarding demand restraint measures are recommended. These publications offer estimations of volumetric savings in various global regions, providing valuable insights for developing effective strategies.

3. Gas supply emergency exercise:

3.1. Gas emergency scenario: stages 1, 2, and 3

Background

While Thailand is highly dependent on natural gas, its energy system makes it exceptionally resilient to gas supply disruptions. Several structural components contribute to this. Firstly, its electricity sector is built to respond to emergencies through fuel-switching. Its electricity sector has a reserve margin of over 30%, and over 40% of its capacity possesses boilers with dual-fuel (either gas-fuel oil or gas-diesel) sophistication, which are required to keep a minimum stock of secondary fuel for 3 to 5 days. Furthermore, EGAT has a team dedicated to acquiring fuel stocks, and Thailand could lean into its refinery sector to prioritise supplies of diesel and fuel oil towards domestic power facilities in the event of a gas disruption. Thailand also recently increased its supply flexibility of LNG supply by commissioning a second terminal (Map Ta Phut 2) in late-2022. This increased LNG storage capacity by three-quarters to almost 15 billion cubic feet (1.1 Mm^3) and LNG import capacity by two-thirds to 2.5 billion cubic feet per day (bcf/d) (19 Mtpa). Furthermore, adding a separate terminal adds more redundancy in the event of an equipment failure at either facility. Thailand's offshore gas production could theoretically provide it with some ability to ramp up domestic production in response to emergencies, but this has recently been limited by a handover of Erawan assets from Chevron to PTTEP.

More importantly, Thailand has a strong record for building resilience by committing to continuously improving its energy security framework. Since the first Oil and Gas Security Network Forum in 2013, Thailand has committed to an annual energy system exercise to identify new threats to its energy system and participates in other security exercises by APERC, IEA, and ASEAN Economic Community (AEC). Furthermore, the Gas Disruption and Disaster Prevention Team developed a War Room in 2023 to maintain an adequate gas supply following recent turmoil in oil and gas markets. These exercises reveal some degree of demand response that Thailand can exercise to provide additional flexibility during a supply disruption.

However, despite all this preparedness, there are several vulnerabilities to Thailand's gas security. While PTT is reducing its reliance on Qatar for LNG supply, falling from 61% in 2017 to 28% in 2022, this has been chiefly achieved via a higher exposure to LNG spot markets (GIIGNL, 2023). Over a third of PTT's long-term LNG contracts are still with Qatar, specifically the Qatargas III export terminal, with the rest being provided via the assortment available to portfolio players. PTTGL did sign a long-term contract to supply PTT with US LNG exports from Corpus Cristi, but this will not be active for another two years. As such, Thailand's primary source of low-cost LNG supply is vulnerable to disruption if something were to prevent Qatar from fulfilling its contracted volumes. There is precedence for this. In 2009, a cooling water failure halted output from the Qatargas I terminal, leading to a three-to-four-week force majeure that prevented it from delivering its contractual deliveries to LNG buyers (Reuters, 2009). A similar occurrence at Qatargas III would eliminate much of Thailand's low-cost, reliable gas supply.

Short-term LNG purchases have risen significantly in recent years. This strategy provides Thailand with supply flexibility and lower-priced spot volumes during periods of LNG oversupply. However, it also exposes Thailand to higher, volatile LNG prices during periods of tight supply. Competing for spot market volumes during the current global gas market restructuring following the Russian-Ukrainian war will challenge Thailand's affordability and availability of LNG supply for the next couple of years. These vulnerabilities could be mitigated by increasing domestic production. However, Thailand's offshore resource is currently plagued by a structural decline from low investment and a significant drop in output from the Erawan region following a complicated hand-off of assets from Chevron to PTTEP. Thailand hopes to reverse this decline over the next couple of years. Until then, any supply disruption to gas imports will have to be met from short-term LNG imports.

There is a historical precedent for both equipment failure and tropical storms to reduce production from Thailand's offshore. Pipeline leaks, compressor failures, and production complications can temporarily reduce production from any gas facility. While rare, ten tropical cyclones have passed through the Gulf of Thailand in the past 60 years. In 2019, PTTEP curtailed production by about a quarter after typhoon Pabluk passed over the prolific offshore producing areas of Erawan and Bongkot.

Thailand imports over a tenth of its supply from Myanmar via pipeline imports (EPPO, 2023). However, these imports mainly serve its West gas market. These gas specifications of this market are of a lower quality (energy content) that is unsuitable for use in its East market, where most end-users use equipment that cannot handle the lower quality gas. While there is a small mix market bridging the East and West markets, the infrastructure to move gas between the two is minimal. Because of this, it is assumed that Myanmar imports from the West market will be of little use to alleviate any East market supply disruptions. The East market is estimated to require about 3.5 bcf/d of gas in 2023 and is primarily served by domestic (offshore) production and LNG imports.

In the 5th APEC OGSE, the three gas emergency stages are structured to test the demand and supply flexibility of Thailand's response measures. This first stage tests the ability of LNG storage to mitigate disruptions to long-term LNG contracts. The second stage further stresses storage mitigation and begins to test the demand response ability of gas users. The third stage forces Thailand to conduct an acute demand response. To the best of our knowledge, Thailand has never had an emergency scenario wherein long-term LNG supply and offshore production are seriously impaired by a force majeure combined with the effects of a typhoon, followed by a pipeline failure. Future exercises may want to also combine a disruption to oil product supply to gas emergency scenarios further strain the power sector's flexibility, particularly from its dual-fire boilers that rely on diesel or fuel oil stocks for fuel switching during gas disruptions.

Stage 1 of the gas supply emergency scenario: *force majeure* at Qatargas III

On 2 October 2023, Qatargas declared *force majeure* on all LNG delivery obligations from its Qatargas III terminal due to a conflagration and equipment failure. The company and insiders believed that the equipment, and its associated contract deliveries, would be out of commission for at least a month. With Qatargas unable to fulfil October LNG deliveries to Thailand, the Eastern gas market lost a third of its LNG supply (0.41 bcf/d) for the month. This

reduced the LNG import rate from 1.1 bcf/d to 0.73 bcf/d. If Thailand continued to regasify LNG at a rate of 1.1 bcf/d, LNG storage would draw at a rate of about 0.41 bcf/d. Unlike other major APEC LNG importers, such as Japan and Korea, Thailand did not make its LNG inventory levels publicly available. As such, the exercise assumed that its LNG storage is around 60% full at the time of the incident. At a depletion rate of 0.41 bcf/d, it would take Thailand around 36 days to deplete storage at these levels.

Stage 2 of the gas supply emergency scenario: Typhoon Zigzag

On 5 October 2023, tropical storm Zigzag formed in the South China Sea. Zigzag was projected to intensify into a typhoon and enter the Gulf of Thailand the following day. To avoid resource and equipment damage and avoid loss of life, offshore production needed to be shut off in stages between 7 and 11 October 2023. The approach of any short-term LNG tanker imports was also affected, falling further to 0.35 bcf/d.

While the scenario initially assumed that the production offset due to the typhoon would be 0.8 bcf/d, input from Thai stakeholders informed exercise participants that experience with previous typhoons suggest that all production in the offshore and MTJDA could be curtailed during Zigzag's approach. The production impact was increased to 1.6 bcf/d to reflect this reality.

Stage 3 of the gas supply emergency scenario: offshore pipeline failure

After typhoon Zigzag passed through the Gulf of Thailand, on 12 October 2023, LNG imports resumed at their previous rates of 0.73 bcf/d. While attempting to resume offshore production, a pipeline failure occurred, resulting in a production curtailment of 0.70 bcf/d from the offshore fields and MTJDAs.

3.2. The response

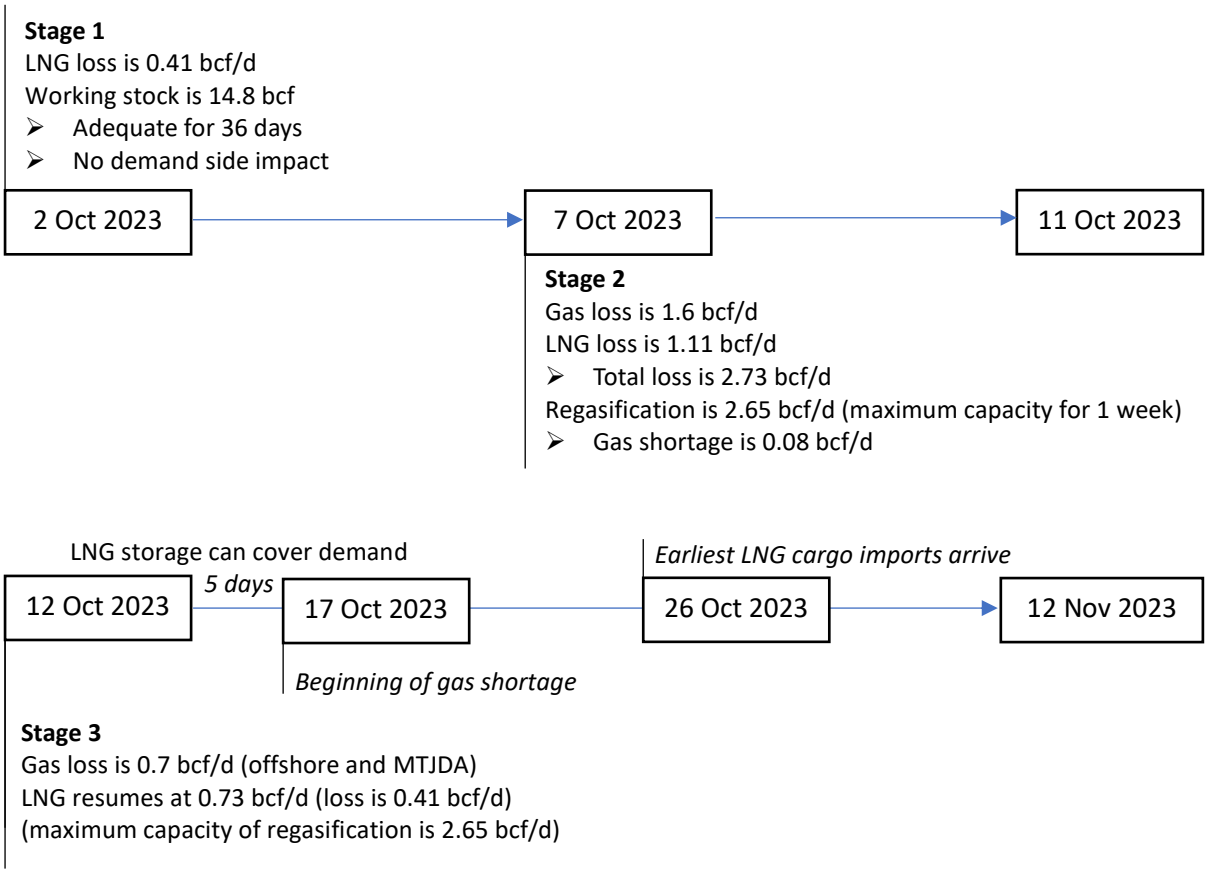
During the consultation regarding the impact of Typhoon Zigzag in the second stage of gas scenario, Thai stakeholders highlighted a recurring pattern of similar typhoons occurring in the vicinity of the platforms over the past few years. The Thai stakeholders decided to assume a more substantial impact of 1.6 bcf/d, doubling the initial estimate of 0.8 bcf/d, due to a complete halt in production for all platforms, except for MTJDA. This adjustment was deemed essential to enhance scenario response. In response to this realistic scenario adaptation, APERC allowed Thai stakeholders to consider this higher impact level in their assessments, acknowledging the importance of a robust evaluation.

Figure 30 illustrates the sequence of the gas scenario across Stage 1, Stage 2, and Stage 3. Stage 1 occurs from 2 October to 2 November 2023, spanning 30 days. Stage 2 occurs from 7 to 11 October 2023, lasting 5 days. Subsequently, Stage 3 extends until 12 November 2023, encompassing a period of 30 days. The numerical values in the figure represent the status of

gas supply and the corresponding supply requirements. Thai stakeholders formulated strategic responses to address the situation as follows.

The Thai stakeholders assessed the impact of the given scenarios through an illustration as follows:

Figure 30: Timeline of gas scenarios



3.2.1. Response on gas scenario: stage 1

A. Government's response

Similarly with the oil emergency exercise, the government will have to activate the Emergency Response Working Team, a committee that will consult with Thai stakeholders, to act on the emergency situation.

B. Assessment to the impact

The 1st stage of gas emergency will result in 0.41 bcf/d of LNG loss. With a working stock of 14.8 bcf, supply is adequate and there is no immediate impact on gas demand.

C. Basic stance of the government

- ❖ Supply measures

Thai stakeholders emphasise an active role of ERC and PTT in evaluating the existing gas supply and strategising their decisions regarding gas procurement. Additionally, the utilisation of LNG storage, specifically the working stock, is explored as a strategic resource. Importantly, these decisions are being carefully considered to ensure they are both effective and financially viable.

- ❖ Demand measures

Currently, the LNG storage site features a sufficient supply to sustain operations for the next 36 days, thereby eliminating any immediate demand-related concerns. Consequently, there is no necessity for implementing demand-side measures at this stage.

3.2.2. Response on gas scenario: stage 2

A. Government's response

Activate the Emergency Response Working Team.

B. Assessment of Impact

In the second stage, there is a significant gas production loss of 1.6 bcf/d and an additional loss of 1.11 bcf/d in LNG supply, resulting in a total loss of 2.73 bcf/d. The regasification capacity stands at 2.65 bcf/d, operating at its maximum capacity. Consequently, there is a shortage of 0.08 bcf/d in the gas supply, posing a challenge to meet demand effectively. This situation necessitates immediate attention and strategic planning to ensure a stable gas supply to meet the requirements of various sectors.

C. Basic stance of the government

- ❖ Supply measures

On the supply side, efforts are underway to optimise the existing gas infrastructure. This involves a comprehensive evaluation of LNG capacity and the strategic optimisation of regasification capabilities. Additionally, there is a focus on increasing LNG imports to bolster the available supply. Measures such as reducing LNG send-out are implemented to prolong LNG storage. Furthermore, there is an exploration of relaxing gas specifications, to increase the heat content, and thus gas supply, from domestic sources.

- ❖ Demand measures

On the demand side, a pragmatic approach is being taken to address the challenges. One significant strategy involves switching power generation to diesel at dual-fire generating facilities, due to a notable 50% loss of gas demand in power plants. This switch is facilitated by utilising the existing oil stock in power plants. Concurrently, efforts are being made to

secure additional supply sources to replenish and sustain the oil stock such that there is a seamless fuel switch while mitigating potential disruptions in power generation.

3.2.3. Response on gas scenario: stage 3

A. Government's response

In addition to the activation of the emergency response team, an international cooperation is proposed to address the broader regional implications of the gas and LNG supply emergency. Establishing a cooperation mechanism among ASEAN member economies is recommended to respond effectively to gas and LNG emergency situations. This collaborative approach aims to enhance preparedness, facilitate resource sharing, and promote collective responses to mitigate the impact of gas supply challenges on regional energy security.

B. Assessment of impact

It is essential to address the immediate challenges and strategise to bolster Thailand's long-term energy security. The available LNG storage can sustain the demand for approximately 5 days, or until 17 October 2023. The situation intensifies as there is a 15-day gap until the arrival of the first imported LNG cargo, anticipated on 26 October 2023.

C. Basic stance of the governme3t

- Supply measures

To manage this critical period, several supply-side measures have been proposed. This includes sourcing spot LNG cargoes to cover short-term gas demand, reducing the LNG send-out rate until the arrival of the first imported cargo, relaxing gas specifications, and fostering cooperation among gas suppliers and buyers. Thai stakeholders consider increasing regasification and storage capacity necessary to improve gas security in the longer term. However, it is crucial to acknowledge concerns related to the potential increase in electricity costs due to the installation of additional LNG infrastructure.

- Demand measures

On the demand side, measures are proposed to curtail consumption through prioritisation. This involves managing the power generation system to enhance efficiency and reducing gas supply to the petrochemical sector. Additionally, maximising the utilisation of alternative fuels, such as diesel and coal, is suggested as a backup to meet power demand. However, these initiatives raise concerns, particularly the need to revise the principle of natural gas prioritisation established in 1996, and the consideration of additional costs related to fuel transportation.

3.3. Observations and recommendations from the expert team

APERC formed a team comprising seven specialists in oil and gas (energy) supply security, whose profiles can be found in **Annex III**. Considering the distinctive aspects of the Thai energy industry as well as natural gas and LNG market, this group of experts evaluated how Thai stakeholders responded to the three stages of gas emergency scenarios and provided corresponding suggestions.

Institutional arrangements and communication strategy

1. Documentation of emergency response exercises is advised for future reference. Thai stakeholders emphasised that they have been recording the results of annual energy security exercises since 2013, when Thailand first initiated these drills. The reports covered hypothetical scenarios and various measures related to power, oil, gas, and energy efficiency. Additionally, the emergency manuals are reviewed and revised annually to incorporate best practices and lessons learned, serving as a guide for energy-related ministries and the private sector in handling supply disruption. These manuals provide detailed instructions for the response teams on appropriate actions.

Supply measures

2. It is recommended to assess the grid's flexibility, specifically its ability to import electricity. This suggestion arises from the fact that the existing market lacks complete integration, making it challenging to freely access surplus electricity. However, substantial flexibility lies within the generation sector itself. Some power plants in Thailand have the capability to switch from gas to oil. Notably, dual-fuel power plant maintains a diesel reserve, ensuring a continuous power supply for a period ranging from three to five days.
3. Thai stakeholders explained the relaxation of gas specifications, focusing specifically on adjusting the carbon dioxide content in the gas. Currently set at 23%, this level can be increased to 25-26% as part of the relaxation measures.
4. It is advisable to consider an additional regasification capacity ranging from 5% to 10%. Such an augmentation would increase the regasification capacity from 2.65 bcf/d to approximately 2.9 bcf/d, ensuring sufficient capacity to fulfill the demand needs. However, this is a longer-term strategy and would not require additional investment in storage to support it.
5. Evaluating the option of offering a higher fee to LNG carriers to expedite LNG shipments should be considered, particularly if there is available storage capacity. However, this approach poses challenges, especially when there is a commitment to regasification, making it difficult to control the LNG send-out rate, especially when the LNG tank is at full capacity.
6. Subsidising LNG pass-through cost during emergency scenario is recommended to alleviate widespread economic impacts. These subsidies are crucial as they help shield consumers and industries from sudden spikes in energy prices.
7. A revision of the secondary fuel strategy for power plants is recommended. Typically, power plants have a diesel reserve that can last for 3 days and the ability to adjust power generation for 8 to 10 days, providing a safety buffer for electricity generation in Thailand.

Furthermore, with the incorporation of LNG imports and responsive supply mechanisms, the economy can manage emergencies for over 2 weeks without relying on gas reserves. However, it is worth noting that maintaining LNG reserves could become crucial as the proportion of LNG in the gas pool approaching 60% in the total gas consumption mix.

8. There is a proposal to explore diverse gas trading mechanisms like long-term contracts and cargo diversion strategies as well as maintaining the optimal LNG contract-to-spot ratio. Thai stakeholders have noted the strict nature of current long-term contracts and ongoing discussions about cargo diversion with Japanese companies, considering the seasonal differences between the two economies. Limited LNG storage, providing only a week's buffer, raises concerns. To address this, establishing an LNG hub in the region has been considered, allowing users to pay for access.

9. The suggestion to expand gas infrastructure to remote regions has been raised. Thai stakeholders responded that installing an LNG terminal in the south has been considered as a pipeline incident can halt the operation of two power plants. Additionally, building a gas pipeline has been contemplated in the northeast because one power plant is currently relying on an onshore gas field with depleting reserves. A cost-benefit analysis for these initiatives is underway.

10. Integrating Terminal 3 into emergency response plans could offer a considerable safeguard against various scenarios, although it might not cover all of them.

11. It is essential to exercise caution when considering the relaxation of gas specifications. A case study is Japan, where households increasingly rely on natural gas for heating and cooking purposes. Accidents have occurred in Japanese households due to changes in gas specifications. Therefore, if energy ministries plan to adopt this approach in the future, extra consideration and care should be taken.

Demand measures

12. Proactive discussions between gas suppliers and major consumers to establish a voluntary program aimed at preparing for emergencies should be encouraged. This collaborative initiative ensures that demand restraint measures can be efficiently put into action when needed, enabling a prompt and coordinated response during emergency situations.

13. Prioritising long-term end-use fuel flexibility is essential, enabling businesses and industries to adapt, minimize impacts, and avoid emergencies effectively. A robust strategy ensures seamless transitions between different fuel sources, enhancing energy resilience.

Data management and accessibility

14. Leveraging weather forecast data from the Thai Meteorological Department is crucial for proactive response planning. This information enables authorities to anticipate adverse weather conditions, facilitating early implementation of effective strategies and minimising potential damage and disruptions.

15. Access to real-time data during emergency situations is important so that the government or concerned stakeholders can act accordingly. This includes all necessary data, e.g. gas demand and supply, gas storage levels and etc. The commanding central data center also

facilitates rapid and non-disclosed exchange of information between agencies, without the need for authorization processes under the mandate authority.

Regional cooperation

16. There were concerns about importing electricity from neighbouring economies and the available spare capacity within Thailand. Thai stakeholders clarified that the EGAT has contracts allowing it to request imports from neighbouring economies. However, they acknowledged that these contracts operate on a voluntary basis subject to availability.

4. Evaluation and feedback from the expert team and Thai stakeholders

From the experts

The expert team's evaluation of the emergency response exercises highlighted several key points.

- Firstly, they commended the Thai stakeholders for their professionalism and effective communication as well as acknowledged the robust data and information sources in Thailand that provided a strong foundation for emergency response efforts.
- The importance of documentation, institutional memory, and understanding the quantitative impact of measures was emphasised, with stress on regular updates for accurate assessment.
- Additionally, the expert team recommended the inclusion of a more comprehensive emergency response team from various ministries in future exercises to enhance overall effectiveness.
- The experts appreciated the participants' initiative, recognising their systematic problem-solving approach. The expert team also advocated for the incorporation of various scenarios provided by APERC and the introduction of these scenarios in the Ministry of Energy's future emergency response exercises.
- Lastly, the significance of international cooperation was underscored with the mention of an upcoming ASEAN meeting to discuss APSA.

From Thai stakeholders

The emergency exercises, evaluation and feedback from the expert team provided significant value for both the Thai public and private sectors by improving their oil and gas supply crisis management capabilities. Thai stakeholders highly appreciated the exercises as a platform for sharing previously unexplored ideas. The scenarios presented by APERC during the exercises were crucial in shaping comprehensive emergency plans and providing practical testing grounds for existing strategies.

The constructive expert feedback played a crucial role in strengthening emergency response protocols and enhancing preparedness for potential future supply crises. Thai stakeholders acknowledged the importance of prioritising different situations and procedures in developing emergency response strategies. Furthermore, the exercises underscored the importance of international cooperation in ensuring energy security. Overall, the exercises served as a vital learning platform, enhancing stakeholders' readiness for future challenges.

5. Conclusions

The 5th APEC OGSE held in Bangkok provided an invaluable opportunity for Thailand to assess and strengthen its preparedness for potential oil and gas supply disruptions. Through systematic planning, comprehensive scenario analysis, and active participation, Thai stakeholders demonstrated their commitment to ensuring energy security in the face of emergencies. This exercise not only highlighted Thailand's resilience in managing severe disruptions but also showcased the economy's proactive approach in addressing complex challenges and high-level expertise and coordination of the Thai response team.

In response to the simulated oil emergency scenarios, Thailand displayed remarkable versatility. The multi-staged approach, addressing both supply and demand sides, emphasised the economy's capacity to swiftly adjust its strategies. Measures such as banning petroleum product exports, increasing product imports, adjusting refinery operations, and optimising transportation methods underscored Thailand's ability to make informed decisions in crisis situations.

Likewise, in the gas emergency scenarios, Thailand showcased its strategic responses. The three-stage response plan, ranging from optimising existing resources to exploring alternative supply channels, highlighted the economy's comprehensive approach to crisis management. By managing LNG capacities, optimising regasification capabilities, and fostering cooperation among gas suppliers and buyers, Thailand demonstrated its ability to handle complex supply disruptions. Additionally, the prioritisation of consumption and the strategic utilisation of alternative fuels showcased Thailand's energy flexibility.

The collaboration and fruitful feedback of international experts and the APERC team significantly deepened the exercise. Expert insights, particularly in areas such as institutional strategies, supply and demand management, as well as regional cooperation, provided invaluable guidance to Thai stakeholders. These recommendations serve as a foundation for further strengthening Thailand's emergency response mechanisms, ensuring that the economy remains at the forefront of energy security initiatives.

The 5th APEC OGSE not only served as a test of Thailand's emergency response capabilities but also offered crucial lessons for the future. Effective communication strategies, data-driven decision-making processes, and flexible supply chain management emerged as pivotal factors in crisis mitigation. As Thailand moves forward, it is crucial to integrate these lessons into its energy security policies. Strengthening domestic capabilities, enhancing bilateral and international partnerships, as well as investing in oil and gas infrastructure will be vital in ensuring a resilient energy future.

In conclusion, Thailand's active engagement in the 5th APEC OGSE demonstrated its commitment to ensuring energy security for its economy and neighbouring economies. The structured brainstorming and constructive discussions among Thai public and private stakeholders underscore Thailand's remarkable preparedness in the face of potential oil and gas supply disruptions. By integrating the lessons learned, Thailand is well-positioned to navigate future challenges in energy transition and uncertainties, ensuring a stable and secure energy landscape. The economy's proactive approach and dedication to continuous improvement stand as a foundation for its energy resilience.

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Annex I: Agenda

5th Oil and Gas Security Exercise
6-7 September 2023
15th Floor, Ministry of Energy, Bangkok, Thailand

Wednesday, 6 September 2023	
09:00 (30)	Registration
09:30 (10)	Welcome remarks by Permanent Secretary, Minister of Energy Dr. Veerapat Kiatfuengfoo
09:40 (10)	Opening remarks by APERC President Dr. Kazutomo Irie
09:50 (20)	Introduction of participants and experts
10:10 (10)	Photo session
Session 1	
10:20 (10)	Presentation on the whole schedule for the exercise case study Ms. Elvira Torres Gelindon, Research Fellow, APERC
10:30 (25)	Presentation on the Exercise Model Procedure (EMP) including Q & A Mr. Thanan Marukatat, Research Fellow, APERC
10:55 (15)	Coffee break
11:10 (15)	Presentation on emergency response plans in Thailand by the Strategy and Planning Division Ms. Karnnalin Theerarattananoon
11:25 (15)	Presentation on oil security in Thailand by the Department of Energy Business (DOEB) Ms. Nisachol Pluemjai
11:40 (60)	Lunch break
Session 2	
12:40 (180)	Introduction of the Oil Supply Emergency Scenario Mr. Thanan Marukatat, Research Fellow, APERC Discussion by Thailand's stakeholders on the response to the Oil Supply Emergency Scenario, and presentation on the response to the Oil Supply Emergency Scenario by Thailand representatives (coffee break will be available during the session)
15:40 (60)	Q & A and discussion on the responses to the Oil Supply Emergency Scenario
16:40	Closing of day 1

Thursday, 7 September 2023	
08:30 (30)	Registration
Session 3	
09:00 (10)	Presentation on the schedule for day 2 Ms. Elvira Torres Gelindon, Research Fellow, APERC
09:10 (30)	Presentation on gas security in Thailand by the Department of Mineral Fuels (DMF) Ms. Jittama Mantajit
09:40 (180)	Introduction of the Gas Supply Emergency Scenario Mr. Christopher James Doleman, Senior Researcher, APERC Discussion by Thailand's stakeholders on the response to the Gas Supply Emergency Scenario, and presentation on the response to the Gas Supply Emergency Scenario by Thailand representatives (coffee break will be available during the session)
12:40 (60)	Lunch break
Session 4	
13:40 (60)	Q & A and discussion on the responses to the Gas Supply Emergency Scenario
14:40 (45)	Discussion time to prepare an evaluation by experts and by Thailand's stakeholders.
15:25 (60)	Evaluation of the Exercise by Expert Review Team
16:25 (15)	Questions/answers and general discussion on the Exercise
16:40 (15)	Coffee break
16:55 (15)	Evaluation of the Exercise by Thailand's stakeholders
17:10 (15)	Questions/answers and general discussion on the Exercise
17:25 (10)	Final remarks by Permanent Secretary, Minister of Energy Ms. Krittiya Petsee
17:35 (10)	Closing remarks by APERC President Dr. Kazutomo Irie

Annex II: List of participants from Thailand

Name	Organisation	Position
Dr. Veerapat Kiatfuengfoo	Office of the Permanent Secretary of Energy	Deputy Permanent Secretary of Energy
Ms. Krittiya Petsee	International Affairs Division	Plan and Policy Analyst, Senior Professional Level
Ms. Onvara Vadhanavisala	International Affairs Division	Plan and Policy Analyst, Professional Level
Ms. Patcharaporn Khajorn-in	International Affairs Division	Plan and Policy Analyst, Professional Level
Ms. Aunchana Laohaprasart	International Affairs Division	Plan and Policy Analyst, Practitioner Level
Mr. Vetis Thanakorndit	International Affairs Division	Plan and Policy Analyst, Practitioner Level
Ms. Chonticha Inta	International Affairs Division	Plan and Policy Analyst, Practitioner Level
Ms. Chalermkwan Uparawat	International Affairs Division	Analyst
Ms. Boonnian Na Thalang	International Affairs Division	Foreign Relations Officer
Ms. Arisa Chuenklang	International Affairs Division	General Administration Officer
Ms. Nattanih Sarapab	International Affairs Division	Coordination Officer
Ms. Penpitcha Pimonekasorn	International Affairs Division	Coordination Officer
Ms. Pranom Penglee	International Affairs Division	General Administrator
Ms. Karnnalin Theerarattananoon	Strategy and Planning Division	Plan and Policy Analyst, Senior Professional Level
Ms. Lalitvadee Pumboonrit	Strategy and Planning Division	Plan and Policy Analyst
Ms. Jittama Mantajit	Department of Mineral Fuels (DMF)	Director, International Petroleum Management Division
Mr. Kritvit Visitsakulchai	Department of Mineral Fuels (DMF)	Petroleum Engineer, Professional Level
Mr. Thanasorn Thanavibul	Department of Mineral Fuels (DMF)	Petroleum Engineer, Professional Level
Ms. Nattaporn Chumphonwong	Department of Mineral Fuels (DMF)	Scientist, Professional Level

Ms. Sirikarn Hirunsalee	Department of Mineral Fuels (DMF)	Plan and Policy Analyst, Professional Level
Ms. Sureeluck Takkavatakar	Department of Mineral Fuels (DMF)	Plan and Policy Analyst
Mr. Pichitchai Pongtham	Department of Mineral Fuels (DMF)	Engineer
Ms. Duangta Tongsakul	Energy Policy and Planning Office (EPPO)	Plan and Policy Analyst, Senior Professional Level
Ms. Pumarin Sukavast	Energy Policy and Planning Office (EPPO)	Plan and Policy Analyst, Professional Level
Ms. Sutassa Sangsumran	Department of Energy Business (DOEB)	Plan and Policy Analyst, Senior Professional Level
Ms. Nisachol Pluemjai	Department of Energy Business (DOEB)	Plan and Policy Analyst, Practitioner Level
Mr. Worapot Laopom	Electricity Generating Authority of Thailand (EGAT)	Assistant Director of Procurement and Fuel Contract Management Department 2
Mr. Paramaet Payattapin	Electricity Generating Authority of Thailand (EGAT)	Assistant Director of Procurement and Fuel Contract Management Department 1
Ms. Kwanruthai Rachabungsa	Petroleum Institute of Thailand (PTIT)	Senior Analyst
Ms. Auchareeya Chotikadachanarong	Petroleum Institute of Thailand (PTIT)	Senior Analyst
Ms. Suthida Chokthanyawat	Petroleum Institute of Thailand (PTIT)	Senior Analyst
Mr. Puchong Intasalo	PTT Exploration and Production Public Company Limited (PTTEP)	Manager, Erawan Geology and Geophysics Section
Ms. Sirapa Preteepamornkul	Thai Oil Public Company Limited	Manager - Domestic Commercial Planning
Ms. Nareerat Krobnoparat	PTT Global Chemical Public Company Limited (PTTGC)	Senior Analyst
Ms. Usakanok Thamnijkul	Bangchak Corporation Public Company Limited	Supply Planning Division Manager
Ms. Narakorn Kukreja	Global Power Synergy Public Company Limited (GPSC)	Senior Analyst
Mr. Pakorn Polsena	Global Power Synergy Public Company Limited (GPSC)	Senior Analyst

Mr. Somboon Satasin	IRPC Public Company Limited	Senior Vice President
Mr. Chirawut Tumzhim	IRPC Public Company Limited	Specialize
Mr. Suthee Keepthong	IRPC Public Company Limited	Senior Vice President
Ms. Sutita Prapant	PTT Public Company Limited (PTT)	Manager
Mr. Atthapong Vorayothin	PTT Public Company Limited (PTT)	Senior Analyst
Mr. Krit Tungkaterakul	PTT Public Company Limited (PTT)	Natural Gas Logistics Manager
Mr. Sorawit Aungkananukul	PTT Public Company Limited (PTT)	Analyst
Mrs. Sucheela Suwan	PTT Public Company Limited (PTT)	Vice President, Natural Gas Operations Management
Mr. Varut Ruangtrakool	PTT Public Company Limited (PTT)	Senior Trader
Ms. Pichanee Tassanasatien	PTT Public Company Limited (PTT)	Senior Analyst
Ms. Natcha Chairamluk	PTT Public Company Limited (PTT)	Senior Analyst
Mr. Teeranut Rutwaree	PTT Public Company Limited (PTT)	Trading Operator
Mr. Torpong Suphadul	PTT Public Company Limited (PTT)	Division Manager
Mr. Vorapoj Niramitranont	PTT Public Company Limited (PTT)	Senior Analyst

Annex III: Expert review team

Name	Organisation	Position
Experts from APEC and non-APEC economies		
Mr. Beni Suryadi	ASEAN Centre for Energy (ACE)	Manager of power, fossil fuels, alternative energy and storage
Mr. Cuauhtemoc Lopez-Bassols	International Energy Agency (IEA)	Senior Analyst
Mr. Masashi Nemoto	Japan Organization for Metals and Energy Security (JOGMEC)	Deputy Director
Dr. Phoumin Han	Economic Research Institute for ASEAN and East Asia (ERIA)	Senior Energy Economist
Dr. Robert Perry Jr.	United States Department of Energy (DOE)	Senior advisor/Chief of staff
Dr. Ruengsak Thitiratsakul	Petroleum Institute of Thailand (PTIT)	Advisor
Dr. Weerin Wangjiraniran	Energy Research Institute (ERI), Chulalongkorn University	Researcher
APERC		
Dr. Kazutomo Irie	APERC	President
Mr. Thanan Marukatat	APERC	Research Fellow
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