THAILAND´S LNG SECTOR

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Norwegian Embassy

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Contents

Foreword

Access to energy plays an important role in safeguarding Thailand's sustainable economic future. If Thailand is to fully exploit its potential for growth and sustainable development, a diversity of energy sources is needed.

In line with the Paris accord and the Sustainable Development Goals (SDGs), it is also important that the energy mix is as CO_2-friendly as possible.

Liquefied Natural Gas (LNG) is a commodity that is globally available and relatively clean. With an increased planned import capacity towards 2036, Thailand is set to become the largest importer of LNG in Southeast Asia. Even if a fossil source of energy, LNG contributes to reducing CO_2 emissions while at the same time improving local pollution, compared to other sources of energy production.

For 50 years, Norway has been a trusted partner on the global energy market, both in terms of oil, gas and renewables. In recent decades, Norway's export of LNG from the Norwegian continental shelf has played an increasing role as a global source of energy. Norway's competitiveness in LNG trade as well as Norway's well-documented expertise in the LNG sector bodes well for a closer partnership on energy between Norway and Thailand.

I hope this report can contribute towards raising the awareness among all stakeholders as to the potential for collaboration between our two countries within the LNG sector.

Kjetil Paulsen
Ambassador of Norway to Thailand

About the Report

This report is commissioned by the Royal Norwegian Embassy in Thailand. It is written by Alexander Dodge at the Department of Geography at the Norwegian University of Science and Technology (NTNU).

The intention of the report is to lay the groundwork for developing and strengthening Norwegian and Thai Partnership in the LNG sector of Thailand. Although this report is written primarily for Norwegian business and counterparts in Thailand, we believe that it will also be useful to everyone who is interested in Thailand's LNG sector.

Research at the Department of Geography covers a broad range of fields across human and physical geography, including recourse management, sustainable restructuring, entrepreneurship and innovation, and urban development. The Department places a strong focus on sustainable restructuring in the energy sector, particularly within the Norwegian Oil and Gas Sector. Our current research projects focus on internationalization of Norwegian maritime and offshore firms into offshore wind markets and Small-Scale LNG Market Development in Peripheral Regions of Southeast Asia.

The development of the report has been supported by Innovation Norway in Thailand and the Network LNG Norway. The writer of report would like to extend his gratitude to the following organizations that provided their views on Thailand's LNG, Natural Gas, and Energy Market development:

- PTT Public Company Limited
- PTTLNG Company Limited
- Petroleum Institute of Thailand
- Electricity Generating Authority of Thailand
- Energy Planning and Policy Office
- Energy Regulatory Commission
- Energy Generating Public Company Limited

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EXECUTIVE SUMMARY

After the commissioning of the Map Ta Phut LNG terminal in 2011, Thailand became the first LNG importer in Southeast Asia. Thailand has been a net importer of natural gas since 1998 and today 20% of gas supply is imported, mainly through gas pipelines from Myanmar. However, domestic natural gas production is set to decline, with only 5.5 years of reserves in 2014, and there have been few discoveries to offset decline. In addition, Myanmar authorities are unlikely to extend gas supply agreements with Thailand, which are set to expire in ten years, to support national electrification and growth. Therefore, to balance declines in domestic natural gas production and Myanmar imports, Thailand will need to significantly increase its LNG import capacity, from 5 MPTA in 2016 to 39 MPTA in 2035 (in the high case scenario).

However, the scale of LNG imports is uncertain. Thailand currently consumes around 5,000 mmscfd of natural gas. The Department of Mineral Fuels (DMF) estimates that Thailand has 5.8 tcf of possible reserves and 2.7 tcf of probable reserves. The extension of concessions in the Gulf of Thailand and a bidding round for 29 concessions may help extend the lifetime of natural gas production by 15 years, however several delays have occurred due to calls to reforming the concession-based system in Thailand. Such reforms require changes in the Petroleum Act, which are still being debated in parliament.

Natural Gas accounted for 64% of the energy generation mix in 2014. Thai Authorities, who are concerned about energy security and overdependence on LNG imports, are planning to decrease the share of natural gas in the energy mix. Beyond the Power Purchase Agreements for gas-fired power plants (6,600 MW total capacity) to be completed by 2025, few new gas fired power plants are planned to be built. Natural Gas consumption in Thailand is therefore likely to stagnate. However, to meet increases in electricity demand, Thai Authorities have planned to build several coal-fired power plants in Southern Thailand. Nevertheless, these power plants have been highly disputed by residents and have been delayed. If coal-fired power plants are shelved, then LNG will be a likely alternative.

Thai authorities have implemented a Third Party Access Regime in Thailand. Liberalization reforms of the natural gas industry have been a decade's long process of back and forth shifts between political trajectories. Liquid Natural Gas

has provided a "window of opportunity" for continuing liberalization reforms, as authorities have granted third parties the right to retail, procure and distribute LNG. However, despite the issuing of Third Party Access codes, the national oil company, PTT PLC continues to hold an effective monopoly over procurement and distribution, as PTT holds 100% of grandfathered capacity on Liquid Natural Gas terminals and pipeline transmission systems. Nevertheless, the Electricity Generating Authority of Thailand (EGAT) is planning to enter the LNG business through procuring an FSRU to supply gas to its North and South Power Plants.

There are several uncertainties and challenges regarding the Thai LNG sector including:

1) Domestic Natural Gas Production Forecasts
2) Disputed Power Plants in Southern Thailand
3) Natural Gas pricing
4) Regulatory Risk in Third Party Access implementation
5) Environmental and Social Challenges and
6) Energy Security Concerns

Nevertheless, there is ample room for Thai and Norwegian Partnership in the LNG sector on several areas. Norwegian firms have a long experience in LNG Transport and Small-Scale LNG Distribution and Supply. In addition, several Norwegian Firms are global leaders in FSRU construction, deployment and operations. Norwegian firms can help EGAT enter the LNG business through their technologies and expertise. In addition, Norwegian firms can help PTT expand its domestic gas retail operations through small-scale LNG distribution. Norwegian firms can also provide alternatives to coal-fired power generation in Southern Thailand and help improve gas-fired power plant efficiency.

1. Natural Gas Sector in Thailand

Thailand's energy sector is highly dependent on Natural Gas. However, domestic natural gas reserves in Thailand are depleting while the production and consumption of natural gas is growing. The high growth in production has not been offset by new discoveries in the Gulf of Thailand. In addition, current pipeline imports from Myanmar are set to expire in the mid 2020's. LNG will be essential to meeting energy demand in Thailand in the future.

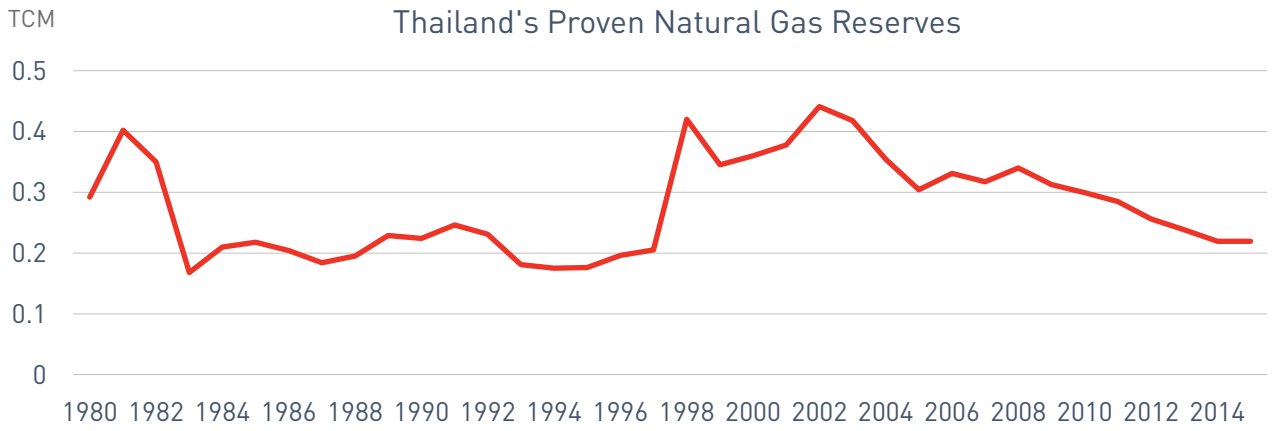

Figure 1: Graph of Thailand's proven natural gas reserves. Source: BP

INTRODUCTION

Thailand is the second largest economy in Southeast Asia and in 2011 became an upper-middle income country. Poverty rates have been reduced from 67% in 1986 to 11% in 2014. Much of Thailand's economic success has resulted in a steep increase in energy consumption. Natural Gas accounts for 28.2% of the primary energy supply mix. However, Natural Gas reserves have been halved since their peak in 2005. Thailand will therefore increasingly rely on natural gas imports, which already account for 20% of Natural Gas Supply in Thailand. Most of these imports are sourced via pipelines from Myanmar.

However, gas supply agreements with Myanmar are set to expire as Myanmar seeks to develop its domestic energy sector. It is unlikely that Myanmar will continue the current gas supply agreements with Thailand after they expire. Therefore, Thailand is likely to rely heavily on LNG imports to subset its waning domestic natural gas production.

The following overview illustrates the situation:

- Since 2000, Natural Gas Consumption has increased at an annual pace of almost 6%[1].
- In 2014, Total Natural Gas Demand was 49.7 BCM.

1 (OECD/IEA, 2016)

- Domestic Natural Gas Production was 42.09 BCM in 2014[2].

STRUCTURE OF NATURAL GAS SECTOR IN THAILAND

The Natural Gas Sector in Thailand is dominated by PTT Public Company Limited. PTT PLC is the largest corporation in Thailand and employs 24,790 employees. PTT PLC has revenues of USD 59,196 million and ranks 140 in the Fortune 500. The Ministry of Finance currently holds 51% equity in shareholdings, while 49% of the equity is floated on the stock market. PTT, with some minor exceptions, acts as the sole purchaser, transporter, and distributor of natural gas in Thailand[3].

PTT procures all domestic gas from producers, including its subsidy PTT Exploration and Production (PTTEP). In addition, PTT acquired HESS in 2014. PTT operates a network of pipelines that stretches 3,100 km, and links all commercial gas fields to power plants and its own five gas separation plants, as well as 200 industrial users.

Gas pricing in Thailand is based on a cost-plus regime where producers may pass costs onto customers. Natural Gas is divided into two pools: "Gulf Gas, or Pool 1" which consists of legacy gas from the gulf of Thailand and the JDA, and is relatively low priced. Pool 1 is dedicated to gas separation plants. Pool 2 is the remainder of Gulf gas, imported gas from Myanmar, and imported LNG. Pool 2 gas is retailed mainly to the power sector. The price for natural gas from pool 2 is the average combined wellhead and import price, which is normally linked to fuel-oil prices.

Current Gulf Gas Price is around THB 250/mmbtu (USD 7.24), Myanmar import prices are around THB 400/mmbtu (USD 11.59) and usually ranges between THB 250 to 400. LNG import prices are currently THB 300 (USD 8.60), but has fluctuated between THB 300-700. PTTLNG also charges a THB 24.93/mmbtu demand charge and a THB 0.856 commodity charge for LNG imports at the Map Ta Phut Terminal.

NATURAL GAS PRODUCTION IN THAILAND

The majority of natural gas consumed in Thailand is sourced from offshore fields in the Gulf of Thailand. In 2014, proved reserves stood at 219.5

2 BP Statistical Review (British Petroleum Company, 2016)

3 (Nikomborirak, 2013)

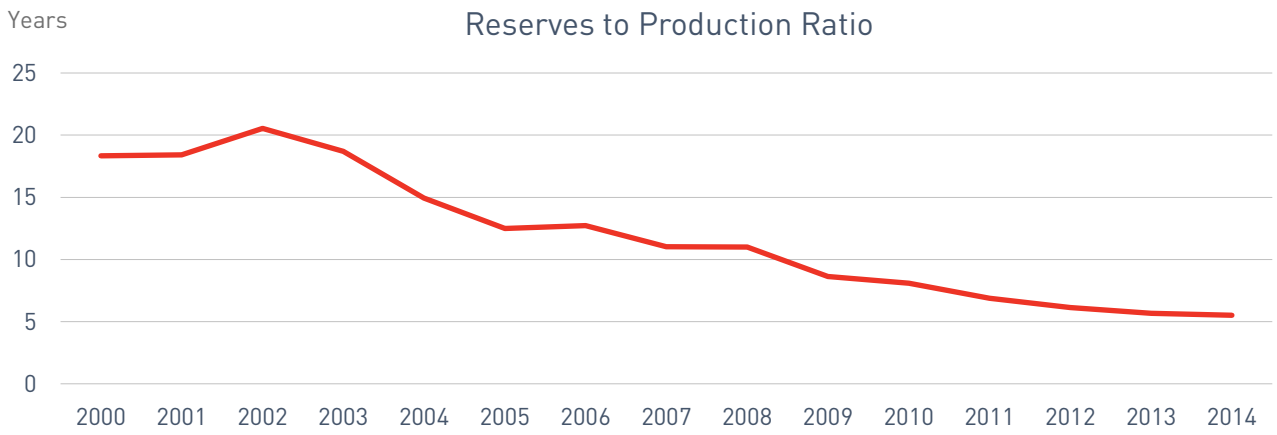

Figure 2: Graph of Reserves to Production Ratio. Source: BP

bcm. Natural gas reserves to production ratio has declined from 20.54 years in 2002 to 5.5 years in 2014. Natural gas production in Thailand is set to decrease even further when production concessions for two major natural gas blocks, Bongkot, owned by PTTEP, and Erawan, owned by Chevron, expire in 2022-2023 (IEA). Currently, there is an open bidding round for these two concessions, and the final awarding should be given by the end of 2017. There is a possibility of extending natural gas output by 15 years in these concessions[4]

- Offshore fields account for 3400 MMBTU of gas supply.
- There are a few onshore fields, but they only accounted for 160 mmbtu of natural gas consumption in 2014.
- Bongkot is the largest offshore gas field, accounting for 19% of production. Production Output in 2014 was 975 mmsfcd.
- The Malaysia-Thailand Joint Development Area (JDA) accounts for 15% of Production. The JDA is an area of an overlapping continental shelf that is claimed by both Thailand and Malaysia. In 1973, the two governments agreed to jointly explore and produce the recourses in the area. Production output in 2014 was 761 mmsfcd

4 PTT Interview

EXPLORATION AND PRODUCTION

Thailand's reserve-to-production ratio stands now at only 5.5 years. While the maturity of the countries assets is a major factor for the small number of new discoveries, uncertainty over domestic concessions and changes in the regulatory framework create additional risks for investors[5]. Two projects that remain uncertain is the 21st Bidding Round and the extension of the Bongkot and Erawan concessions. The 21st bidding round for 29 concessions was set to be open for bidding in 2014. The bidding round included 26 onshore blocks and 6 offshore blocks. However, the offering faced considerable protest from non-governmental organizations, environmental activists and some politicians who argued for reforming the concession-based regime in the Thailand Petroleum Act. Campaigners argue that the current regime does not provide the state with adequate revenues. Civic groups have called for the introduction of production-sharing contracts (PSC's) which would transfer risk to private exploration until the well begins yielding oil, at which point the government takes a cut and would receive most of the profit.[6] Changing the system, however, requires an amendment to the Petroleum act. Additionally, the amendment would bring into question if a National Oil Company should be established. In other words, whether PTTEP should be nationalized. The 21st bidding round is currently delayed as the proposed amendments are debated. The Ministry of Energy estimates the petroleum potential to be between 28.3 and 141.6 bcm of natural gas [7].

Figure 3: Map of Thailand's oil and gas fields Source: PTT

5 (OECD/IEA, 2016)

6 (Oxford Business Group, 2016a)

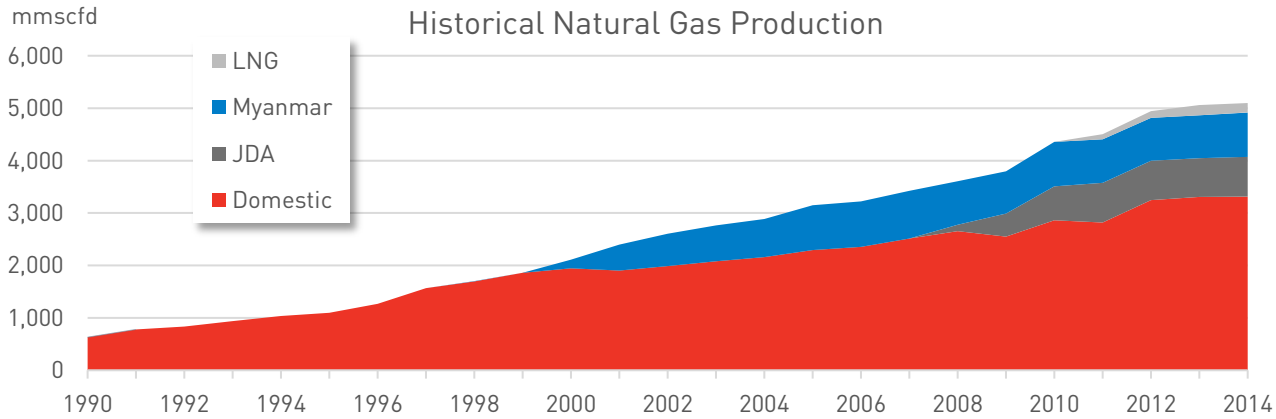

Figure 4: Graph of Thailand's historical natural gas production. Source: DMF

There is still uncertainty regarding a decision on regulatory changes, and while changes have been drafted by the Department of Mineral Fuels and approved by the cabinet in 2015, they have yet to be forwarded to the National Legislative Assembly. However, the draft has not yet been made public. It is uncertain on what will happen to existing petroleum contracts if the Petroleum Act changes. One issue, for example, is whether the government will grant extensions on expiring contracts to the current concession holders.

Due to delays in Natural Gas exploration and uncertainty regarding amendments to the Petroleum act, E&P (Exploration and Production) activities have absent. In March 2017, Thailand's legislature approved an amendment to the Petroleum Law that allows companies the option between concession or production-sharing agreements or service contracts[8]. A clause about setting up a national oil company was dropped, but the cabinet must now set up a committee to conduct further studies on how the state company should operate within the year.

- Proven reserves in Thailand stand at 7,305.16 bcf. Thailand also has 5,886 bcf of probable reserves and 2,746.75 bcf of possible reserves. [9]

8 (Reuters, 2017)

9 (Department of Mineral Fuels, 2015)

- The Khorat Basin in Northeast Thailand has an estimated 5 tcf of risked technically recoverable shale[10]. However, output has been smaller than expected in shale reserves that have been developed before in Thailand[11].

NATURAL GAS PIPELINE IMPORTS

Thailand became a gas importer in 1998 following the development of the Yadana Gas Project in Myanmar. In addition, PTTEP also operates the Yetagun and Zawtika gas fields. Currently Thailand is heavily dependent on gas from Myanmar. However, there is uncertainty if Myanmar will export larger volumes to Thailand. Myanmar's domestic demand is set to increase rapidly as the country's economy is opening and is experiencing growth in electrification and industrialization. The Yetagun, Yadana and Zawtika Gas Supply Agreements with Myanmar are set to expire in 2022, 2024, and 2028 respectively.

- Myanmar Imports account for 18% of Gas Supply in Thailand
- Thailand imported 11.5 bcm in 2014 from Myanmar.
- In 2014, imports from Myanmar stood at 11.5 bcm (IEA)
- The recent Zawtika gas project has an anticipated peak output of 3 bcm. However, the output is relatively small compared to Thailand's gas demand.
- The Yadana field is expected to decline at an annual rate of 2% from 2018 to 2024 due to the lack of new projects.

NATURAL GAS CONSUMPTION IN THAILAND

Natural Gas Consumption was 4,670 mmscfd in 2014. Most Natural Gas Supply is consumed for electricity generation. However, Thailand is also a significant producer of natural gas products including Ethane, Propane and NGL (6.7 Million Tons per Year)[12]. PTT owns five gas separation units with a combined capacity of 2,740 mmscfd. In addition, demand from natural gas vehicles has grown significantly since operations launched in 2004. In addition, demand from natural gas vehicles has grown significantly since operations launched in 2004.

10 (EIA, 2015)

11 Interview with PTT

12 (PTT Plc., 2012)

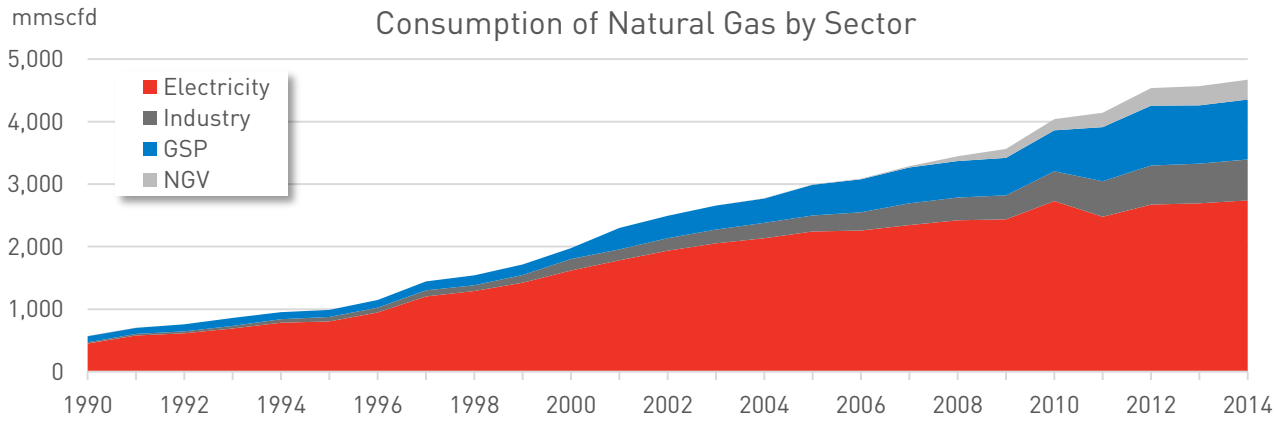

Figure 5: Graph of Thailand's consumption of natural gas by sector. Source: DMF

- The electricity sector consumed 2,740 mmscfd in 2014.
- Natural Gas Consumption of NGV's has risen from 3 mmsfcd in 2004 to 317 in 2014 (Energy Statistics).
- The combined capacity of gas separation units was 2,740 in 2012.
- Industrial Consumption of Natural Gas was 653 mmsfcd in 2014.

NATURAL GAS VEHICLES

Transport accounted for 7% of natural gas consumption in Thailand in 2014[13]. PTT has had several projects related to truck-loading including a number of LCNG stations located around Thailand for Natural Gas Vehicles. However due to subsidies, PTT was unable to recover costs on CNG stations, mainly due to retail price caps. From 2005 to 2011 the retail prices of CNG was fixed at 28c/kg and 34c/kg in 2012. In 2013, PTT indicated that is NGV operations would incur losses of 23bn in 2013 and 10bn THB in 2015. In 2016, the Ministry of Energy floated NGV pump prices within 50 km of Bangkok in order to reflect NGV costs.[14] However, the price of natural gas is capped at .37c/kg (13.5 THB) for the time being.

13 (Hammond, 2015)

14 (The Nation, 2016)

INDUSTRIAL CONSUMPTION OF NATURAL GAS

Industry accounted for 14% of Natural Gas Consumption in Thailand in 2014. The main industries that utilize natural gas as a feedstock are agriculture, ceramics, paper plants and natural rubber. PTT NGD and AMATA NGD are the two main retailers and distributors of natural gas to industrial customers in Thailand. The multinational company, ENGIE, owns a 40% stake in PTT NGD. PTT NGD purchases gas from PTT PLC at the gas Pool Price and is sold to industrial customers at a cost replacement formula, linked to either LPG or Fuel Oil prices[15]. Lately PTT NGD has struggled with business, as fuel oil prices are low. The Energy Regulatory Commission sets the formula, which is now under review. However, PTT does not want the Energy Regulatory Commission to delink the price from oil because the oil prices may increase.

GAS SEPARATION PLANTS

Gas Separation Plants accounted for 20% of natural gas consumption in 2014. Gas Separation Plants account for a significant portion of PTT's income. A decline in domestic natural gas production is currently a threat to future profits, and PTT will need to diversify their business portfolio to account for the decline in the gas separation business.

[15] Interview EPPO


BW SINGAPORE

2. Electricity Generation Sector in Thailand

Electricity Demand in Thailand relies heavily on natural gas, which made up 64% of the electricity generation mix in 2014. Due to energy security concerns, Thai Authorities plan to reduce the share of natural gas in the energy fuel mix by increasing coal-fired power capacity. Such plans, however, are highly contested by local residents and activists. LNG will be a likely alternative to coal-fired power plant development.

INTRODUCTION

Between 1990 and 2010, Energy Demand in Thailand grew at an average annual rate of 4.5% and 3.2% between 2011 and 2013[16]. Thai Energy Authorities expect power demand to grow at 2.67% annually between 2014 and 2036[17]. Electricity Demand in Thailand relies heavily on natural gas, which made up 64% of the electricity generation mix in 2014. The 2015 Thailand Power Development Plan (PDP2015) aims to maintain energy security and affordability by reducing the share of natural gas in the energy mix, and increasing the share of coal-powered generation through electricity imports from neighboring countries and domestic coal projects[18]. In addition, authorities also plan to significantly increase the share of renewable energy in the Energy Mix.

Thai Energy Authorities fear that increased LNG imports, due to the decline of domestic natural gas supply, will increase electricity prices in Thailand by exposing the country to volatile prices in the LNG market[19]. However, planned coal projects in Southern Thailand are highly disputed by local activists and NGO's, and projects have been continuously delayed. Coal Plants are disputed due to environmental concerns and effect on local tourist, agriculture, and fishing industries. Importing LNG will be the most likely alternative to energy development in Southern Thailand if coal-fired power plant projects are shelved.

Fuel	2014	2026	2036
Imported Hydropower	7	10 – 15	15 – 20
Coal	20	20 – 25	20 – 25
Renewables	8	10 – 20	15 – 20
Natural Gas	64	45 – 50	30 – 40
Nuclear	-	-	0 – 5
Fuel Oils	1	-	-

Table 1: Energy Fuel Mix Forecast. Source: PDP 2015

Total contract capacity in Thailand is 37,612 MW as of December 2014. Peak Energy Generation is expected to increase to 56,701 MW in 2020, 60,403 in 2025 and 70,335 in 2036.

16 IEA (OECD/IEA, 2016)

17 (Energy Policy and Planning Office, 2015)

18 ibid.

19 Interview EPPO

Thailand is expected to introduce several energy efficiency measures expected to reduce energy intensity 30% by 2036.

The relative share of natural gas in the energy mix is projected to decline; however total natural gas fueled electricity generation is expected to plateau. Power purchases from neighboring countries should not be larger than 20%.

ENERGY SECTOR OF THAILAND

Thailand's energy sector is run on the basis of an "Enhanced Single Buyer Model". The Electricity Generating Authority of Thailand (EGAT) holds a monopoly on power system operations and planning for generation and transmission. The Metropolitan Electricity Authority (MEA) is responsible for the distribution and retail market in the Bangkok metropolitan area, while the Provincial Electricity Authority is responsible for the rest of Thailand. EGAT owns approximately 50% of Energy Generation in Thailand, in addition to the high-voltage transmission network. The remaining generation is purchased from independent power producers (IPP) and Small-Power Producers (SPP). Large customers purchase power directly from EGAT, while smaller commercial and residential customers purchase power from the MEA and PEA. SPPs can sell electricity directly to consumers.

The National Energy Policy Council (NEPC) is responsible for energy policy and The National Energy Management and Development Plan. The Prime Minister is the Chairman of the NEPC. The Energy Policy and Planning Office (EPPO) recommends energy policies, advises on the energy development plan, and acts as the secretariat to the NEPC. The Energy Regulatory Commission regulates the energy industry according to the Energy Industry Act of 2007 and operates separately from the Ministry of Energy, but works within the policy framework of the NEPC. The ERC issues operational licenses to the energy industry and implements regulation and criteria for power purchases.

GAS-FIRED POWER PLANTS

In 2015, Energy Generation from Natural Gas totaled 122,180 Gwh. From 2015 to 2024, Thailand is expected to build new combined-cycle power plants with an installed capacity of 6,600 MW. However, in the long-term Thailand is set to retire a number of Gas-Fired Power Plants (See Appendix for Details). Overall Gas-Fired Power Generation will increase slightly, peaking at 151,577 Gwh in 2033, but then decreasing to 120,152 Gwh in 2036.

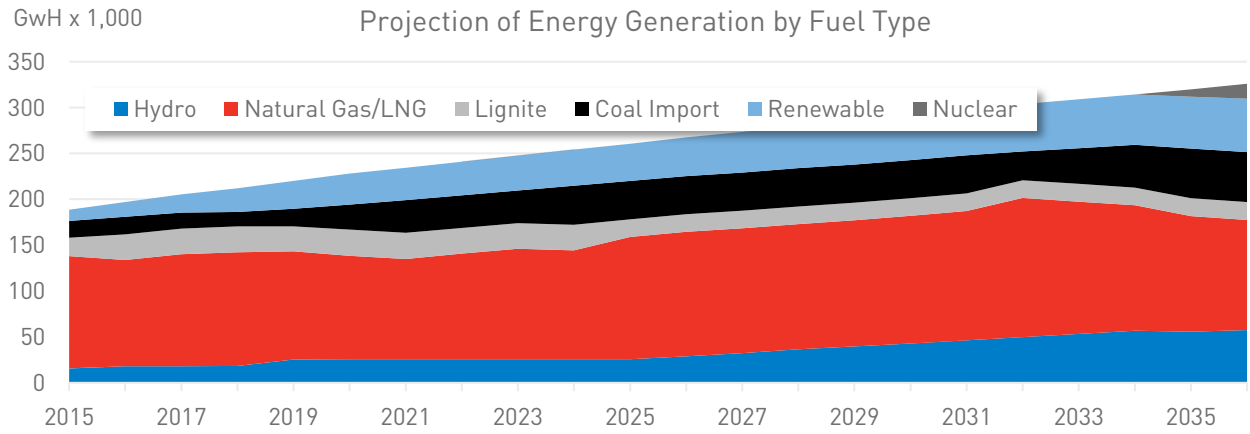

Figure 6: Graph showing projection of Thailand's energy generation by fuel type. Source: PDP 2015

The majority of Power-Purchase Agreements for new Gas Fired Power Plants have already been signed with the IPP, Gulf Energy Development, which won the tender for 5,000 MW of generation capacity in 2013.

Planned Gas-Fired Power Plants from 2015 to 2024

- 2015 – Gulf JP UT CC 1-2, 2 X 800
- 2016 - North Bangkok CC # 2, 848.3
- 2021 - Gulf SRC CC #1-2, 1,250 MW
- 2022 - Gulf SRC CC #3-4, 1,250 MW
- 2023 - Gulf PD CC #1-2, 1,250 MW
- 2024 - Gulf PD CC #3-4, 1,250 MW

Thai Authorities are also expected to extend the SPP program with 25 new cogeneration power plants with a total capacity of 424 MW. The PPA's for these power-plants have yet to be signed.

DISPUTED POWER PLANTS IN SOUTHERN THAILAND

Currently, Electricity in Southern Thailand is primarily generated from combined cycle power plants in Khanom (678 MW) and Chana (710+800 MW) and a Thermal Power Plant in Krabi (340 MW). However, existing gas-fired power plants are not sufficient for dealing with growing electricity demand. The region has experienced several blackouts, thus highlighting the need for

a more robust electricity generation network[20]. However, due to expected declines in the JDA and Bangkot offshore gas fields, Thai Authorities seek to meet growing energy demand in Southern Thailand by developing several Coal-Fired power plants. These power plants include:

- 2019 – Krabi Coal Fired Power Plant, 800 MW
- 2021 – Thepa Coal Fired Power Plant Unit 1, 1,000 MW
- 2024 – Thepa Coal Fired Power Plant Unit 2, 1,000 MW

The development of Coal-Fired Power Plants in Thailand is a highly contested issue. The first directive of the PDP2015 is to "deal with an increase in power demand by taking into account fuel diversification to lessen the dependency of one fuel". The aim of development of coal-fired power plants is to therefore meet growing industrial growth and energy demand in the region, and at the same time meet the energy security needs of Thailand by reducing dependence on natural gas. The Energy Ministry has noted that power demand in Southern Thailand has grown at an average of 4.2% a year over the past decade, compared to 2-3% in the central region.[21]

Southern Thailand is argued to be main area where coal-fired power plants can be developed due to sea access for imported coal[22]. Activists and NGO's have heavily campaigned against the development of coal-fired power plants. Proponents cite experience with the 2,625 MW Mae Moh coal-fired power plant in the Lampang Province that caused a health crisis for the surrounding community in 1992. Large amounts of SO2 and fly ash was emitted from the power plant, which accumulated in the air in the Mae Moh Basin[23]. Villagers dwelling near the power plant complained of respiratory problems and agricultural degradation due to acid rain. Subsequent lawsuits from 2003 to 2005 were filed against EGAT. EGAT was ordered by courts to compensate for health and agricultural damages.

The court held that the power plant exceeded the legal emissions of SO_2 according to a pollution report released by the pollution control department.[24] EGAT and Thai Authorities, however, argue that "Clean-Coal" technologies

20 (Fredrickson, 2013)

21 (Jinakul, 2017)

22 Interview with EGAT

23 (Bloonlong, 2009)

24 (Sattha, 2015)

address environmental concerns and have been promoting the concept in Southern Thailand.

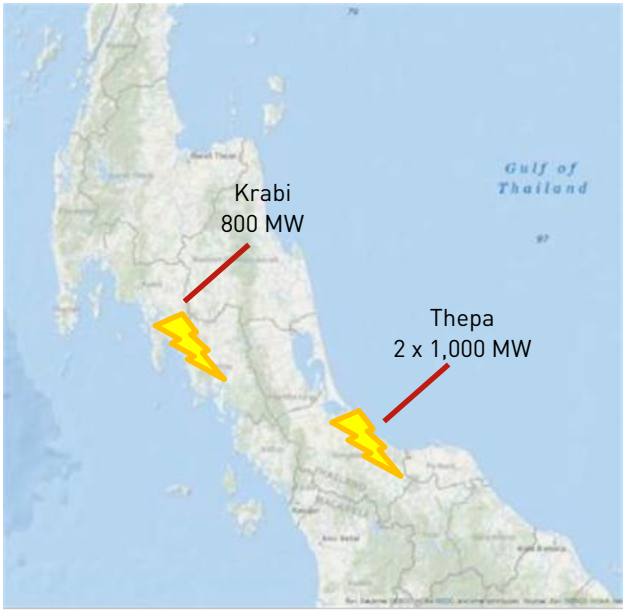

Figure 7: Location of Planned Coal-Fired Power Plants in Southern Thailand

KRABI COAL FIRED POWER PLANT

Krabi is a popular tourist destination located on the west coast of southern Thailand in the Phang Nga Bay. Tourism and agriculture are the primary industries in Krabi. Currently electricity in Krabi is supplied by a 340 MW thermal power plant running on fuel oil. The power plant is located the Klong Kanan sub-district. The Krabi Power Plant is one of the few power plants in Thailand still running on fuel oils and electricity generation costs are high. Originally the power plant had comprised of three 20 MW generating units that used lignite since 1964, but the plant was converted to a 340mw generating unit running on gas and fuel oil in 2004. EGAT has planned to build an 800 MW coal-fired power plant to begin development in 2015 and to start operations in 2019. However, the project has been put on hold due to opposition from local residents and activists. EGAT is pushing for the coal-fired power plant in Krabi as it already hosts existing EGAT infrastructure facilities, and is linked to the main electric transmission system. Additionally, it is possible to import coal from abroad as there is a pre-existing route for oil tankers[25].

The feasibility study for the project details the use imported sub-bituminous coal to be transported to the Klong Rau dock with 1-2 coal barges (10,000 DWT) every day. The coal will be loaded by conveyer system that is 9km in length to the power plant with a storage capacity of 480,000 tons and reserve usage for 60 days. The project coast total is expected to be 71.83 Billion THB and

25 Interview EGAT

the average selling price of electricity is expected to be 2.4709 THB/Kwh[26].

EGAT claims that the Krabi coal-fired power plant will utilize "Clean Coal" technologies such as a supercritical boiler, Low NOx burner, pulverized coal-combustion, and flue-gas desulfurization (ESP, Sulfur Dioxide Removal using limestone, and SCR.). Residents, however, fear that such technologies are not adequate to address health concerns and argue that the project may have negative effects on tourism and agricultural industries in the area.

Since 2007, projects effecting the surrounding community and environment are not permitted until the impact on environment and health is assessed, and a public hearing process is conducted. Therefore, an Environment and Health Impact Assessment (EHIA) is required. EGAT originally hired a consulting firm to conduct the report, which was sent to the Office of Natural Resource and Environment Policy and Planning for approval in July 2013. The report claimed that the power plant would meet air quality and water quality standards according the National Environmental Board. However, the EHIA has been highly disputed by proponents who argue that public scoping was flawed and there was no evaluation of the effects on livelihood and tourism[27].

In February 2017, the National Energy Policy Council was to make a final decision on whether to proceed with the power plant[28]. The committee resolved to go ahead with the plan and for construction to begin the following year. However, the decision was followed by immediate protests who called for restarting the EHIA. The NEPC backed down and agreed to restart the process. EGAT claims that the new EHIA will take two years to complete and has expressed concerns about possible blackouts and power shortages in the southern region due to delays of planned coal power plants.[29]

Commenters claim that coal-fired power plants in Thepa are likely to face similar opposition from local residents, activists and NGO's. Therefore, if the Krabi Power Plant Project is shelved, then it is unlikely that plans for power plants in Thepa will be realized. Industry leaders in the region have argued that if coal-fired power plants are shelved, with no alternative to power generation,

26 (Power Plant Development Planning, 2014)

27 (Greenpeace, 2014)

28 (Bangkok Post, 2017)

29 (Praiwan, 2017)

then investors will contemplate moving production bases to other regions in Thailand.

ALTERNATIVES

If plans for the Coal-Fired Power Plant in Krabi do not go ahead, EGAT has argued that one alternative is to upgrade high-voltage transmission lines (HVTL) of 500 kilovolts to transmit power from the central region of Thailand to the South. The plan is to transmit up to 650 MW of power. An HVTL extension from Prachuap Khiri Khan is already underway and expected to go online in 2020.

Another extension line from Phuket to Hat Yai, Songkhla is due to start operations in 2024.[30] However, because of the Eastern Economic Corridor project and planned investments in the eastern and central regions of Thailand, diverting energy to the south may prove challenging.

Electricity could also be imported from Malaysia, but Thai Authorities are skeptical due to energy security reasons. Another option may be to renegotiate the current JDA, so that more output is directed towards Thailand, but commentators argue that Malaysia is unlikely to approve such a plan.

The most likely alternative, therefore, to coal-fired power generation in Southern Thailand will be to build new gas-fired power plants and to import LNG via a FSRU or onshore terminal. EGAT is contemplating building a FSRU in the Andaman Sea, but has not yet conducted a feasibility study[31]. In addition, PTT has been directed by the NEPC to conduct a feasibility study on a LNG terminal in the Songkhla region.

30 (Phoonphongphiphat, 2017)

31 Interview with EGAT


fjordline.com


PGN FSRU LAMPUNG

3. LNG Sector and Plans in Thailand

Due to declining domestic natural gas output, rising demand, and uncertainty regarding Myanmar imports, Thailand is expected to significantly increase LNG imports. Thailand started to import LNG in 2011 following the construction of the Map Ta Phut LNG Terminal. In 2016, Thailand imported 2.9 MPTA and the current import capacity stands at 5 MPTA.

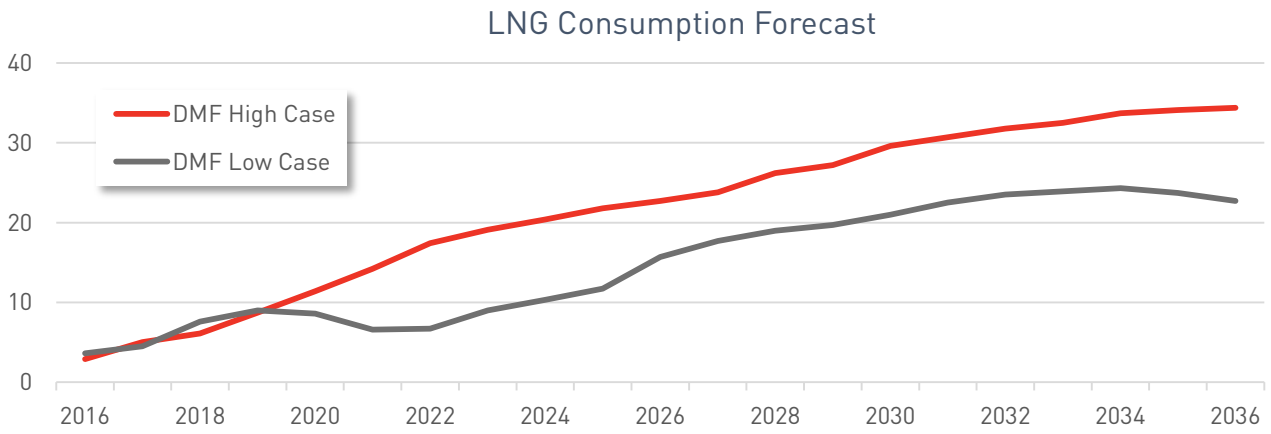

Figure 8: Graph showing Thailand's LNG consumption forecast. Source: DMF

The Department of Mineral Fuels (DMF) forecasts that LNG consumption will increase from 2.9 MPTA to 21.8 MPTA in 2025 and 29.6 MTPA in 2030. This is a high case scenario where plans for coal-fired power plants in Southern Thailand are shelved. The high case scenario also does not take in account exploration success and field development. In a low case scenario, the DMF forecasts that LNG consumption will rise from 2.9 MPTA in 2016, to 15.7 MPTA in 2025, to 22 MPTA in 2030.

The growth of LNG consumption in Thailand will depend on several factors including economic growth, the outcome of contested power plant plans in Southern Thailand, and potential new gas discoveries. This chapter reviews planned and potential LNG receiving terminal projects. Currently PTT PLC is the only procurer of LNG in the Thai market and holds 100% of the "grandfathered" capacity. However, after introduction of the Third Party Access Regime in 2014, EGAT is also currently studying LNG import options.

Acquiring land for LNG receiving terminals is usually not problematic for PTT or EGAT. However, such projects may be disputed for social and environmental reasons. In addition, due to shallow waters in the Gulf of Thailand, FSRU options that can be located in deeper seas are being considered.

2011	2017	2019	2022	2023	2027	2028	2030	2035
5 MPTA	5 MPTA	1.5	7.5 MPTA	5 MPTA	3 MPTA	2 MPTA	5 MPTA	5 MPTA
Map Ta Phut Phase 1	Map Ta Phut Phase 2	Map Ta Phut Expansion	Nong Fab Terminal	EGAT FSRU	FSRU Myanmar	FSRU Chana	New Terminal	New Terminal

Figure 9: Table of Thailand's LNG Infrastructure Development Plans. Source: DMF

MAP TA PHUT LNG TERMINAL

Phase 1

The Map Ta Phut LNG terminal was developed in 2011 by PTT LNG Company Ltd., a subsidy of PTT. The facility was constructed near the Map Ta Phut Industrial complex where industries are setting up plants that require natural gas feedstock. These industries include petrochemical, refinery, steel, fertilizer, aromatics and polypropylene.

The facility includes a 5 MPTA regasification train and two 160,000 LNG Storage tanks. The facility has one jetty that accommodates ships from 125,000 to 264,000 m^3. The terminal started operations in 2011. The terminal also has a truck-loading terminal of 500 ton/day.

Phase 2

An additional 5 MPTA expansion and second jetty is currently under construction and is expected to be completed in July 2017. The additional terminal will also expand truck loading by 500 ton/day. In addition, a small jetty for LNG break-bulk is planned that will accommodate 5,000 m^3 LNG carriers. PTT has already reserved the capacity of the expansion[32].

1.5 MPTA Expansion

Currently there are plans for an additional 1.5 MPTA expansion on the Map Ta Phut terminal. There is open season on this expansion, and therefore the terminal is open for bidding to third party actors. The 1.5 MPTA expansion is expected to be commissioned in 2019[33].

Fifth Transmission Pipeline Project

In 2015, the energy ministry approved a plan by PTT to construct a fifth gas pipeline in order to increase transmission capacity from the Map Ta Phut LNG Terminal. The 435 km pipeline will serve new power plants planned by Gulf Energy

32 Interview ERC

33 Interview ERC

Development and the North and South Bangkok Power Plant. The Pipeline is expected to be completed in 2021.[34]

NONG FAB LNG TERMINAL

PTTLNG is also planning for the construction of a 7.5 MTPA LNG receiving terminal in Nong Fab to completed in 2022-24. PTTLNG released an invitation for prequalification in December 2013 for Engineering, Procurement, and Construction. Invitation to bids is expected to be issued in March 2017.

FSRU MYANMAR

PTT is also currently studying a 3 MPTA FSRU to be located in Myanmar in order to mitigate against lower gas imports that currently supply power plants in east Thailand. PTT is currently conducting a feasibility study on this power plant that they presented in February. According to commentators, PTT will have to determine the costs of building the terminal and paying for the pipelines on the Myanmar side, in addition to any taxes and the price at the order. PTT will have to weigh this option against building a terminal and pipelines in Thailand.

EGAT FSRU

EGAT is currently conducting a feasibility study to construct a 5 MPTA FSRU to be located in the North of the Gulf of Thailand. The study will be sent to the National Energy Policy Council for approval in 2018. The proposed FSRU will supply natural gas to EGAT's North and South Bangkok Power Station. While EGAT already has Gas Supply Agreements with PTT for these power plants, there are plans for a 1,000 MW expansion of the North Bangkok Power Plant.

Originally, EGAT had planned for a 3 MPTA FSRU with 175,000 m^3 storage, but after looking at the long-term needs decided upon a larger 5 MPTA terminal of 210,000 m^3. However, this precludes procuring a converted LNG carrier, as there are few carriers of that size. Therefore, the FSRU will be a newbuild[35].

EGAT expects the terminal to be commissioned in 2023 and the Capital expenditure is estimated to be around USD 700-800 million. One of the challenges however is the shallow waters off the coast of Bangkok, which will require the FSRU to be located 20 KM from the shore.

34 (Thongrung, 2015)

35 Interview with EGAT

LNG IMPORT TERMINALS IN SOUTHERN THAILAND

If the planned Coal-Fired Power Plants in Krabi and Thepa are shelved, then LNG will need to be imported in order to mitigate against declines in gas production from the JDA and Bongkot gas fields. PTT was requested by the government to conduct a feasibility study for a 3 MPTA LNG terminal in the Thepa and Chana districts in Songkhla. The feasibility study was scheduled to be completed in May 2017[36].

PTT argued that one solution is to place an FSRU in Chana, where there already is a gas-fired power plant with gas supplied from the JDA gas field. In addition, the FSRU may also potentially feed gas through existing subsea pipelines to supply the Khanom gas-fired power plant.

EGAT is also considering a FSRU project in the Andaman Sea if the Krabi Coal-Fired Power Plant is scrapped. However, EGAT has yet to conduct a feasibility study on this project.

Commenters claim that FSRU projects are likely to be disputed by local residents. One commentator gave an example of concession for a drilling well, around 40 km from the coast that was scrapped due to protests from local residents.

SMALL-SCALE LNG IN THAILAND

A few small-scale LNG projects have taken place in Thailand, but due to current price of fuel oils and LPG, the market for small-scale LNG is currently limited. Potential users of small-scale LNG include natural rubber industry (For drying Process), Boat Taxis, LCNG Stations, Heating for Ceramic Industry, Industrial Estates, and Steel Factories.

- There was some LNG trucking to Myanmar by LNG Plus international, but this lasted only for a short period due to poor cost recovery in the project[37].
- A small-scale liquefaction facility was developed by Cryothai Co., Ltd. in Nongtoom-Sukhothai, in Northern Thailand. According to informants, this project has not been profitable.[38]

36 (Jinakul, 2017)

37 Interview with PTT LNG

38 Interview with PTT

- There was a project coordinated between PTT and Krobkrua Khonsong Co. to convert boat taxis in the Saen Saeb Canal to run on LNG and Diesel. However, in 2016 there was a gas explosion that injured 65 passengers. The Marine Department has since banned the mixed use of diesel and LNG as a fuel in commuter boats in the Saen Saeb Canal.
- PTTLNG has noted that several industrial representatives have expressed interest in the small-scale LNG jetty on the Map Ta Phut Terminal, particularly in Southern and Central Thailand.
- There are also several LCNG stations used for distribution of compressed Natural Gas for the NGV market.

LNG PROCUREMENT

PTT is also looking to secure access to long-term supplies as LNG imports increase. The company owns an 8.5% equity stake in a new LNG production facility in Mozambique. PTT signed a preliminary deal with Anadarko to purchase 3.5 bcm of LNG per year.


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4. Natural Gas Sector Reforms in Thailand

Norwegian firms that seek partnership in Thailand for Energy Projects should note that electricity in Thailand is a political commodity. Since the 1980's, the political economy of Thailand has shifted back-and-forth between agendas of "Liberalization" and "National-Champion building" in the energy sector. Currently, a single-buyer model dominates the energy sector, with tariffs set by government stakeholders. For a long period, electricity prices in Thailand have been relatively inexpensive due to favourable pricing policies. Inexpensive electricity and energy infrastructure expansion is deeply associated with rapid urbanization and industrialization, particularly as Thailand moved into energy-intensive production platforms in petrochemicals, manufacturing, steel, cement production, etc.

This chapter presents a brief history of Thailand energy market reform since the 1980's and outlines the current issues of energy market reform. The agenda of liberalization in the energy sector, including the policy of establishing Third Party Access, has continued into the emerging LNG sector in Thailand. Reforms have struggled to develop a competitive market in the Thai energy sector. In reality, the energy sector is largely dominated by the two "National Champions", EGAT and PTT. Norwegian firms should therefore be reflexive of the current situation of energy reform in Thailand when strategically positioning themselves in the Thai energy market. While the legal framework for liberalization in the energy sector is in place, there is still a deal of discussion and uncertainty in regards to how reforms should be implemented.

The result is a high degree of "regulatory risk" due to "variations in the quality of regulatory design, regulatory tools and regulatory institutions that may generate a series of risks that detract from or degrade the credibility of the regulatory commitment."[39] Norwegian firms should be aware of the current regulatory risks and manage to navigate around restructuring efforts in the Thai Energy Industry.

HISTORY OF THAI ENERGY REFORM IN THE NATURAL GAS SECTOR

The history of Thai energy sector reform dates to the 1980's. The Thai energy sector traditionally relied heavily on imported oil. However, due to oil shocks of the 1970's, Thai utilities built up high debts within the energy sector that accounted for over 46% of foreign loans between 1967 and 1971. The charged tariff was lower than the cost of electricity generation. Electricity costs had risen 259% between 1979 and 1982 due to debt-financing of state-led electricity development projects (Javis 2011).

Due to political pressure to maintain low electricity tariffs, Thailand sought emergency assistance from the International Monetary Fund and negotiated a series of conditional structural adjustment loans from the World Bank. During the 1980's the World Bank provided loans to Thailand on the condition that there was deregulation and liberalization in the utilities sector. Therefore, from 1990-2000, in the so-called "Neo-liberal" era of Thailand[40], authorities in Thailand sought to introduce competition into

39 Javis

40 Greacan

utilities markets. Authorities enacted new regulatory frameworks, largely adopted from models developed in the UK, in order to rapidly deploy new energy infrastructure.

The National Energy Policy Office (NEPO) was established in 1992, which had the duty of reorganizing the institutions involved in the energy sector[41]. The deregulation efforts were spearheaded by Dr. Piyasvasti Amarand, the secretary general of NEPO at the time. Dr. Piyasvasti drove forward a strong agenda of market rationalism and privatization, and lobbied the prime minister and cabinet for reform in the energy sector. NEPO was a largely influential body and assumed significant powers over all facets of energy policy, planning and pricing[42].

NEPO secured technical assistance from the Word Bank to assist in privatization of the energy sector. In 1998, London Economics, a consortium of companies on a World Bank funded project submitted a report outlining the plan for reform and restructuring of its energy sector. The report suggested the establishment of an independent regulatory agency, providing companies with incentives through price regulation, facilitating a role for the private sector, developing a primary legislation for the regulatory office, and secondary regulation such as licenses[43]. In addition, the report made some recommendations for regulating of the natural gas industry, including limiting PTT from entering further take-or-pay contracts and from contracting for all the gas in any new gas field, to establish a price control through a revenue-cap system, and to introduce accounting separation and conduct-based controls.

Following the London economics report, in 1998, NEPO proposed the plan "Privatization and Liberalization of the Energy Sector in Thailand"[44]. The cabinet, led by then Prime Minister Chuan Leekpai accepted NEPO's plan and agreed to implement the reform of the gas sector. The reforms included legal separation of PTT's transmission from its marketing business through establishing PTT Transmission Co. Ltd. The cabinet also approved the principle of Third Party Access.

NATIONAL CHAMPION ERA

When the Thaksin Shinawatra's government came to power in 2001, there was an intent to

41 (Wattana, Sharma, & Vaiyavuth, 2008)

42 (Jarvis, Ramesh, Wu, & Araral Jr, 2011)

43 (London Economics, 1998)

44 (National Energy Policy Office, 1998)

corporatize private enterprises and sell shares on the private market. However, at the same time the Thaksin regime dropped several of the market liberalization efforts. The new government entered Thailand in a so-called "National Champion" political trajectory. State-owned enterprises would be corporatized in order to increase national growth and avoid IMF loan obligations[45]. PTT was incorporated and floated on the Thai Stock Exchange in order to stimulate investment in the Thai equity and generate finance for expenditure programs. Foreign equity ceilings and ownership limits were imposed. However, after public offering was implemented in 2001, it was later criticized for being politically manipulated, with allegations that shares were allocated to government party supporters[46].

The government ended up partially corporatizing PTT (floated 49% equity share) but without structurally separating the gas sector and opening access to facilities. PTT was able to dominate the gas supply market by owning all of the gas pipelines and controlled the market as the sole procurer and transporter of gas[47]. The privatization of PTT and other State-Owned Enterprises led to strong protest movements from consumer protection NGOs that campaigned against the way that the government handled privatization.

In 2002, Dr. Piyasvasti was transferred out of NEPO, and established the Ministry of Energy. NEPO was renamed as the Energy Policy and Planning Office. The electricity policy making role of EEPO was relocated to the ministry, and EPPO was downgraded and was to report to the energy permanent secretary instead of the cabinet. Hence, EPPO (compared to NEPO) lost its reformative power and energy policy was controlled firmly inside the executive branch and subject to direct political considerations.

ENERGY INDUSTRY ACT 2007

In August 2006, a Supreme Court case against the corporatization of PTT was filed by the federation of consumers who petitioned to revoke the decrees pertinent to privatization and for the company be renationalized[48]. During the court case, the Thaksin government was ousted following a Coup D'état by the Royal Thai Army in September 2006. In October 2006, Dr. Piyasvasti was instated as the minister of energy. The post-

45 (Jarvis et al., 2011)

46 (Koomsup & Sirasoontorn, 2007)

47 (Wisuttisak, 2012)

48 (Nikomborirak, 2013)

coup period provided a brief "window of opportunity" for energy reform as the public demanded due process and regulatory oversight. One of the key initiatives that Dr. Piyasvasti took during this time period was the passage of the Energy Industry Act in 2007. The Energy Industry Act established a single regulatory body, the Energy Regulatory Commission (ERC) and was modelled after the UK office of Gas and Electricity Markets[49]. The ERC would be responsible for promoting competitive practices, having oversight over tariff review, distribute licenses, etc.

Energy Regulatory Commission Duties (IEA 2015)
• Regulate energy industry operations according to the Energy Industry Act and Ministry of Energy Policies • Issue operational licenses for the energy industry • Implement regulations and criteria for power purchases • Promote energy efficiency • Approve electricity tariff • Set safety standards • Protect Energy Consumers • Set pipeline tariffs

Table 2 Proposed Energy Regulatory Commission (ERC) responsibilities

The Energy Industry Act was an import factor for the December 2007 decision of the administrative court not to delist and nationalize PTT. Instead, state land and gas pipeline assets was to be transferred to the Ministry of Finance. The Energy Industry Act also restarted the liberalization of the Thai Energy Sector that had been stalled for almost 14 years. However, the reform period from 2006 was short-lived, as in 2008, Dr. Piyasvasti was again moved from his position as the Thai Minister of Energy. The Thai cabinet adopted a "go-slow" attitude towards the ERC, and delayed approval for its budget. Nevertheless, the Energy Industry Act continued to live on through the operations of the ERC and EPPO, while not necessarily being pushed politically.

10 years since the passage of the Energy Industry Act, PTT continues to act as the sole purchaser, transporter, and distributor of natural gas in Thailand. PTT continued to operate the pipelines on a monopoly basis, but agreed to pay the ministry of Finance an annual access fee (10 to 30% of total transmission revenue, depending on size of revenue). Today the government is in dispute on whether PTT has returned the gas pipelines back to the state following the Supreme

49 (Jarvis et al., 2011)

Court decision in 2007. The State Audit Commission has ruled that PTT must pay 32.6 Baht in compensation to the Ministry of Finance. [50]

IMPLEMENTATION OF A THIRD PARTY ACCESS REGIME IN THE LNG SECTOR

The advent of liquid natural gas imports in Thailand has provided a new avenue for liberalization efforts in Thailand. PTT continues to hold a monopoly on procurement of domestic natural gas production output and Myanmar pipeline imports. Breaking this monopoly would require parliamentary changes on the Petroleum Industry Act and would be therefore difficult to implement. However, a Third Party Access (TPA) regime on LNG imports provides an avenue for allowing third parties to procure, distribute and retail LNG.

On 13 December 2014, the ERC issued the Third Party Access Regime for Thailand. The TPA regime was issued by virtue of the Energy Industry Act 2007 section 81 "A Licensee who owns an energy network system must allow other licenses or energy industry operators to utilize or connect to his system in accordance with the terms stipulated and announced by the licensee". However, despite issuing the TPA access regime, the ERC has not issued any licenses to new shippers. There are a number of issues for new shippers to enter the market. According to the ERC[51], there is no limitation for issuing shipper licenses to foreign firms, as long as they are registered in Thailand.

The ERC is currently devising a road map for introducing a competitive market in Thailand; however, there is still several regulatory challenges to developing a competitive market. Despite these regulatory challenges, the most likely outcome of the TPA regime is that EGAT will enter the LNG market (See chapter 3). The following section outlines the various challenges associated with developing a competitive market.

1. LONG TERM GAS SUPPLY AGREEMENTS

PTT continues to hold all long-term gas supply agreements (GSA) with currently operating power plants in Thailand. A GSA is required before a Power Purchase Agreement (PPA) is signed, and the GSA normally lasts the lifetime of the PPA[52]. Exit clauses are usually not incorporated in the

50 (Wipatayotin, 2016)

51 Interview ERC

52 Interview EGCO

GSA, as PTT was previously the sole retailer of natural gas in Thailand.

It will only be possible for new shippers to come into the market if there is a need for a new GSA. However, the 2015 power development plant ultimately calls for the decrease of the share of natural gas in the energy mix. The next round of PPA and GSA for power plants planned between 2017 and 2024 has already been signed.

However, there is still room for new gas supply. EGAT runs several power plants at less than full capacity. As electricity demand in Thailand rises, there are prospects for EGAT to procure their own LNG supply for energy generation. In addition, replacements for to-be-retired power plants are planned (See appendix for details).

In addition, there is a plan to extend the small-power plant producer program with 25 new cogeneration power plants with a total capacity of 424 MW. The SPP's may therefore choose to import their own LNG or go through a third party

2. RESERVED CAPACITY IN PIPELINES AND LNG TERMINAL

PTT continues to hold reserved capacity at the Map Ta Phut Terminal and pipelines on a "grandfathered" Basis. "Grandfathered" is the continuation of existing contractual rights to use a natural gas facility. In effect, PTT continues to hold 100% of reserved pipeline and LNG terminal capacity. Effectively new producers have little chance to actually use the terminal and the pipelines and LNG terminal, despite third party access. However, there is a "Use-it-or-lose-it" clause in which PTT must announce available capacity, every 3 or 6 months. On average, PTT only uses around 3 MPTA of the 5 MPTA terminal, and a case could be made that PTT should give up some of that capacity. However, one commentator pointed that while PTT in practice might not be utilizing full terminal and pipeline capacity, when they report gas send out, they can point to peak demand periods where full terminal and pipeline capacity are used.

Therefore, in practice, if new shippers are to enter the natural gas sector in Thailand, they must build their own terminal capacity[53]. This is a major reason EGAT is considering procuring a

53 Interview EGCO

FSRU and to build its own pipelines. In addition, there is a planned 1.5 MPTA expansion on the Map Ta Phut Terminal. The expansion will be "open season" and third parties are encouraged to submit bids[54].

3. NATIONAL ENERGY POLICY COUNCIL APPROVAL

The national energy policy council must approve all long-term LNG supply contracts. The reasoning is since the price of LNG is pooled with domestic natural gas, then higher-priced LNG imports will raise the pool price. Therefore, based on energy security and tariffs, long-term contracts are subject to cabinet approval[55].

Spot contracts are not subject to cabinet approval. However, if the price of the spot contract is higher than the price of fuel oils, then it is not permitted to import spot LNG unless an exclusion is approved from the EPPO and the ERC on a case-by-case basis.

4. PTT CONTINUES TO HOLD MONOPOLY OVER PROCUREMENT OF DOMESTIC GAS RESERVES

PTT continues to be the sole procurer of domestic gas reserves in Thailand, which are notably less costly than Liquid Natural Gas Imports. Thailand's gas markets operate on the basis of gas pool pricing as explained in chapter 1.

The challenge of pool pricing for prospective shippers into the natural gas market is an unfair competitive advantage for PTT. As PTT continues to hold a monopoly over gas procurement from relatively inexpensive domestic offshore fields it can sell liquid natural gas at pool price while continuing to recover costs. Gulf Gas prices are around 250 THB per MMBTU, while LNG prices have fluctuated between 300 and 700 THB/MMBTU. Myanmar import prices are around 400 THB/mmbtu. However, if a new shipper would come into the market by procuring LNG, the price of LNG could not compete with the price that PTT would offer. PTT can use the average price of Gulf Gas and LNG, and therefore sell at a lower price than their competitors sell. However, the Energy Policy Office and the Energy Regulatory Commission is considering how to regulate gas pricing.

5. EGAT AS AN LNG EMERGING PLAYER

Despite the number of challenges regarding the regulatory framework, EGAT is likely to enter the LNG sector in Thailand. EGAT is essentially the

54 Interview ERC

55 Interview EPPO

main customer of natural gas in Thailand, as 59% of natural gas is used for electricity generation. Even though gas supply agreements are also signed with independent power producers, EGAT still holds a monopoly on power system operations and transmission. Thus, EGAT has some leverage to negotiate pricing with PTT (To pay wellhead price for gulf gas), and to procure LNG on its own terms.

EGAT will nevertheless face some issues to enter the market. Currently EGAT lacks the capacity and capability to be a LNG importer. Currently EGAT has a memorandum of understanding with the Tokyo Electric Power Company on LNG imports. However, EGAT is looking for consulting on market issues and procurement.

According to one commentator, the incentive for EGAT to enter the LNG market is uncertain. Economically the gas supply agreements between PTT and EGAT are decent, but PTT charges a premium and earns a margin on gas. On the other hand, PTT takes some price risk to ensure the EGAT will be supplied according to the committed volumes, even if it must be supplied at a higher cost to PTT. EGAT may avoid this margin, but would essentially be taking on the risk or paying a premium to a third party to take the risk.


Chief Officer
G. Macan
HÖEGH LNG

5. Challenges in the Thai LNG Sector

It is clear that Thailand is set to substantially increase its LNG import capacity and is likely to be one of the largest LNG importers in Southeast Asia. There are a number of opportunities available for Norwegian-Thai partnership. However, at the same time there is a certain level of uncertainty regarding the scale of LNG imports in Thailand. In the high case scenario, there are few new natural gas discoveries and coal-fired power plants are shelved, calling for the need to import more LNG. In the low case scenario, the next bidding round for E&P blocks is opened, new discoveries are made, and reserve-to-production ratios are extended. Coal-fired power plants could be pushed through despite opposition.

Thai-Norwegian LNG partnerships will need to carry through this uncertainty. At the same time, an implemented TPA Regime could widen the scope of stakeholders involved in the LNG industry. However there a number of issues regarding TPA in regards to developing a truly competitive natural gas market. PTT will continue to be the most important stakeholder in the Thai LNG industry and is likely to seek new business opportunities, particularly if production at its Gas Separation Plants declines. Nevertheless, EGAT may likely emerge as a LNG player and will look for partnership to develop its business portfolio.

This chapter summarizes the different challenges for the Thai LNG sector.

1. DOMESTIC NATURAL GAS PRODUCTION FORECASTS ARE UNCERTAIN

The key driver for the import of LNG is the decline of reserve-to-production ratios and the lack of new discoveries. However, there is still a relative uncertainty regarding the exploration and production of new gas finds in Thailand, and current LNG forecasts do not take in account new discoveries. Therefore, while domestic gas supply is likely to decrease in the short term, the long-term prospects are unclear and subject to change.

a) Delays in E&P activities are mainly the result of the current political process surrounding amendments to the Petroleum Act.
b) The extension for the Bongkot and Erawan concessions will be tendered in 2017.
c) The 21st bidding round of 29 blocks has been delayed since 2009.
d) Due to a current process of amending the Petroleum Act, there is an uncertainty regarding new exploration and production activities.
e) There is still some uncertainty regarding the extension of Myanmar gas supply agreements.

2. POWER PLANTS IN SOUTHERN THAILAND ARE DISPUTED

Thai Authorities have expressed concern over-reliance on natural gas in the energy mix as Thailand imports more LNG due to domestic gas supply declines. Therefore, Thai Authorities are pushing for coal-fired power plants in Southern Thailand, but these projects remain highly uncertain as local residents and activists are protesting against these projects. However, electricity demand in Thailand is rising, and continued blackouts and shortages may impact the economy. Therefore, a quick alternative is needed.

a) According to the current power development plan, there will be little new gas demand beyond the current 6,600 MW PPA's that have already been signed.
b) There is still uncertainty regarding Coal-Fired Power Plants in Southern Thailand. Plans have been delayed due to considerable opposition from local residents and activists. EGAT was currently required to conduct a new Environment and Health Assessment that will take two years to complete.

3. UNCERTAINTY REGARDING NATURAL GAS PRICING

Natural Gas and LNG pricing is an issue in Thailand, particularly if new shippers are to enter the LNG market. In the short-term, LNG will struggle to compete with Gulf Gas production which are less expensive (250 THB/mmbtu). However, at current prices LNG (300 THB/mmbtu) is competitive with Myanmar imports (400 THB/mmbtu).

a) Current pool pricing models gives an advantage to PTT, who is the sole procurer of domestic gas and Myanmar imports, and therefore can sell LNG at the average pool price. However, the Energy Regulatory Commission is working at a scheme for gas-to-gas competition. The ERC will need to split LNG from the pool price and recalculate the prices to find an adequate pricing scheme.
b) Natural Gas is sold to industry at a cost-replacement basis to LPG and Fuel Oils. However due to declines in fuel oil and LPG prices, natural gas is now sold at a loss. Changes in the price formula will need to be made, but there is dispute between the industry and PTT on if the price formula should be linked to fuel oil or LPG.

4. REGULATORY RISK IN THIRD PARTY ACCESS IMPLEMENTATION

A Third Party Access Regime was implemented on LNG terminals in 2014. However, there are several challenges to realizing a competitive natural gas market. The main challenge is namely natural gas consumption will stagnate as few new gas power plants are planned. This is apart from the next 6,600 MW power plants to be constructed until 2024; however, gas supply agreements have already been signed with PTT. Therefore, new shippers will struggle to enter the market.

a) While the legal framework regarding TPA is established, PTT continues to be the sole procurer and distributor of LNG.
b) PTT continues to hold grandfathered capacity on the Map Ta Phut Terminal.
c) PTT also holds 100% grandfathered capacity on transmission pipelines in the country.
d) All long-term gas supply agreements need to be approved by the National Energy Policy Council
e) As PTT continues to hold a monopoly over domestic gas and Myanmar imports procurement, PTT can offer natural gas at the average natural pool price, which is lower than LNG import prices. PTT therefore has a competitive advantage in the domestic LNG market.

5. ENVIRONMENTAL AND SOCIAL CHALLENGES

A number of environmental challenges for LNG terminals such as shallow waters and protected coral areas may pose problematic for LNG import facilities, particularly in the South. In addition, local residents may oppose LNG projects such as FSRU, due to issues regarding fishing and tourism.

a) The Gulf of Thailand is shallow is most areas and it is difficult to maneuver large vessels, therefore most LNG import options will need to be located far from the shore which may incur substantial pipeline infrastructure costs.
b) EGAT and PTT are also mulling options of onshore terminals, as it is relatively easy for them to procure land for such terminals. However due to shallow waters this would require jetties located far from shore, with long insulated subsea LNG pipelines. A FSRU will be a likely alternative.
c) EGAT and PTT fear that local residents and activists will protest against LNG terminals in Southern Thailand, despite the environmental benefits compared to coal.

6. THE COSTS OF COAL-POWERED ENERGY GENERATION

Thai Authorities claim that coal-fired power plants will keep electricity generation costs low. However, a 2015 U.S Department of Energy Report shows that at a coal price of USD 2.94/mmbtu breaks even with a natural gas price at USD 10/mmbtu. In addition, there are a number of externalities and risks associated with coal-fired power generation. Thai Authorities claim that externalities can be managed through

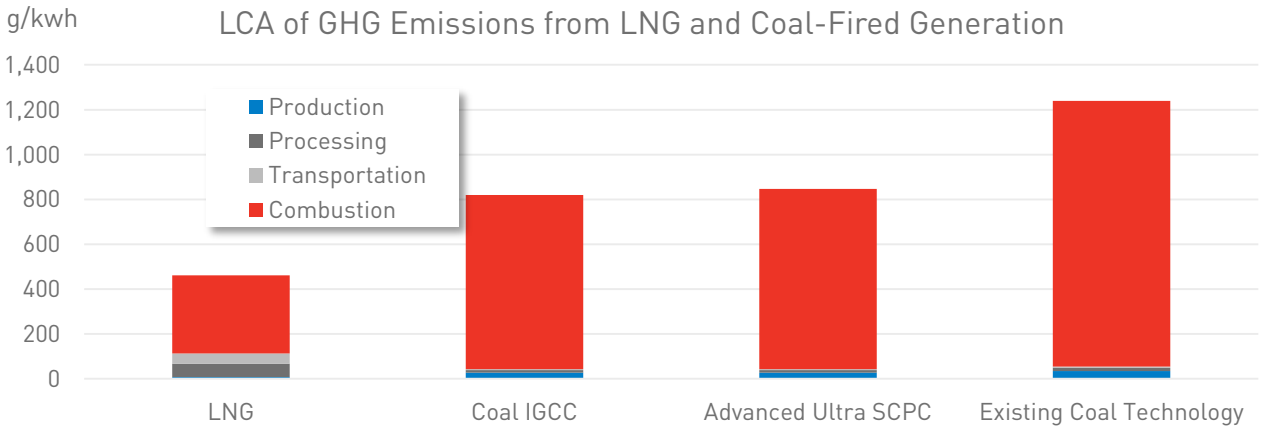


Figure 10: Graph showing LNG life cycle significantly reducing emissions as compared to existing coal technology. Source: Pace Global, 2015

pollution mitigation controls, but such systems also generate large amounts of waste that must be disposed of properly. In addition, the more advanced the pollution mitigation the systems, the larger the costs for power generation. According to the feasibility study for the Krabi Coal-Fired Power Plants, advanced systems such as ultra-supercritical boilers or Integrated Gasification Combined Cycle (IGCC), are not planned for the power plant. In addition, the feasibility study does not account for greenhouse gas emissions and does not utilize any methods for carbon capture and storage. The first graph below shows that LNG life cycle significantly reduces greenhouse gas emissions compared to existing coal technology. The second graph below compares pollutants and cost of electricity (COE) between natural gas and coal-fired power plants.

It is important to also account for the externalities associated with Coal-Fired Power Generation, that when taken account for, dramatically increase the costs. Epstein (2011) has outlines a number of externalities associated with coal-fired combustion including:

- Damage to farmlands and crops due to combustion pollution
- Hospitalization costs resulting from increased morbidity in coal communities
- Climate change due to CO_2 and NOx emissions

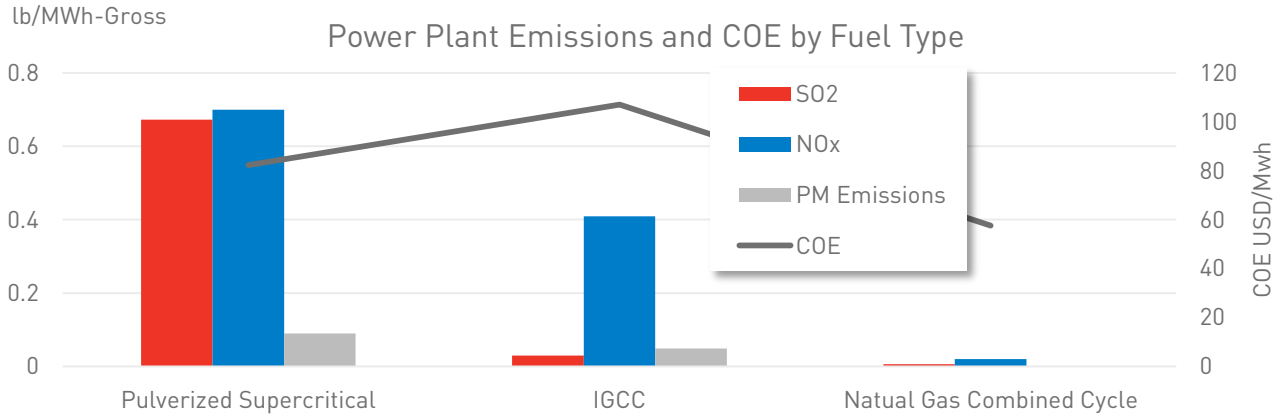


Figure 11: As represented in the graph, supercritical coal power plants produce considerable more pollutants than natural gas fired power plants. The Supercritical plant case is modelled with wet flue gas desulfurization, Low NOx burners, and Selective Catalytic Reduction. While IGCC technology might mitigate such pollutants, the costs rise significantly compared to natural gas. Fuel costs in this model are set at USD 40.7/Mwh for natural gas compared to USD 24.6/Mwh for Coal.[1] Source: National Energy and Technology Laboratory, 2015 a&b

- Corrosion of buildings and monuments from acid rain
- Visibility impairment from NOx emissions
- Environmental contamination as a result of heavy metal pollution
- Higher frequency of sudden infant death syndrome
- Impacts of acid rain
- Environmental impacts of ozone and particulate emissions
- Soil contamination
- Destruction of marine like from mercury pollution
- Freshwater use in coal-fired power plants

7. ENERGY SECURITY CONCERNS AND LNG PRICE STABILITY

A key concern for Thai Authorities is that while LNG Prices are at historic lows in Southeast Asia, this represents another boom and bust cycle in the LNG industry. Historically the LNG industry has grown through periods of high and low prices. In 2007-09, few Final Investment Decisions were made, and in combination with high oil prices, increased LNG prices significantly from 2011-2014. In addition, the Fukushima disaster in Japan, led to a significant increase in LNG demand that rose Asian prices further.

However, during the same period 19 projects took FIDs between 2009 and 2015, which led to 152 MPTA in capacity to come online in 2015. The entry of LNG exporters from Australia and the United States, with 58.2 MPTA and 9 MPTA respectively, has led supply to overtake demand.[56]

Thai Authorities argue that while low prices may continue into the 2020's, if few new FIDs are taken between 2017 and 2020, then the market will again be undersupplied and in combination with rising oil prices, LNG prices will increase significantly. Therefore, Thai Authorities argue that the country needs to reduce its dependence on LNG imports. Essentially, Thai Authorities expect LNG markets to be in a boom and bust cycle.

The "boom and bust cycle" assumption, however, is based on the argument that investors are unwilling to take new FID's on liquefaction projects unless LNG demand is secured through long-term sales and purchase agreements (SPA). This assumption, however, overlooks the expansion and growth of the global LNG market and the willingness for investors to approve projects without securing SPAs. Particularly the substantial growth in the FSRU market that has led to a number of countries, particularly emerging economies, to enter LNG markets. Therefore, it is reasonable to expect that the LNG market is both globalizing and will become more flexible, such that new FID's will be taken even in a low price environment.

Changes in the LNG industry also show a shift in power from LNG producers to buyers. Whereas producers previously maintained tight control over the value chain. Often buyers would sign destination clauses in LNG contracts that restricted the trade of fuel. However, buyers like Tokyo Electric Power Co. and Chubu Electric power have refused to sign destination clauses. In addition, the ratio of long-term contracts compared to short term contracts are falling. Contract lengths have fallen 8.5% in the last few years. The result is a growth in portfolio suppliers and aggregators who purchase LNG on long-term contracts and sell LNG to the spot market (contracts below 5 years). Spot market prices have dropped, allowing more room for flexible contracts. Several traders have taken advantage of the rise in demand for short-term contracts and contract flexibility in order to procure LNG on

56 (Corbeau, Ledesma, Caswell, D'apote, & Flower, 2016)

long-term markets and sell on spot term markets.

The “reconfiguration” of the Asian LNG market points, in terms of flexibility, also points to a period of pricing that is reflective of market value. As China, Japan and Singapore establish gas-to-gas market pricing indexes; Asian LNG may eventually be de-linked from oil pricing. Such events will allow the market to better coordinate supply and demand, and ultimately reduce the premiums that Asia has paid for LNG previously. As Japan and South Korea procure less and less LNG, the pricing should be favorable to Thailand.


POWERED
BY
LNG

6. Opportunities for Norwegian-Thai Partnerships

Despite the number of challenges and uncertainties regarding the LNG sector in Thailand, Thailand is nevertheless set to be one of the largest LNG importers in South East Asia. As PTT looks to expand its business portfolio due to declining domestic natural gas production and expected decline in gas separation production, Norwegian companies may offer new solutions to expand LNG consumption in Transport and Industry. Additionally, as EGAT is set to enter the LNG market, Norwegian firms can help EGAT develop the right capabilities and competences, in addition to design, construction and deployment of FSRU solutions.

However, Norwegian firms will need to promote their solutions in order to be successful. In particular, Norwegian firms must promote LNG as an alternative to coal-fired power generation in Southern Thailand. To do so, Norwegian firms must be able to ease energy security concerns by pointing to developments in global LNG supply chains and the LNG market.

Norwegian firms must also point to the "hidden costs" of coal-fired power generation. First, compared to LNG and gas-fired terminals, coal-fired power plants require larger upfront costs and have a much longer lead-time the FSRU and gas-fired power plant solutions. This lead-time for coal-fired power plants is likely to be even longer than expected, as exemplified in the current situation for Krabi. In addition, the costs of regulatory oversight (to meet opposition demands) may not be taken in consideration. Additionally, costs for coal-fired power plants tend to be higher than expected due to rising prices in operation costs. A report from the EIA shows that fossil steam operation costs have risen 38% from 2005-2015, and have declined 37% for gas-fired power plants.[57] Given that coal-fired power plants will be built later than expected due to delays, prices may be higher than expected.

BACKGROUND OF NORWEGIAN LNG EXPERIENCE

Norwegian firms have a long experience with LNG Transport and LNG Import solutions. The Norwegian company, Moss Maritime, introduced the Moss Spherical Containment system, which has been the leading seaborne transportation system for LNG. Since then several Norwegian firms offer a variety of efficient and cost-effective containment solutions for LNG storage and Transport. In addition, Norwegian firms such as HOEGH LNG, BW LNG, and Golar LNG are world leaders in FSRU design, construction, deployment, and operations. Norwegian firms are also at the forefront of technical advisory services, and health and safety regulations in the LNG industry.

Norway has been a long-time exporter of Natural Gas since discoveries in the 1960s. Due to cheap and abundant hydroelectric recourses, little of Natural Gas production was directed to the

57 https://www.eia.gov/electricity/annual/html/epa_08_04.html

domestic market. Rather most natural gas was exported to continental Europe and the UK. However, a political push to embed natural gas in the domestic market led to a substantial rise in domestic natural gas consumption from 1994. Geographical challenges such as deep waters, scattered demand centers, and topographical barriers made building a domestic pipeline network challenging. Small-Scale LNG distribution via maritime and land transport was developed to supply LNG to industries and LNG-fueled maritime vessels. Today Norway has the most mature small-scale LNG business in the world. A number of firms have spun-off from this industry to offer cost-effective and redeployable small-scale import solutions to the global market.

1. PARTNERING ON FSRU CONSTRUCTION, DEPLOYMENT AND OPERATIONS

Several Norwegian firms are global leaders in the FSRU market. These firms include BW LNG, Golar LNG and HOEGH LNG. As PTT is currently carrying out studies and planning for floating receiving facilities in Myanmar and Southern Thailand, Norwegian FSRU partners could play a key role in realizing such plans. Most importantly Norwegian firms will be able to construct, deploy and operate an FSRU. In addition, Norwegian firms can also help realize EGAT's FSRU plans by contributing to developing the necessary competences and capabilities for FSRU deployment and LNG procurement. Norwegian firms need to promote FSRU solutions as a better cost alternative to land-based terminals.

Norwegian Capabilities

- Safe and reliable long-term time chartered operation of FSRU compliant with international standards
- Sold experience in FSRU Procurement and Operation Management
- Supply of onboard regasification equipment
- Norwegian firms have experience with rapid deployment of FSRU infrastructure (BW maritime deployed a FSRU within 5 months of tender award). FSRU option offers a 50% reduction in lead-time.
- Norwegian firms are flexible with vessel size and regasification capacity, and require lower upfront capital expenditure.

2. PARTNERING ON ALTERNATIVES TO COAL-FIRED POWER GENERATION

Plans for Coal-Fired Power Plants in Southern Thailand have been highly disputed and have caused considerable political tension. Norwegian capabilities that lower LNG transportation and

receiving costs can be a reasonable alternative to coal-fired power generation. In addition, Norwegian technology can work around environmental challenges such as shallow waters. LNG contains negligible amounts of pollutants and reduces carbon emissions by 50% compared to coal. "Clean Coal" technologies are costly and unable to reduce emissions to the same degree. Coal-Fired Power Plants are capital intensive and sunk assets. Floating LNG technology and power plants, on the other hand, can be redeployed. Thailand will need to import subbituminous coal, as it only has lignite coal reserves, therefore importing coal will also impact foreign exchange reserves.

Norwegian and Thai firms can cooperate to promote energy grids that utilize both LNG and renewable energy (waste-to-energy and Solar) in order to ease energy security concerns. EGAT and Norwegian firms can also cooperate on a LNG import solution in the Andaman Sea if the Plan for the Krabi Coal-Fired Power Project is shelved.

3. PARTNERING ON EXPANDING LNG BUSINESS PORTFOLIO'S

Thailand is set to significantly expand its LNG capacity in the short term in order to mitigate against domestic natural gas shortages. However, this precedes significant periods of underutilization on installed capacity. Norwegian firms could collaborate with Thai companies to take advantage of under-utilized LNG capacity to expand the LNG market to the industrial and maritime transportation sector. As fuel oil and LPG prices rise, LNG will be a reasonable alternative for industrial and transportation use.

PTTLNG is already constructing a small-scale LNG jetty for 5000 m^3 ships on the Map Ta Phut Terminal, which has received considerable interest from industrial estates along coastal Thailand. Shallow waters nevertheless may pose a challenge, and therefore it will be important for Norwegian firms to promote shallow water solutions such as low draft LNG carriers, near-shore gravity based import terminals, and floating universal loading platforms.

Norwegian Capabilities

- Supplying LNG engines and Storage and Supply Systems for Maritime Transportation
- Co-developing modular satellite LNG receiving facilities.
- Supplying efficient storage systems for Small-Scale LNG vessels and FSRU's

- Sharing experience on Ship-to-Ship Operations
- Conducting feasibility and safety studies for LNG ship-to-ship transfer
- Supply equipment for LNG ship-to-Ship Transfer e.g. cryogenic hoses.
- Commercial and Technical Advisory Services related to LNG value chain:
  - Concept Selection
  - Tendering Process
  - Design
  - Risk Analysis
  - Financial Assessments
  - Third Party Verification Studies
  - Investment Analysis
  - Evaluation of LNG as Energy Source

4. PARTNERING ON RULES, STANDARDS AND REGULATIONS

Norwegian companies have developed sets of class rules and recommendations for new developments in the LNG industry. This includes LNG Transportation, Floating LNG Import Terminals, LNG-Fueled Maritime Transportation, and Small-Scale LNG Supply Chains.

Norwegian Capabilities

- Advice on International rules, standards, and regulations for onshore LNG terminals, FSRUs, small-scale LNG carriers, and ship-to-ship Transfer
- Developing a risk management framework for Thai organizations in the LNG sector
- Provide advisory services related to environment and safety hazards in LNG fueled Maritime Transportation.

5. PARTNERING ON UPGRADING POWER PLANT EFFICIENCY

As Thailand seeks to reduce its carbon footprint and to reduce natural gas consumption, then upgrading existing natural gas power plants and building energy-efficient replacements will be a key strategy. Norwegian firms have many years of experience in combined cycle gas-fired power plants and can be key partners in energy efficiency:

- Pre-feasibility and feasibility Studies
- Preparation of complete commercial and technical and commercial tender documentation package
- Environmental and Social Assessment Reporting
- Ensuring negligible environmental and social impact
- Reducing NOx and CO_2 emissions

Appendix

ABBREVIATIONS AND ACRONYMS

bcf	Billion Cubic Feet
bcm	Billion Cubic Meters
CO_2	Carbon Dioxide
DMF	Department of Mineral Fuels
E&P	Exploration and Production
EGAT	Electricity Generation Auth. of Thailand
EHIA	Environment and Health Assessment
EPPO	Energy Planning and Policy Office
ERC	Energy Regulatory Commission
FID	Final Investment Decision
FSRU	Floating Storage and Regasification Unit
GSA	Gas Supply Agreement
Gwh	Gigawatt Hour
HVTL	High Voltage Transmission Line
IGCC	Integrated Gasification Combined Cycle
IPP	Independent Power Producer
JDA	Malaysia-Thailand Joint Developmt Area
Kwh	Kilowatt Hours
LCNG	Liquefied-Compressed Natural Gas
LNG	Liquefied Natural Gas
m^3	Cubic Meter
MEA	Metropolitan Energy Authority
mmbtu	Million British Thermal Unit
mmscfd	Million Standard Cubic Feet
MTPA	Million Tons Per Annum
MW	Megawatt
NEPC	National Energy Policy Council
NEPO	National Energy Policy Office
NGV	Natural Gas Vehicle
NOx	Nitrogen Oxides
PEA	Provincial Energy Authority
PDP	Thailand 2015 Power Development Plan
PPA	Power-Purchase Agreement
SO_2	Sulphur Dioxide
SPA	Sale and Purchase Agreement
SPP	Small Power Producer
tcf	Trillion Cubic Feet
THB	Thai Baht
TPA	Third Party Access
USD	United States Dollars

LIST OF INTERVIEWEES

EGAT

- Orapim Sompongse, Head, Fuel Economic Analysis Section Fuel Information Center Department, Fuel Management Division
- Jitraporn Inchunjiw, Head, Natural Gas Supply Section, Natural Gas Management Department, Fuel Management Division
- Somkid Charoenwan, Chief, Mechanical and Electrical Engineering Department

Energy Regulatory Commission

- Phuwanart Choonhapran, Senior Professional, Energy Plan and Procurement Regulation Department

PTT

- Jakkraphan Thavilap, Vice President Natural Gas Strategy and Market Development Department, Natural Gas Supply and Trading

PTTLNG

- Pajaree Lopsathayoodh, Vice President, Corporate Finance Planning and Administration Department

Energy Planning and Policy Office

- Veerapat Kiatfuengfoo, Director of Petroleum Business Group

Petroleum Institute of Thailand

- Dr. Siri Jirapongphan, Executive Director
- Krischasorn Udomwadhanaphorn, Deputy Executive Director

Energy Generating Public Company Limited

- Danuja Simasathien, Executive Vice President Business Development (Domestic)

PLANNED GAS FIRED POWER PLANTS 2015-2036

Year	Project	Capacity
2015	Gulf JP UT CC #1-2 (Jun, Dec)	2 x 800
2016	North Bangkok CC #2 (Jan)	848
2016	Khanom Replacement CC #1 (Jul)	930
2019	Replacement of Bang Pakong TH #1-2 (Apr)	1,300
2019	Replacement of South Bangkok TH #1-5 (Apr)	1,300
2021	Gulf SRC CC #1-2 (Mar, Oct)	1,250
2022	Gulf SRC CC #3-4 (Mar, Oct)	1,250
2022	Replacement of South Bangkok CC #1-2	1,300
2023	Gulf PD CC #1-2 (Mar, Oct)	1,250
2023	Replacement of Wang Noi CC #1-2	1,300
2024	Gulf PD CC #3-4 (Mar, Oct)	1,250
2025	Replacement of Wang Noi CC #3	1,300
2032	Replacement of Bang Pakong CC #3-4	1,300
2033	Replacement of Bang Pakong TH #3-4	1,300

Table 3: Planned gas fired power plants 2015-2036. Source: PDP 2015

RETIRED GAS FIRED POWER PLANTS 2015 – 2036

Year	Project	Capacity
2016	Retirement of Khanom TH #2 (Jun)	-70
2016	Retirement of Khanom CC #1 (Jul)	-678
2017	Retirement of Bang Pakong CC #3 (Jan)	-314
2018	Retirement of Bang Pakong CC #4 (Jan)	-314
2019	Retirement of Wang Noi CC #1-2 (Jan)	-1,224
2020	Retirement of South Bangkok CC #1 (Jan)	-316
2020	Retirement of Tri Energy Power Plant (Jun)	-700
2022	Retirement of South Bangkok CC #2 (Jan)	-562
2023	Retirement of Wang Noi CC #3 (Jan)	-686
2023	Retirement of EPEC (Mar)	-350
2025	Retirement of Nam Pong CC #1-2 (Jan)	-650
2025	Retirement of Global Power Energy (Aug)	-700
2025	Retirement of Ratchaburi TH #1-2 (Oct)	-1,440
2027	Retirement of Bang Pakong CC #3 (Jan)	-576
2027	Retirement of Ratchaburi CC #1-2 (Apr)	-1,360
2027	Retirement of Ratchaburi CC #3 (Oct)	-681
2028	Retirement of Bang Pakong TH #4 (Jan)	-576
2028	Retirement of Glow IPP (Feb)	-713
2032	Retirement of GPG CC #1 (May)	-734
2033	Retirement of GPG CC #2 (Feb)	-734
2033	Retirement of Ratchaburi Power CC #1 (Feb)	-700
2033	Retirement of Ratchaburi Power CC #2 (May)	-700
2034	Retirement of Chana CC #1 (Jan)	-710
2035	Retirement of South Bangkok CC #3 (Jan)	-710
2035	Retirement of Bang Pakong CC #5 (Jan)	-710
2036	Retirement of North Bangkok CC #1 (Jan)	-670

Table 4: Retired gas fired power plants 2015-2036. Source: PDP 2015

PLANNED COAL-FIRED POWER PLANTS 2015 - 2036

Year	Project	Capacity
2016	National Power Supply TH #1-2 (Nov)	270
2016	Loa PDR (Hong Sa) TH #3	491
2017	National Power Supply TH #3-4 (Mar)	270
2018	Replacement of Mae Moh TH #4-7 (Nov)	600
2019	Krabi Coal-Fired TH #1 (Dec)	800
2021	Thepa Coal-Fired TH #1	1,000
2022	Replacement of Mae Moh TH #8-9	450
2022	Replacement of South Bangkok CC #1-2	1,300
2024	Thepa Coal-Fired TH #2	1,000
2033	Coal-Fired Power Plant #4	1,000
2035	Coal-Fired Power Plant #6	1,000

Table 5: Planned coal fired power plants 2015-2036. Source: PDP 2015

NORWEGIAN LNG COMPANIES AND INTEREST ORGANIZATIONS

Terminals, Transport and Distribution

- BW LNG
- Connect LNG
- Gasnor/Shell
- Gassco
- Golar LNG
- Gravifloat/Semcorp
- Höegh LNG
- I.M. Skaugen
- Kanfer Shipping
- Knutsen OAS
- Liquiline LNG
- Norconsult
- Skagerak Naturgass
- Skangass
- Statoil

Shipping Companies

- Awilco
- BW LNG
- Golar LNG
- Höegh LNG
- I.M. Skaugen
- Jahre LNG

Shipping Companies (Users)

- Eidesvik
- Fjord 1
- Fjordline

Bunkering

- Gasnor/Shell
- Knutsen OAS
- Liquiline LNG
- Skangass
- Wärtsilä/Hamworthy

Storage and Engines

- Aker Solutions
- Kanfer Power
- Light Structures
- Mitsubishi
- NLI
- Rolls Royce
- Torgy LNG
- Wärtsilä/Hamworthy
- Wilhelmsen Marine Service

NORWEGIAN LNG COMPANIES AND INTEREST ORGANISATIONS (CONTD.)

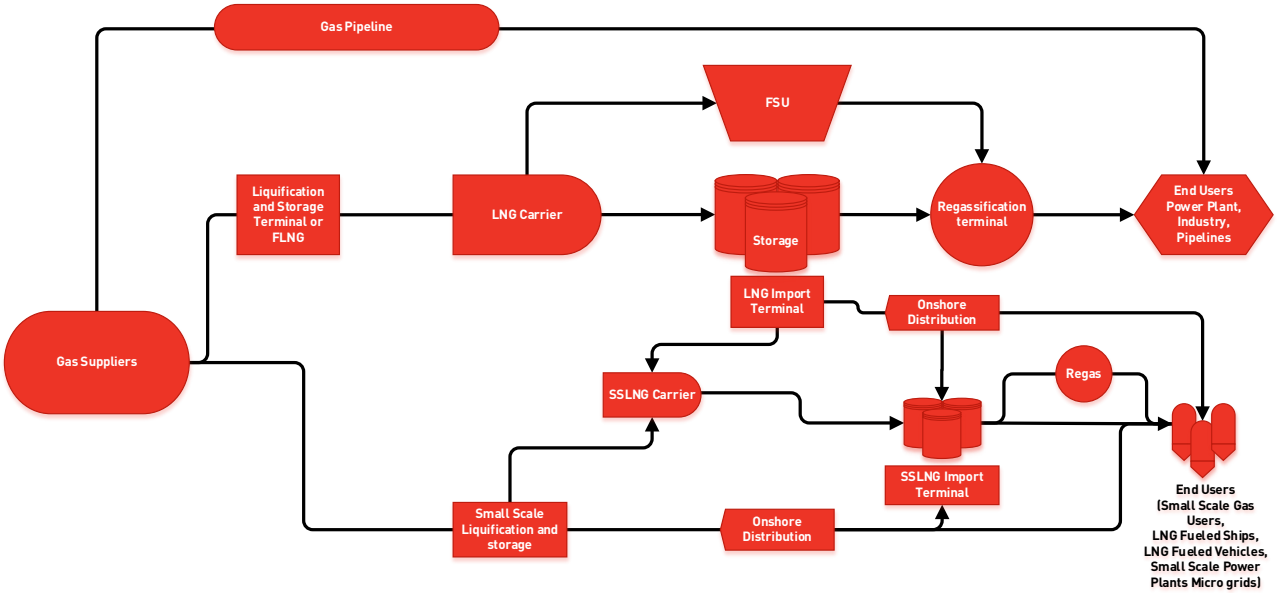
Equipment Suppliers

- Aker Solutions
- Fiskerstrand Verft
- Kongsberg Maritime
- LMG Marine
- Multiconsult
- Siemens
- SINTEF/MARINTEK
- Skipsteknisk AS
- TTS Group
- Wärtsilä/Hamworthy

Other LNG Stakeholders

- Clarksons Platou
- DNV GL
- Export Credit Norway
- Fearnley LNG
- The Norwegian Export Credit Guarantee Agency (GIEK)
- Innovation Norway
- Network LNG Norway
- Norwegian Energy Partners
- Norwegian Maritime Authority
- Norwegian Maritime Exporters
- SINTEF/MARINTEK

SMALL-SCALE LNG VALUE CHAIN



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