ASEANのエネルギー分野の現状・関連動向に係る調査 – 定点調査業務2023

報告書 - Thailand

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エネルギー定点調査

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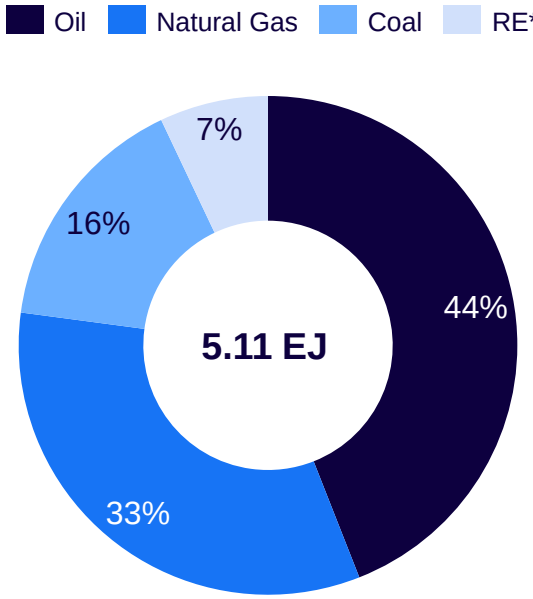
1. 一次エネルギー構成

タイのエネルギー資源の中心は天然ガスと石油である

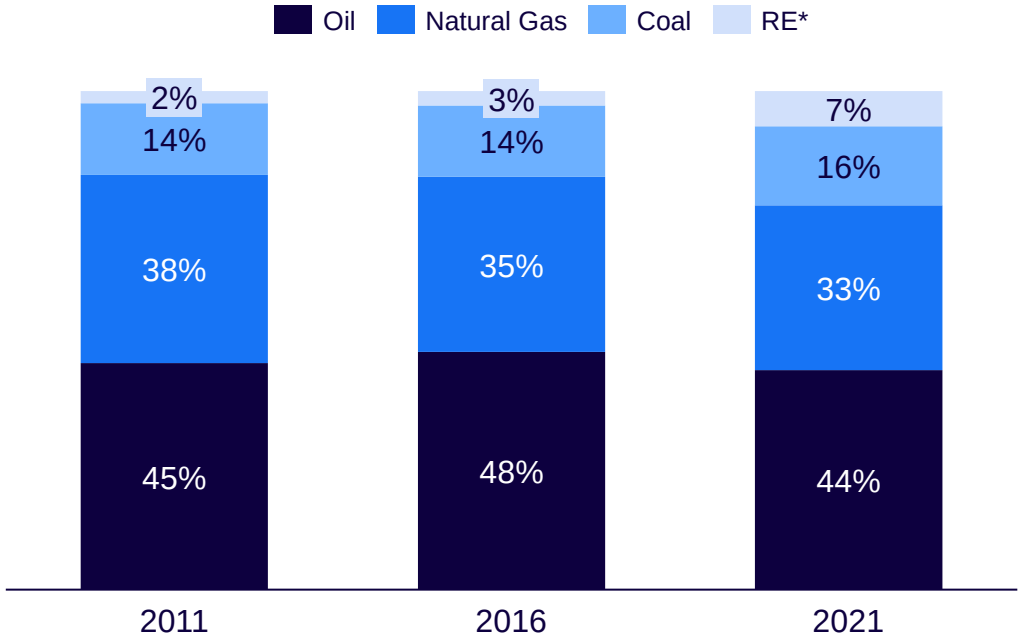
Primary energy consumption
2021, Exajoules

Thailand's primary energy demand in 2021 is 5.11 Exajoules, with oil and natural gas accounting for over 75% with oil at 2.3 EJ (44%) and natural gas at 1.7 EJ (33%). Coal consumption comes in third at 0.8 EJ (16%), followed by renewable energy at 0.4 EJ (7%) of which 0.04EJ is comprised of hydropower



Historical primary energy consumption
2011 – 2021, %

Thailand has generally maintained a stable primary energy consumption mix with, oil averaging 45.7%, natural gas at 45.3% and coal at 14.7%. Renewable energy is increasing in recent years as seen from the jump from 3% in 2016 to 7% in 2021.

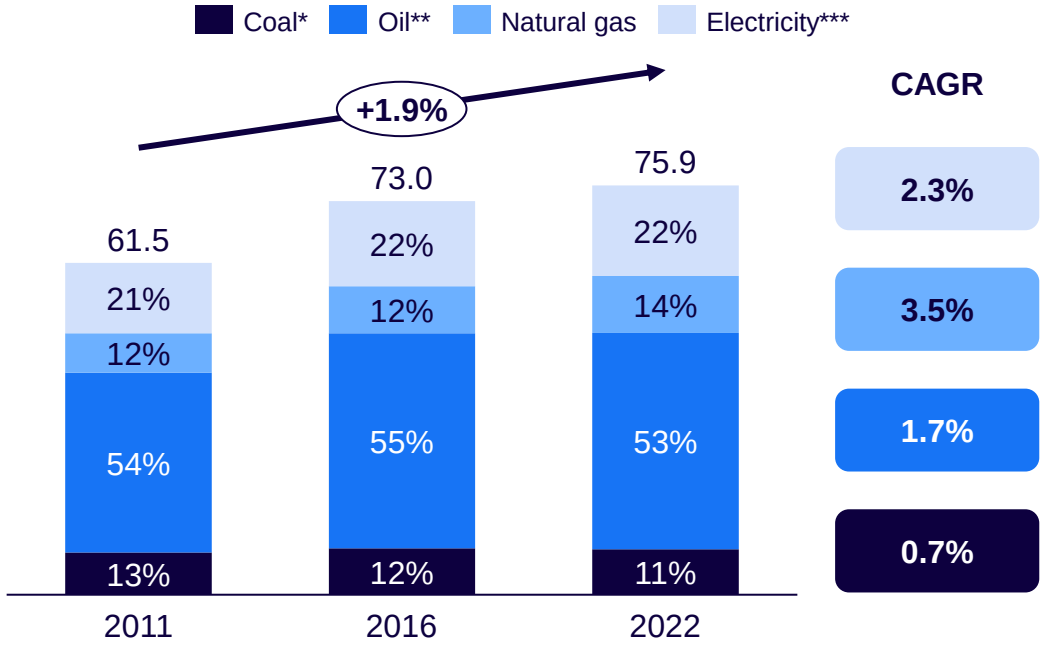


Note: * Renewable energy consists of hydropower and other renewables
Source: BP Statistical Review of World Energy 2013, 2017, 2022, Arthur D. Little analysis

最終電力は、石油と電力に依存

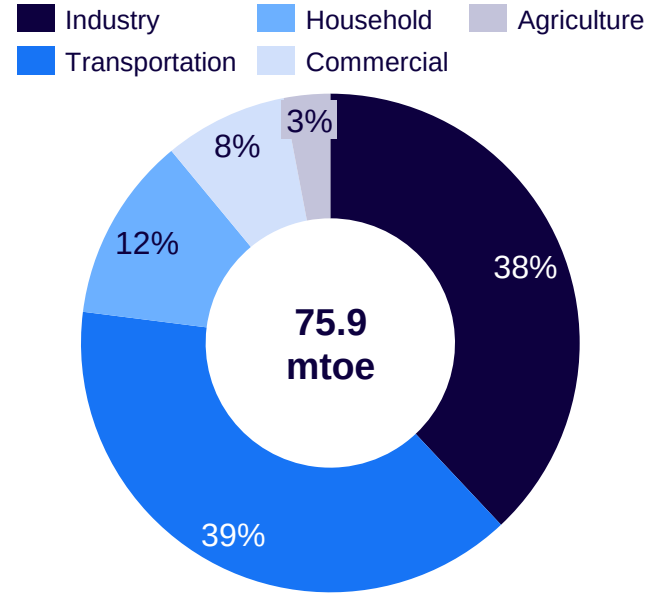
Final energy consumption
2011 - 2022, mtoe[1]

The final energy consumed in 2022 was 75.9 mtoe, experiencing 1.9% YOY growth from 61.5 mtoe in 2011. Oil has retained its dominance since 2011 (33.4 mtoe) and growing YOY at 1.7% to reach 40.1 mtoe in 2022.Electricity comes in second at 16.8 mtoe, trailed by natural gas at 10.5 mtoe and coal at 8.4 mtoe in 2022



Final energy consumption, by sector[2]
2022, mtoe[1]

The transport and industrial sectors are the major final consumers of energy, accounting for >75% in 2022.This is split between transport at 29.6 mtoe (39%) and industry 28.8 mtoe (38%). Household, commercial and agriculture trail behind at 9.1 mtoe (12%), 6.1 mtoe (8%) and 2.3 mtoe (3%) respectively



Note: * Inclusive of lignite, preliminary data for all years, ** Inclusive of LPG (excluding petrochemical industry feedstock amounts), *** Including power generation from SPP; 1) Million tons of oil equivalent; 2) based on preliminary figures
Source: Energy Policy and Planning Office 2023, Arthur D. Little analysis

タイのエネルギー政策の根幹は国家エネルギー計画(NEP）であり、それを支えるようにサブセクターのエネルギー政策がある

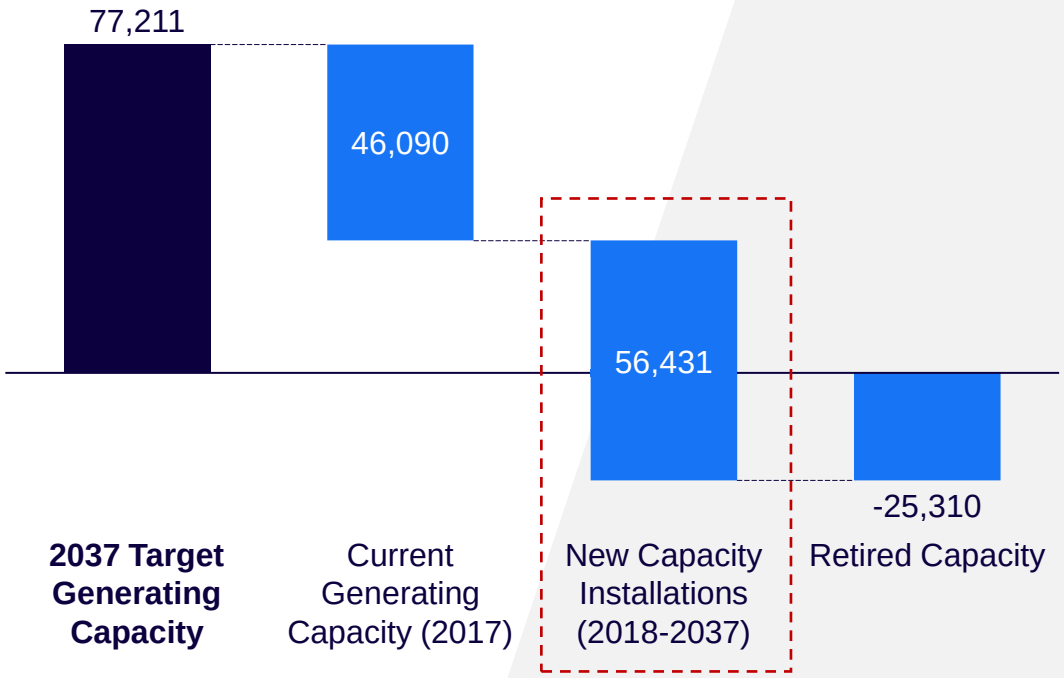
Summary of energy policies in Thailand

2023 (Expected)	**Thailand National Energy Plan (NEP)**	• Combine and **synchronize the five action plans** (below) • Provide the **development policy direction** in the energy sector for both government agencies and private companies
2018	**Power Development Plan (PDP) Revision 1**	• Aims to **increase generating capacity** from 46,090 megawatts to 77,211 megawatts by 2037 • This will be accomplished mainly through power plant construction and power purchases from IPPs,
2018	**Alternative Energy Development Plan (AEDP)**	• Increase the **proportion of renewable and alternative energy to 30%** in the year 2037 • Solar is expected to deliver ~9,290 MW, with ~1,933 MW developed through community-based power plants (from biomass, biogas, wastewater, and solar hybrid systems)
2018	**Gas Plan**	• Promotes the **use of natural gas** as an alternative to coal and other relatively more polluting fossil fuels • Aims to further the development of domestic natural gas production and infrastructure **(e.g., LNG)**
2018	**Oil Plan**	• Promote the use of biofuel, restructure fuel prices, and support measures to achieve fuel savings across all sectors
2018	**Energy Efficiency Plan (EEP)**	• Sets a target for **energy intensity (EI) reduction of 30%** by 2037 (against 2010 baseline) • Research and utilization of disruptive technology to enhance energy conservation (e.g., smart grids)

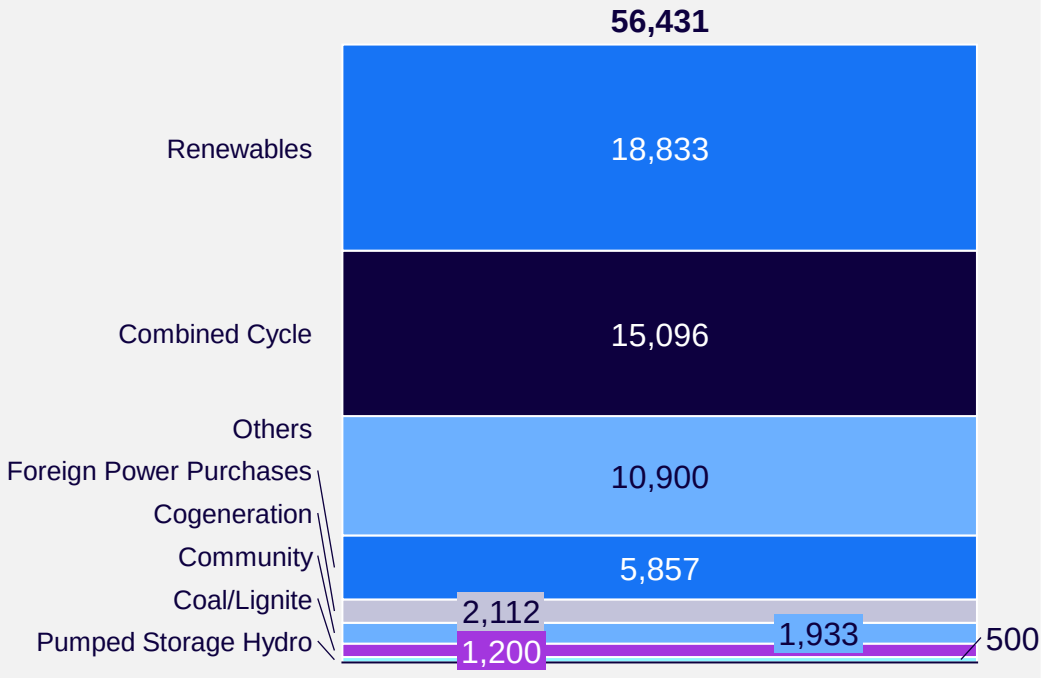
Source: International Trade Administration 2022, Various government sources 2021

電力開発計画では、2037年までに発電能力を77,211メガワットまで増加させることを目指している

Electricity generating capacity targets
Between 2017-2037, MW



Breakdown of new capacity installations
Between 2017-2037, MW



New capacity installations in Thailand between 2018 and 2037 are targeted to be more renewables-focused, while still maintaining reliance on fossil fuels

Source: Power Development Plan 2018 (Revision 1), Arthur D. Little analysis

送電インフラを強化することにより、エネルギー安全保障を強化

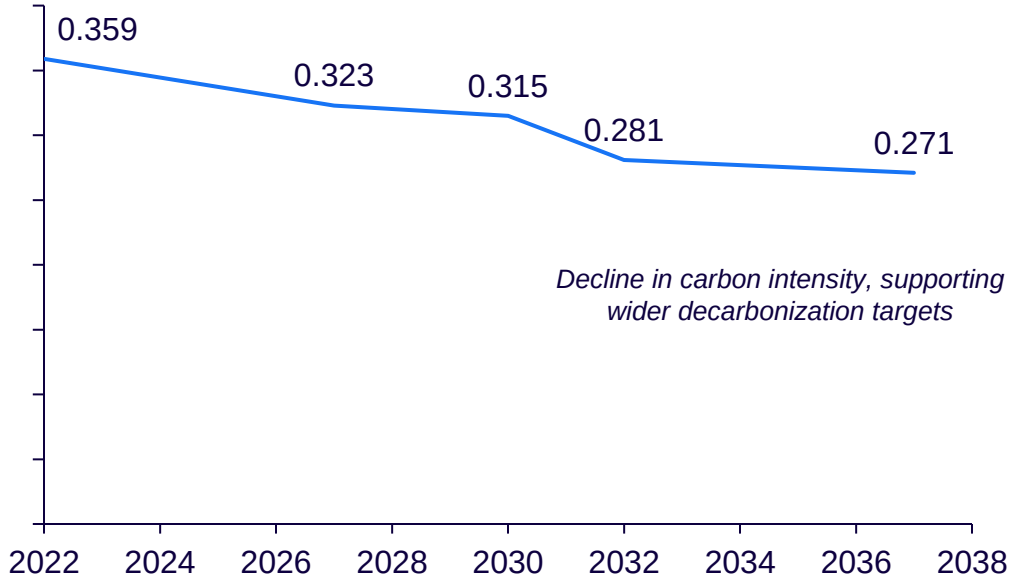
Planned enhancements to transmission infrastructure

NON-EXHAUSTIVE

Region	Details	Purpose
Eastern	• Station construction and additional 500 kV and 230 kV transmission lines	Enhance energy security and support economic growth
Western and Southern	• Constructing a 500 kV transmission line and improving the 230 kV transmission system • Covering long-term power supply to the south, up to Phuket	
Central	• Additional construction of 500 kV and 230 kV transmission systems • Supporting the ASEAN Power Grid system	

Targeted carbon intensity of power generation

kgCO2/kWh*



The objectives of Thailand's Power Development Plan 2018 includes enhancing energy security, while supporting economic growth and wider decarbonization targets

Note: * Per kilo of CO2 released per kilowatt per hour
Source: Power Development Plan 2018 (Revision 1), Arthur D. Little analysis

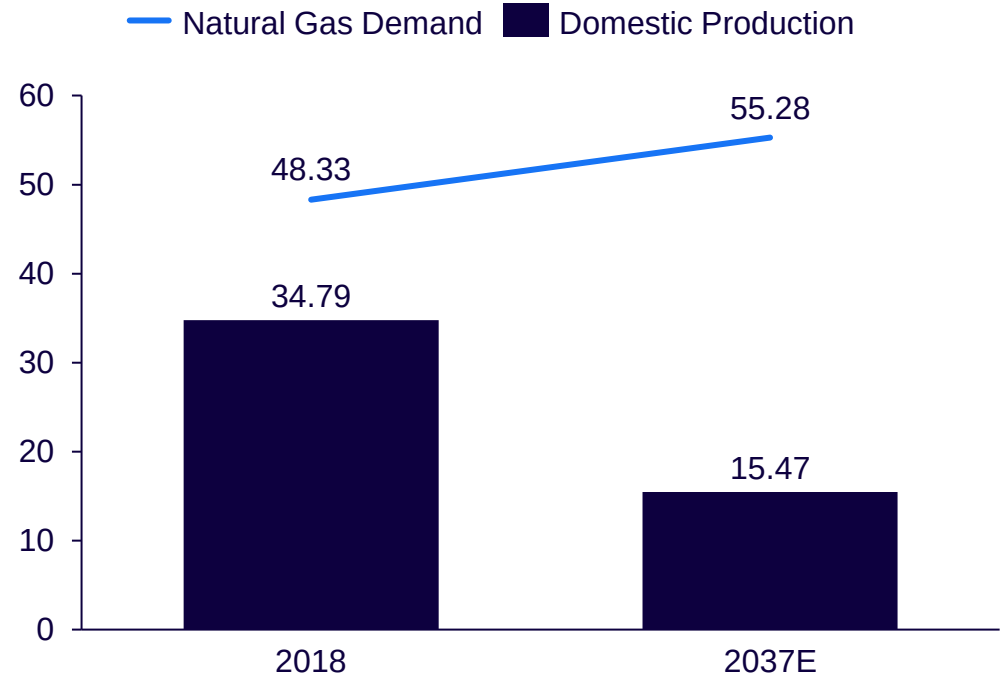
ガス計画の目標は、タイの天然ガス産業を発展させるとともに、将来的に予想される国内生産の減少に備え、天然ガスの供給源を多様化すること

Gas Plan 2018

#	Details of objective
1	Promoting the use of natural gas in various economic sectors to reduce air pollution problems
2	Accelerating the exploration and production of natural gas from domestic petroleum fields
3	Develop natural gas infrastructure to be suitable and sufficient to meet the demand
4	Promote competition in the natural gas business for Thailand's energy security, prosperity and sustainability

Forecasted natural gas demand and production

bcm/year*



While Thailand's Gas Plan seeks to promote the use of natural gas, its domestic reserves are projected to be depleted by 2037, making the country increasingly dependent on pipeline imports/LNG

Note: * Billion cubic metres per year
Source: Thailand Gas Plan 2018, Arthur D. Little analysis

タイの原油への依存度を下げ、代替燃料としてバイオ燃料の利用を促進する計画もOil Planでは公表

NON-EXHAUSTIVE

Oil Plan 2015

Theme	Details of objective
Reduction targets	• Reduce the use of gasoline across all sectors from 13,012 ktoe BAU in 2036 to 4,600 ktoe[1] • Reduce the use of diesel across all sectors from 32,389 ktoe BAU in 2036 to 18,147 ktoe[1]
Fuel conservation	• Support measures to save fuel in the transportation sector • Promote high energy-efficiency vehicles • Infrastructure development in electric rail transit • Infrastructure development in the electric vehicle space (e.g., charging stations)
Fuel substitution	• Encourage the use of ethanol as potential fuel substitutes for cars • Adjust the type of fuel in gasoline-gasohol in accordance with the technology advancements in automobiles
Fuel price adjustments	• Adjust the rate of excise tax on gasoline and diesel fuel to reflect the cost of pollution and road damage
Fuel reserves	• Seek to establish strategic oil reserves, to enhance energy security during times of emergency

Thailand's Oil Plan seeks to decouple its reliance on oil, heavily supported by the strategic objectives of the PDP, AEDP, EEP, and Gas Plan

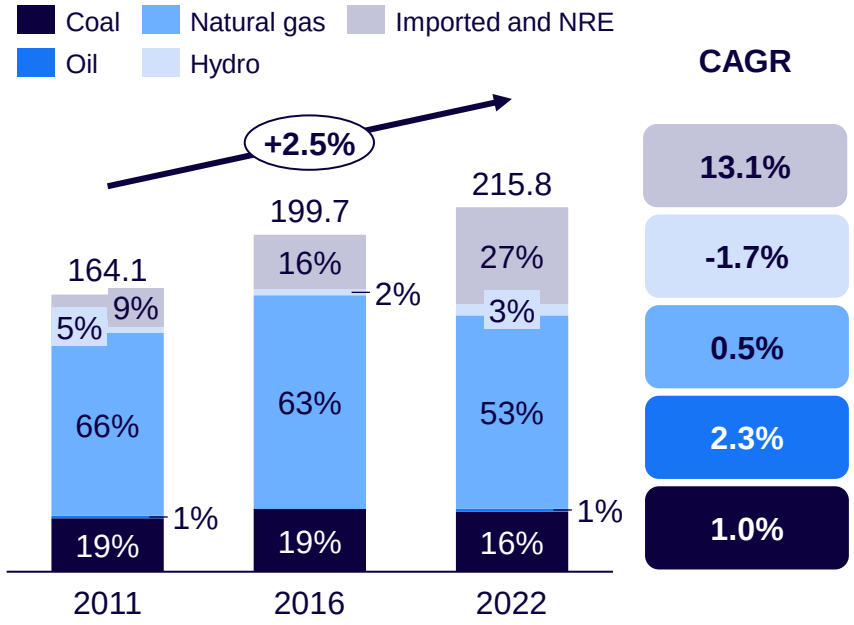
Note: Relates to the initiatives of Thailand's Energy Efficiency Plan
Source: Thailand Oil Plan 2015

天然ガスは115 TWhで発電エネルギー源の約50%を占めており、2037年までこのシェアを維持

Electricity generation mix

2021, TWh[1]

215.8 TWh of electricity was generated in 2021, a 2.5% YOY growth from 164.1 TWh in 2011. Natural gas has retained >50% market share, growing steadily at 0.5% YOY to reach 114.6 TWh in 2022. Net zero policy shift resulted in NRE[2] imported electricity, to grow at an exponential rate of 13.1%.



Electricity mix forecast

2023 – 2030, %

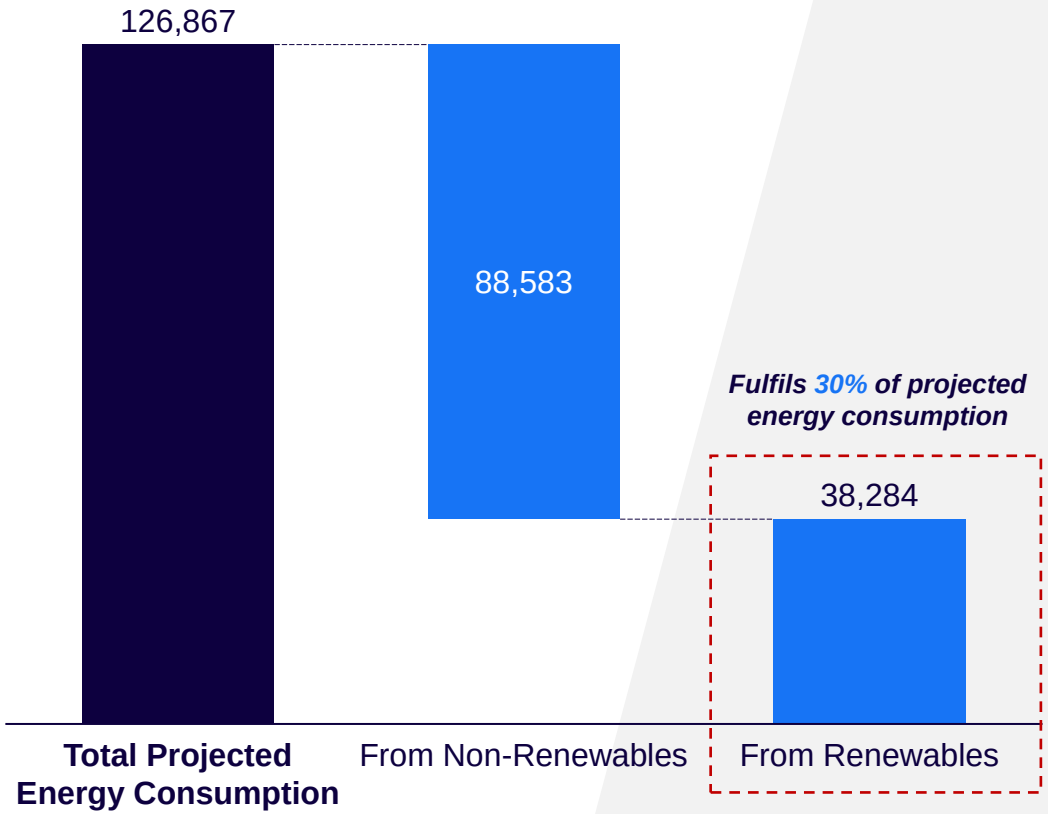
#	Fuel Type	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
1	Hydro	12.8	12.3	11.1	12.1	11.7	12.3	11.8	11.3	11.0	11.8	12.6	12.3	11.6	11.0	10.7
2	Natural gas & LNG	55.4	56.4	60.9	60.7	61.9	61.9	62.5	62.5	61.7	63.7	58.0	55.0	53.7	52.6	53.4
3	Fuel oil	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Stove oil	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Diesel	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	Coal	18.5	17.8	14.8	14.4	14.0	13.6	13.2	12.8	12.5	8.8	10.9	13.0	12.7	12.4	11.4
	Lignite	10.9	10.6	8.1	8.0	7.8	7.6	7.3	7.1	6.9	6.8	6.6	6.4	6.2	6.1	5.9
	Imported	7.6	7.2	6.6	6.4	6.2	6.1	5.9	5.7	5.5	2.0	4.4	6.6	6.5	6.3	5.5
5	NRE[2]	13.2	13.4	13.1	12.7	12.3	12.2	12.4	13.3	14.7	15.0	17.6	17.5	18.4	19.2	18.9
6	Imported electricity[3]	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	Energy efficiency[4]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.9	2.1	3.6	4.7	5.6

Note: 1) Terawatt per hour; 2) New and renewable energy; 3) Via transmission line link from Malaysia; 4) Electricity savings as a result of energy efficient technologies
Source: Power Development Plan 2018 (Revision 1), Arthur D. Little analysis

代替エネルギー開発計画2018は、2037年までに再生可能エネルギーと代替エネルギーの割合を総消費量の30%まで引き上げる

Projected energy consumption and production

2037, ktoe[2]



NON-EXHAUSTIVE

Driven through:

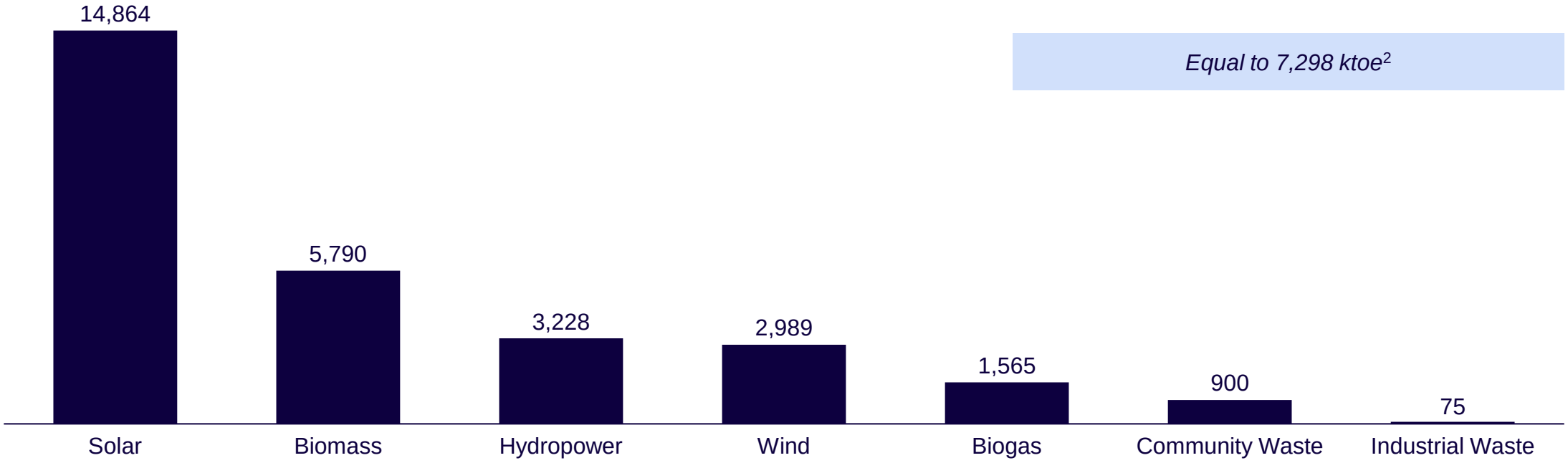
- Setting up a policy for purchasing renewable and alternative energy, at fair prices for producers, buyers, and consumers
- Facilitating easier licensing processes to attract investment
- Use of attractive pricing mechanisms (e.g., FiT schemes)
- Enhancing the availability and yield of required feedstocks to enhance production capacity
- Deployment of applicable technological innovations

Note: 1) The Alternative Energy Development Plan 2018 was approved by the Thai Government in 2020; 2) Kilo tons of oil equivalent
Source: Alternative Energy Development Plan 2018, Arthur D. Little analysis

太陽光発電を増加させることがメインドライバーになる見込み

Targeted electricity production sources in Thailand

2037, MW

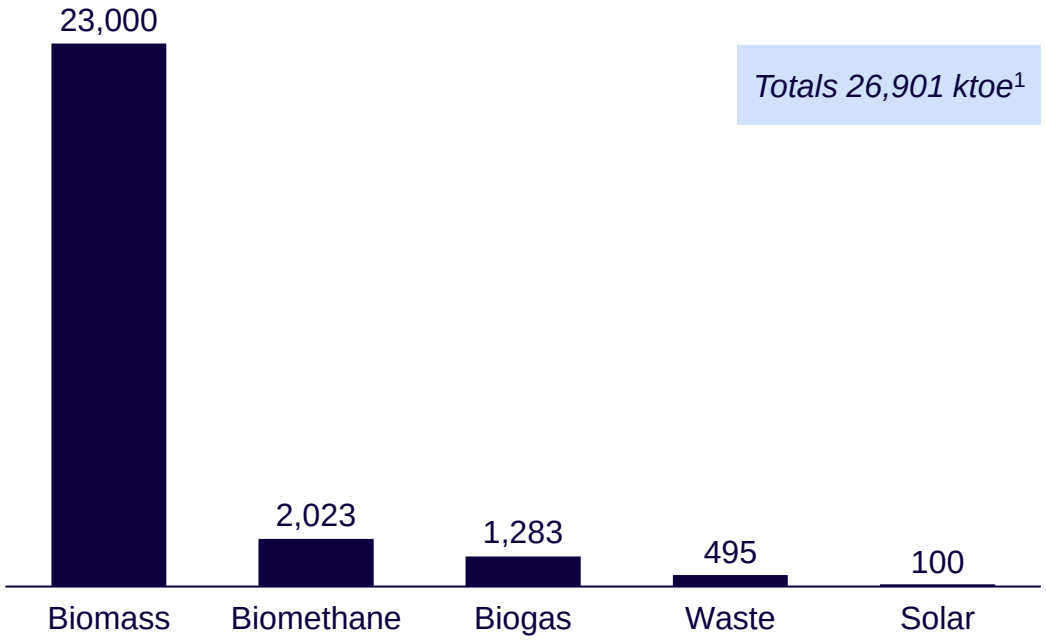


Solar, biomass, and hydropower are seemingly the main drivers of Thailand's push towards the use of renewables to generate electricity

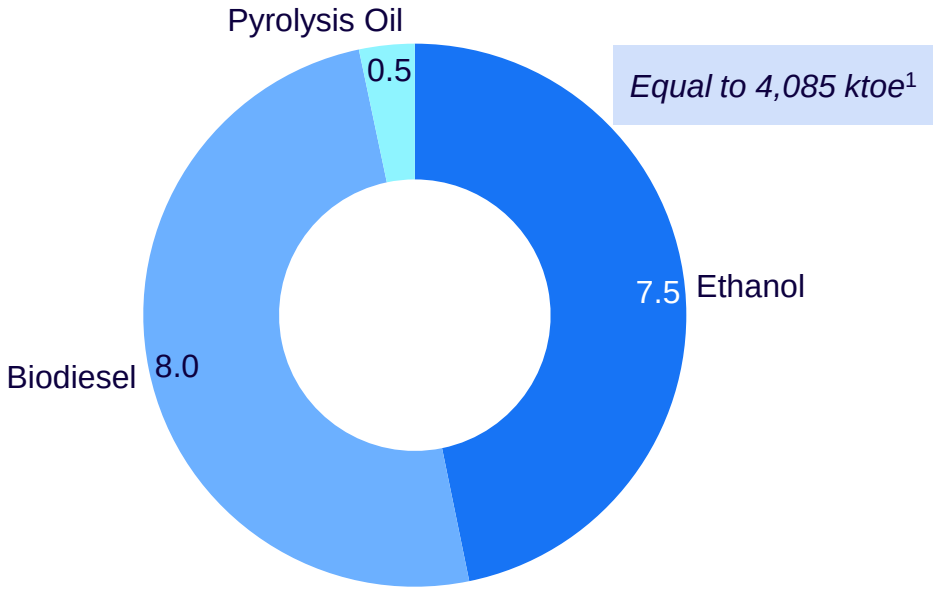
Note: 1) Megawatts; 2) Kilo tons of oil equivalent
Source: Alternative Energy Development Plan 2018, Arthur D. Little analysis

熱利用のソースとしては、バイオマスを重要視している

Heat production sources
2037, ktoe[1]



Biofuel production sources
2037, mn liters/day[2]



Heat production is expected to be the largest use-case of renewable and alternative energy in Thailand, based on projected output in thousand tons of oil equivalent

Note: 1) Kilo tons of oil equivalent; 2) Million litres per day
Source: Thailand Alternative Energy Development Plan 2018, Arthur D. Little analysis

タイの再エネ法案の中心は、AEDP

Renewable energy regulations
1992 – 2018*

#	Policy	Year	Status	Jurisdiction
1	Thailand Alternative Energy Development Plan (AEDP 2018-2037)	2018	In force	National
2	Feed-in Tariff for Very Small Power Producers (VSPP) (excluding solar PV)	2014	In force	National
3	Feed-in tariff for distributed solar systems	2013	In force	National
4	Biodiesel blending mandate	2012	In force	National
5	Renewable energy Development Plan (REDP) 2008-2022	2009	In force	National
6	Solar hot water hybrid system promotion project	2008	In force	National
7	Small and Very Small Power Purchase Agreements	1994	In force	National
8	Energy Conservation Programme (ENCON)	1992	In force	National
9	Feed-in premium for renewable power	2007	Ended	National
10	Strategic Plan for Renewable Energy Development: 8% Target	2004	Ended	National

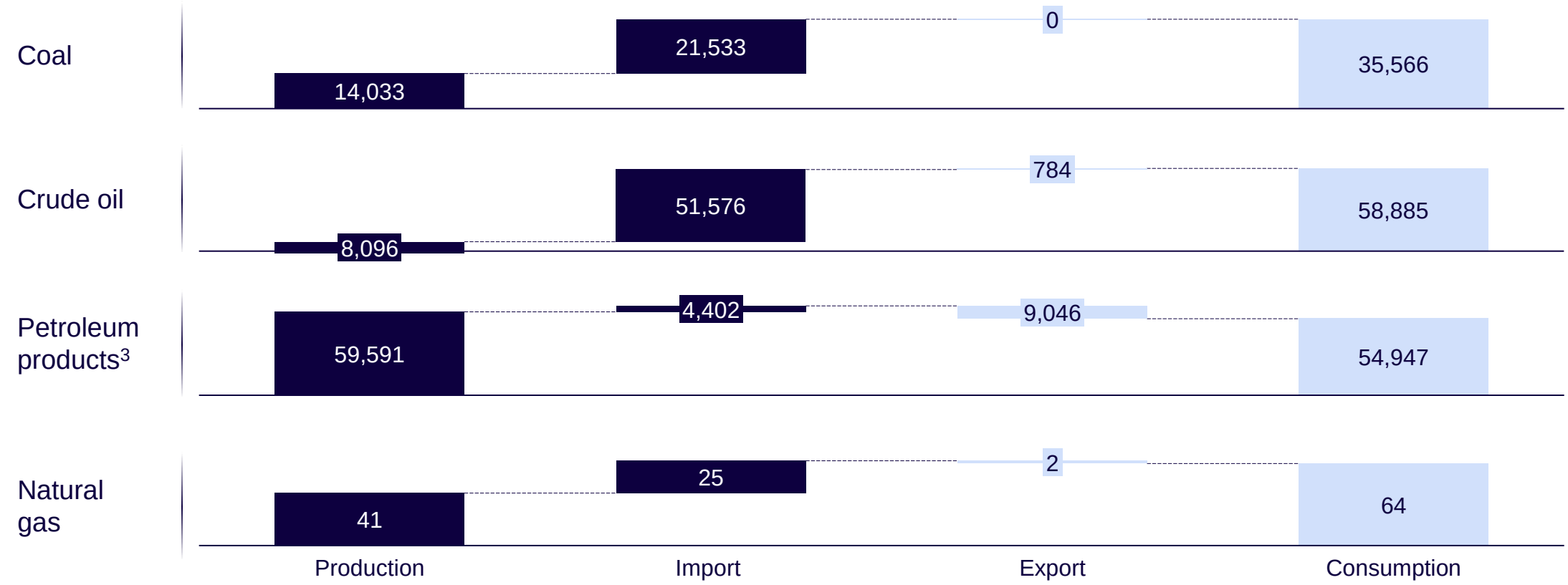
Note: * Excluding amendments
Source: International Energy Agency 2023

2 化石エネルギー

石炭、石油に加え近年では天然ガスまで、多くの資源を輸入している現状

Rate of domestic production and import/export of fossil fuel energy[1]

2022, Mt[2]

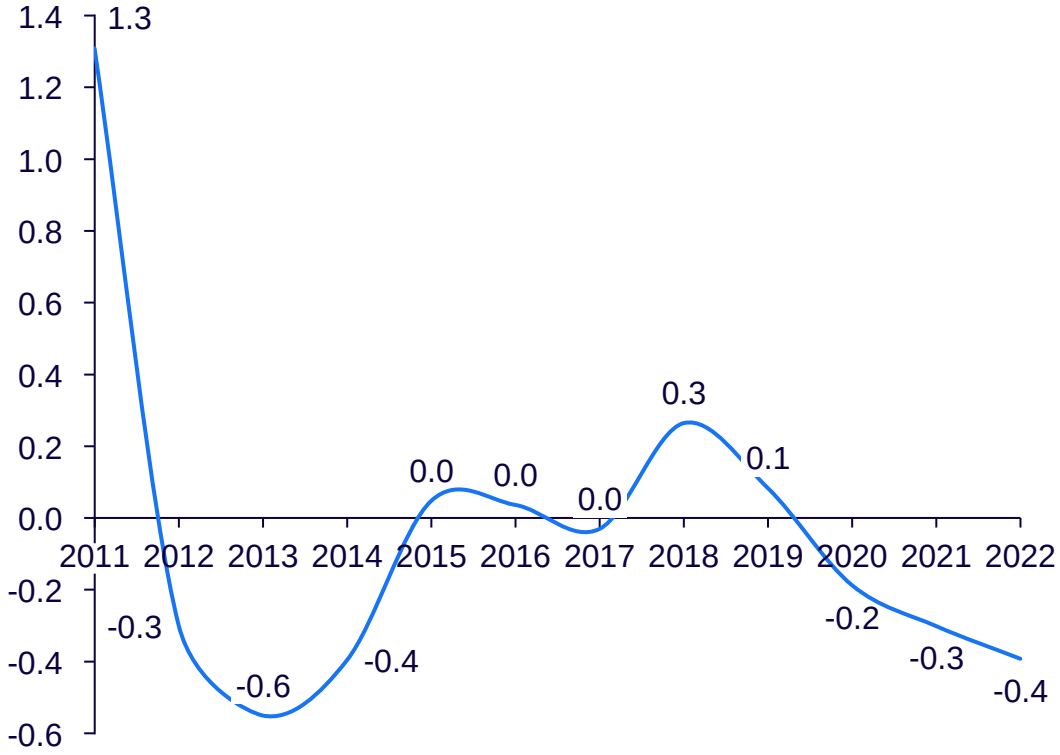


Note: 1) Slight discrepancies in volume may result from conversion of different units and there is an assumption that all fuel produced and imported is either consumed or exported, leaving no room for stock changes; 2) Million tons; 3) Comprised of gasoline, kerosene, diesel, JP, fuel oil, LPG
Source: Energy Policy and Planning Office 2023, Arthur D. Little analysis

タイは、石炭は輸入で賄っている

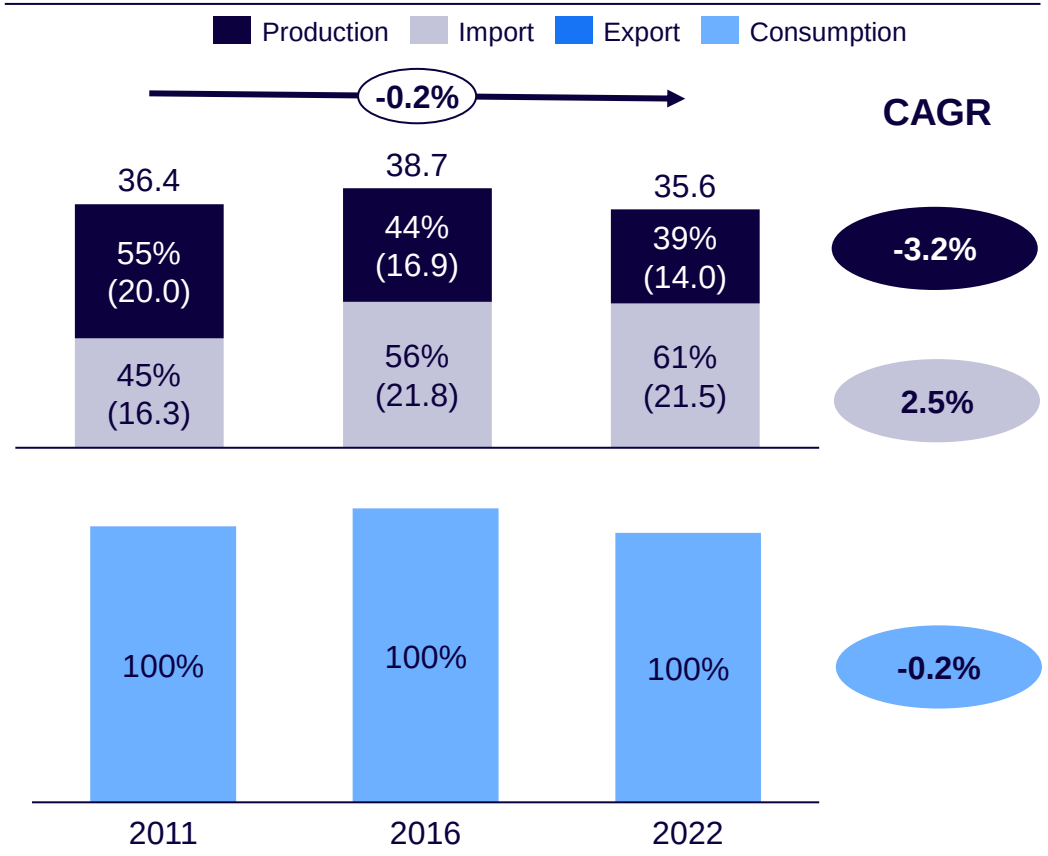
Lignite coal net export trend

2011 – 2021, Mt[2]



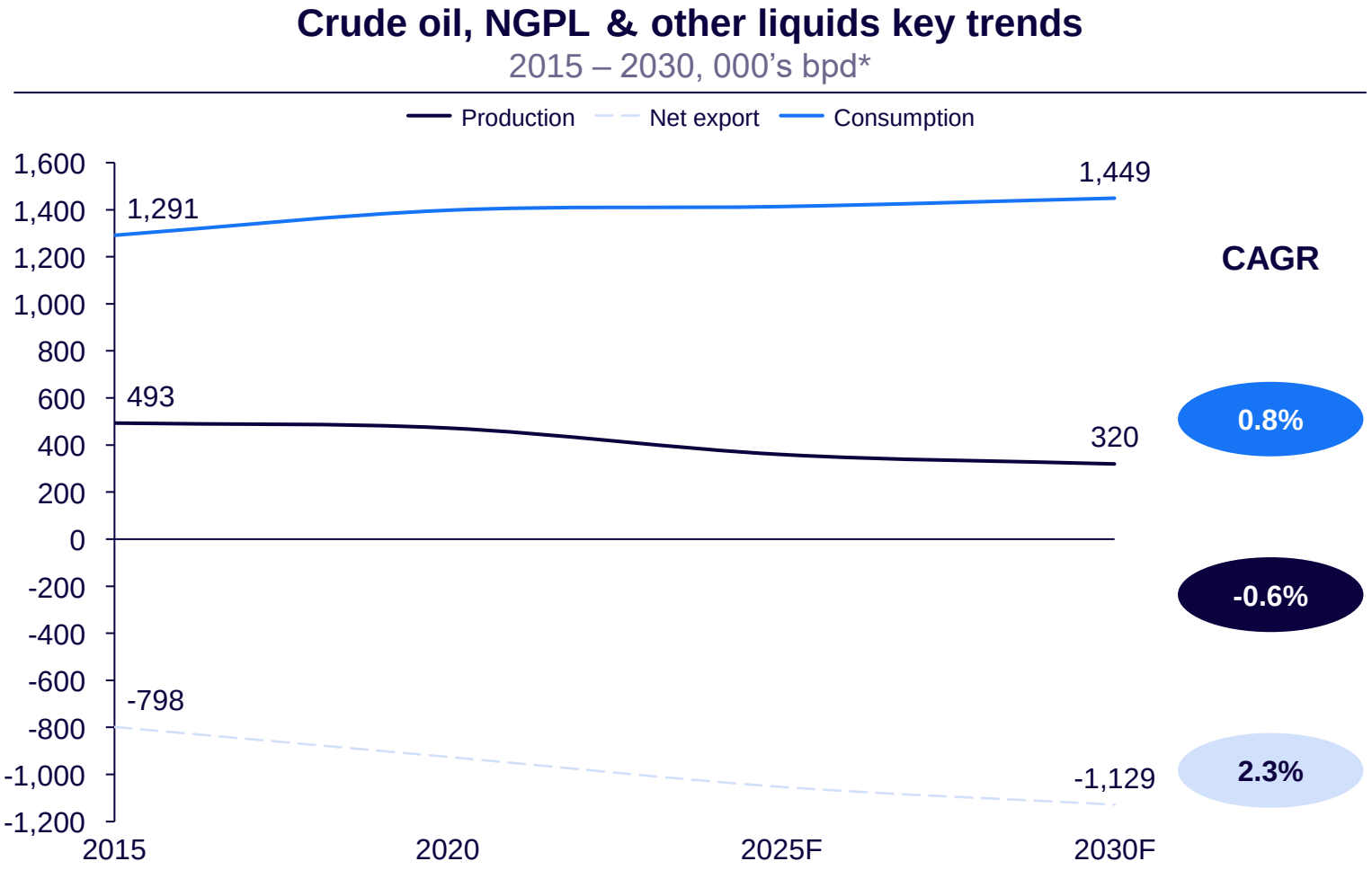
Coal key trends[1]

2011 – 2022, Mt[2]



Note: 1) For the period 2011 – 2022 coal exports are minimal and inclusive of lignite exports; 2) Million tons
Source: Energy Policy and Planning Office 2023, Arthur D. Little analysis

石油備蓄の枯渇と消費の増加が相まって、輸入が増加すると想定されている

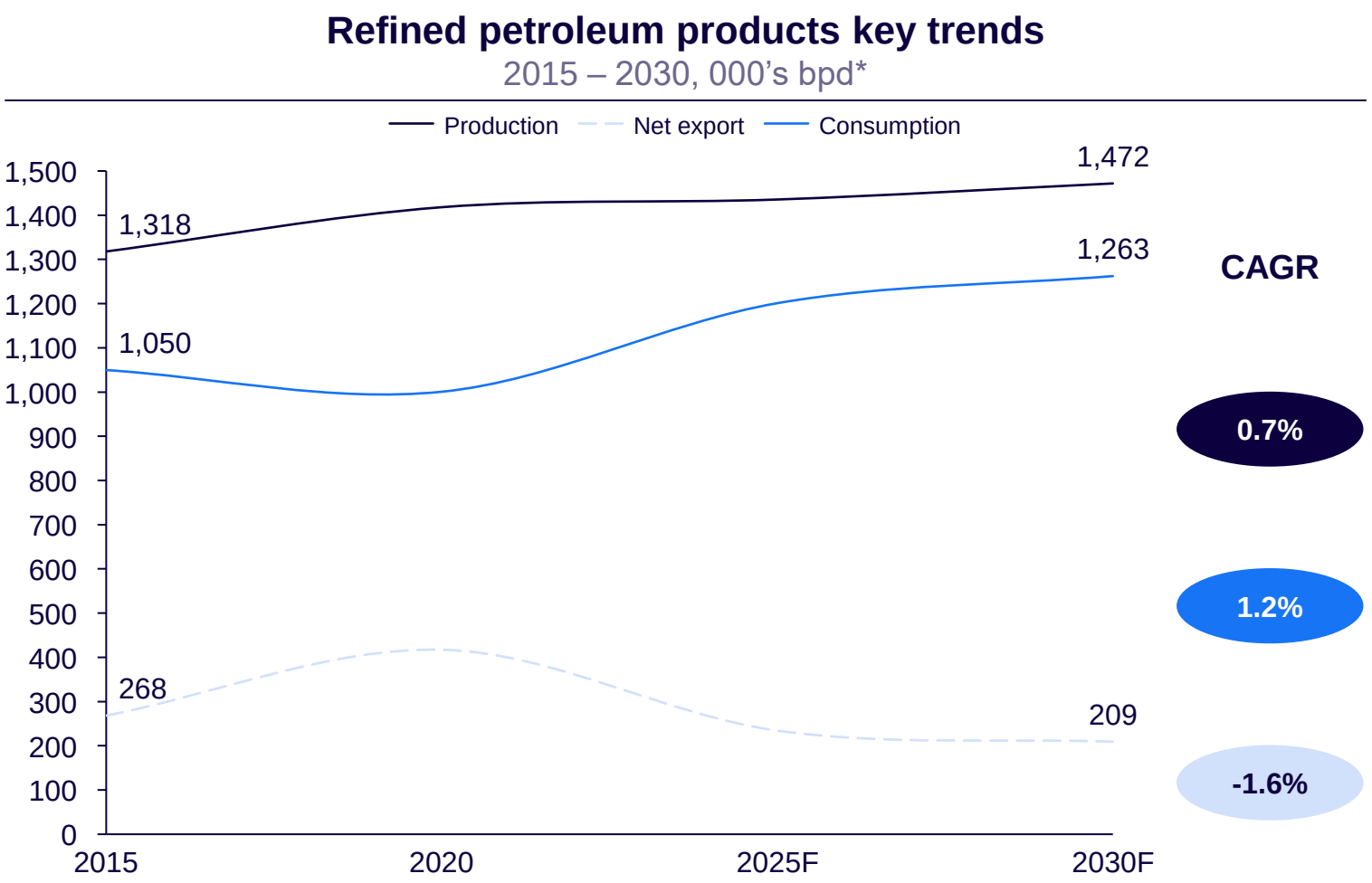


COMMENTS

- Thailand's production has been falling on the back of depleting oil reserves in fields like Erawan and Bongkot with a YOY rate of -0.6%
  - PTTEP bought over the fields from TotalEnergies and Chevron in 2022 and is planning on boosting production via drilling of more sites
- The government hopes to decrease production woes via expectation of hitting new reserves from the auction of blocks G3/65 and G2/65 to PTTEP and Chevron respectively
- The industry is currently held up my PTTEP's investment efforts as a lack of discoveries of new oil fields has led to foreign investment showing disinterest

Note: The negative net export refers to import greater than export; * Barrels per day
Source: Fitch Solutions 2023, International Energy Agency 2023, Lexology 2023, Arthur D. Little analysis

製油所の生産量が増加したことで、消費量の増加傾向に対応できるようになり、輸入への依存度が低下

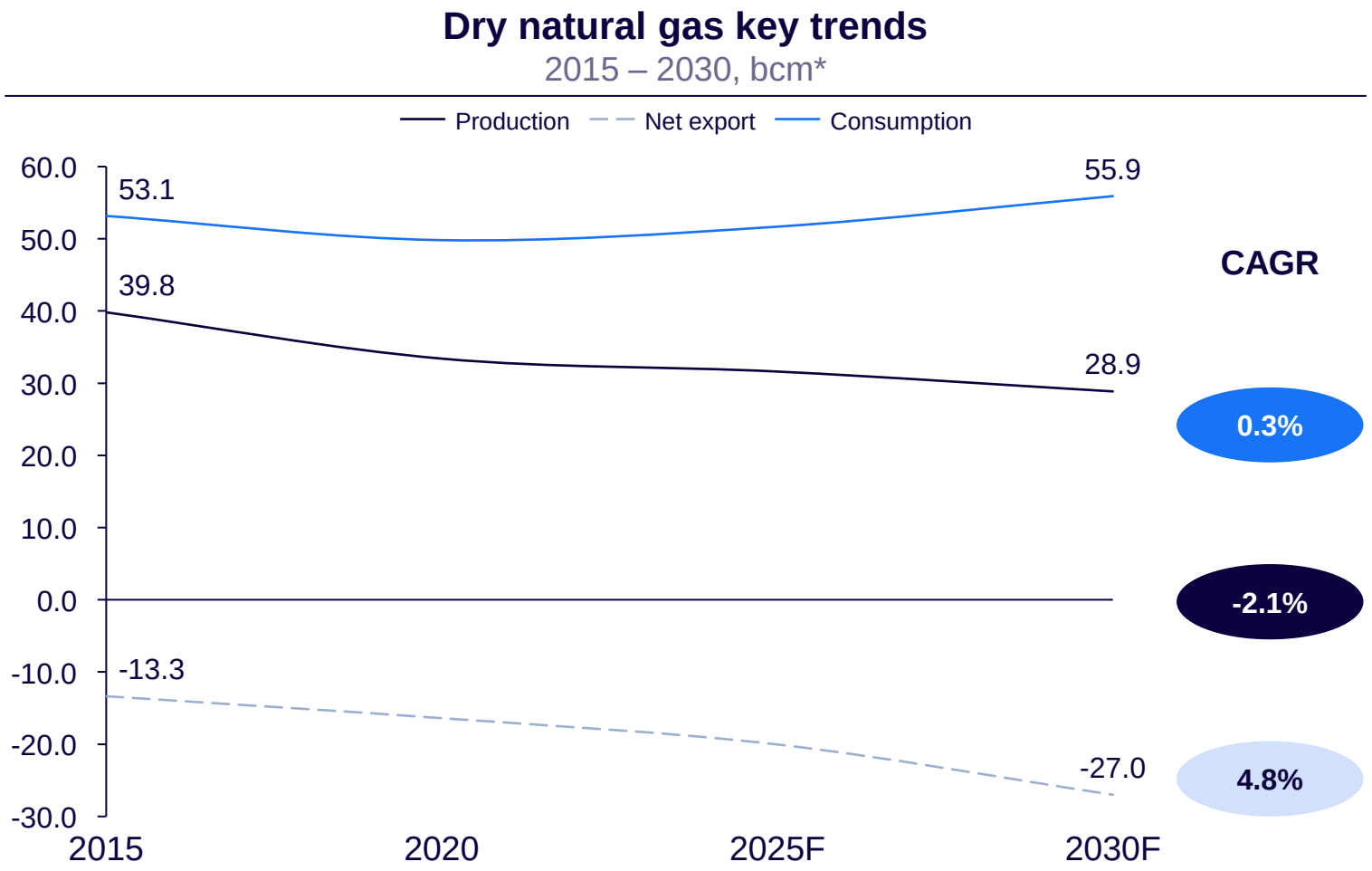


COMMENTS

- Thailand has one of the best refining capabilities in SEA resulting in growth expectations of 0.7%
  - The 8 refineries are largely owned by Thai Oil, IRPC and PTTGC (all are national oil companies)
  - Thai Oil's Clean Fuel project (USD 0.5 bn) is expected to begin operations in mid-2023, and further increase production capabilities from 0.28mn bpd to 0.45 mn bpd
- Consumption growth of 1.2% is largely driven by the transport sector of which diesel makes up ~40%, and is seen to be a key driver
  - For non-transport growth, LPG sees strong demand as feedstock for the petrochemical industry
- In lieu of this, a slight decrease of 1.6% is exported for net exports

Note: The negative net export refers to import greater than export; * Barrels per day
Source: Fitch Solutions 2023, Multiple news sources, Arthur D. Little analysis

天然ガスの埋蔵量が低下しているあおりを受け輸入が年々増加している

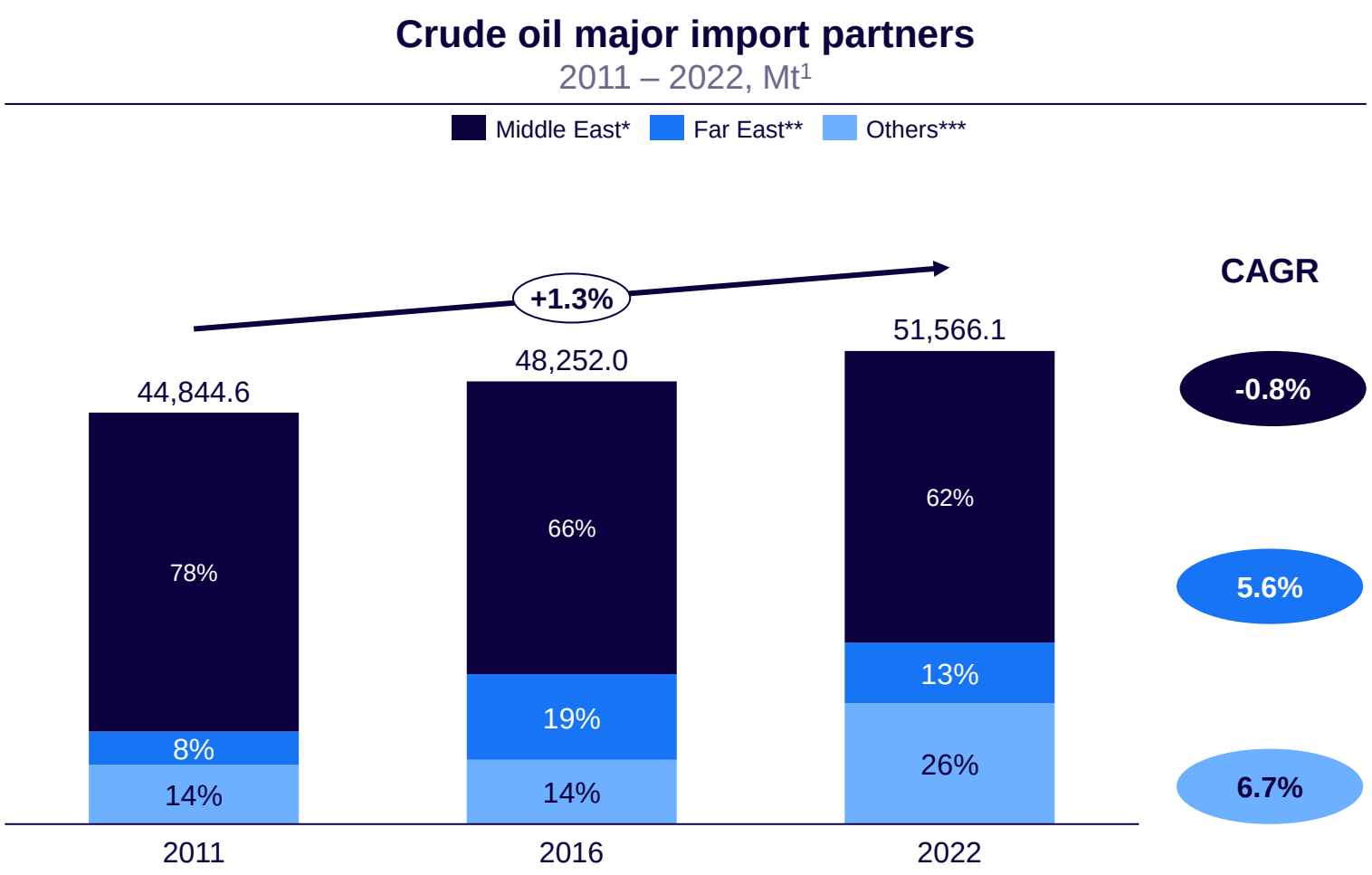


COMMENTS

- Dwindling reserves have led to production dropping to 2.1%, with slight stalling in 2022-2025 due to the possibility of PTTEP taking over the Erawan field and Bongkok fields
- Despite the presence of large foreign companies owning huge in the industry, there is a sustain unwillingness to commit to the capital extensive process of drilling for more wells, with largely state owned PTTEP being the biggest player
- Despite consumption picking up in 2021, government strategies to shift away from gas are estimated to result in a slight increase of 0.3% YOY for the period 2015 - 2030, with imports stepping in to make up for the supply gap
  - Consumption is mainly driven by the power sector at ~58% usage as of Q1 2023

Note: The positive net export refers to export greater than import; * billion cubic metres
Source: Fitch Solutions 2023, Arthur D. Little analysis

石油は中東からの輸入に依存



COMMENTS

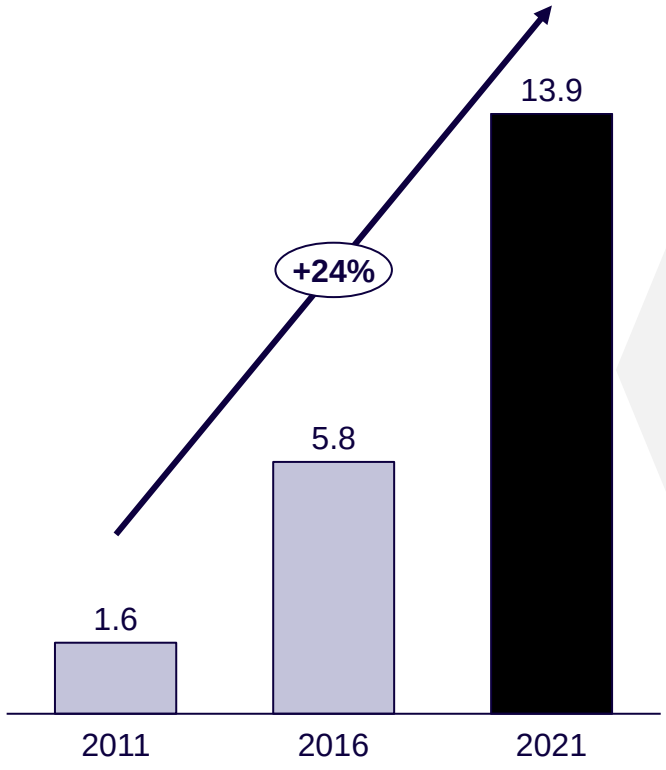
- Thailand is a net importer of crude oil, with overall imports growing at a CAGR of 1.3% for the period 2011 -2022
- Currently Middle East is the dominating partner, holding >60% market share with UAE and Saudi Arabia accounting for more than 53% of total imports in 2022
  - The drop in YOY on -0.8% can be attributed to USA gaining prevalence as a supplier in third place, with ~7.7% in 2021
- Most of the imports are driven by deficits in domestic crude oil supply, combined with increase in refinery capabilities
- Far East and Others are largely suppliers of crude oil condensates which Thailand despite being a producer requires more to supplement demand, growing at 5.6% and 6.7% for the period 2011 - 2022
  - 66% of total condensate imports are from Australia. Nigeria, Indonesia Philippines, Indonesia and Malaysia

Note: * Inclusive of UAE, Saudi Arabia and Qatar; ** Inclusive of Indonesia, Malaysia and Vietnam; *** Inclusive of USA, Angola, Australia, Russia, Libya, Nigeria, Algeria, etc; 1) Million tons
Source: MEMR Statistical Handbook 2022, Arthur D. Little analysis

天然ガスの輸入が増加しており、カタール、マレーシア等から主に輸入

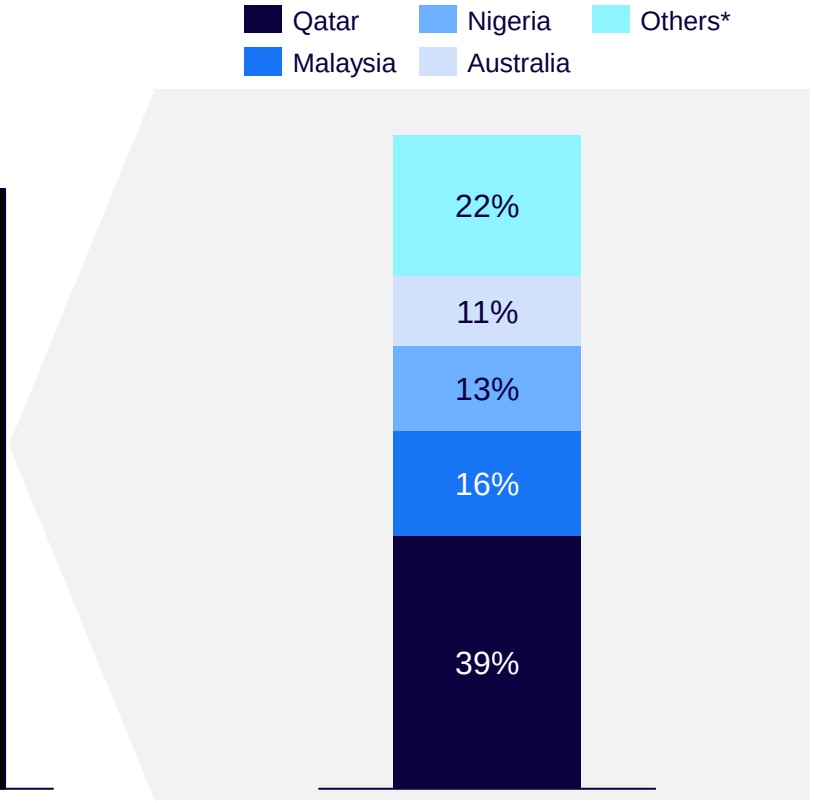
Natural gas imports

2011 - 2021, Mt[2]



Major import partners

2021, Mt[2]



COMMENTS

- The growing domestic demand in Thailand, coupled with the transition from Myanmar gas imports to LNG imports, has resulted in an increased reliance on LNG imports to meet local consumption needs. Between 2011 - 2021, imports have experienced a significant YOY growth rate of 23.8%
  - Softening of LNG spot prices and government investment in import terminals like the 7.5mtpa Map Ta Phut Terminal 2 (LMPT 2) have contributed and will continue to contribute to the rise in imports
- Thailand is emerging as South East Asia's biggest importer of LNG and aims to leverage its substantial investment in regasification infrastructure, which allows third-party access, to establish itself as a regional LNG trading hub. As of Q1Y23,Thailand has a total LNG import capacity of 19 mtpa
- Qatar has the largest share at 5.36 Mt (39%) with a 20-year supply agreement in place from 2015-2035 through QatarEnergy
  - In 2022, Malaysia and Australia increased their LNG exports to Thailand, further influencing the country's import dynamics

Note: * Others inclusive of USA, Oman, Angola, Brunei, Trinidad & Tobago, other Europe and other Africa; 1) Trade movements as LNG; 2) Million tons
Source: BP Statistical Review of World Energy 2022

石油と、ガスの埋蔵量は以下で推移

Proven oil and gas reserves (Thailand 2021 - 2026)						
Indicator	**2021**	**2022e**	**2023f**	**2024f**	**2025f**	**2026f**
Proven oil reserves. bn bbl	0.3	0.3	0.3	0.3	0.3	0.3
Proven oil reserves. mn bbl	300.0	307.7	300.1	293.7	277.9	262.6
Proven oil reserves. % y-o-y	0.0	2.6	-2.5	-2.1	-.5.4	-5.5
Reserves to production ratio (RPR), years	1.9	2.3	2.2	2.2	2.1	2.0
Natural gas proven reserves, tcm	0.1	0.1	0.1	0.1	0.1	0.1
Natural gas proven reserves, bcm	138.0	136.9	136.5	135.7	134.7	133.3
Natural gas proven reserves, % y-o-y	-19.8	-0.8	-0.3	-0.5	-0.8	-1.0
Natural gas reserves-to-production ratio, years	4.2	4.4	4.5	4.4	4.3	4.3

Proven oil and gas reserves (Thailand 2027 - 2032)						
Indicator	**2027f**	**2028f**	**2029f**	**2030f**	**2031f**	**2032f**
Proven oil reserves, bn bbl	0.2	0.2	0.2	0.2	0.2	0.2
Proven oil reserves, mn bbl	247.9	233.7	230.0	216.9	214.3	222.3
Proven Oil reserves, % y-o-y	-5.6	-5.7	-1.6	-5.7	-1.2	3.7
Reserves to production ratio (RPR), years	2.0	1.9	1.9	1.9	1.9	2.0
Natural gas proven reserves, tcm	0.1	0.1	0.1	0.1	0.1	0.1
Natural gas proven reserves, bcm	132.6	132.3	132.6	133.7	135.4	137.4
Natural gas proven reserves. % y-o-y	-0.6	-0.2	0.2	0.8	1.2	1.5
Natural gas reserves-to-production ratio, years	4.3	4.4	4.5	4.6	4.8	4.9

Note: e = estimated and f= forecasted
Source: Fitch Solutions Oil & Gas Report 2023

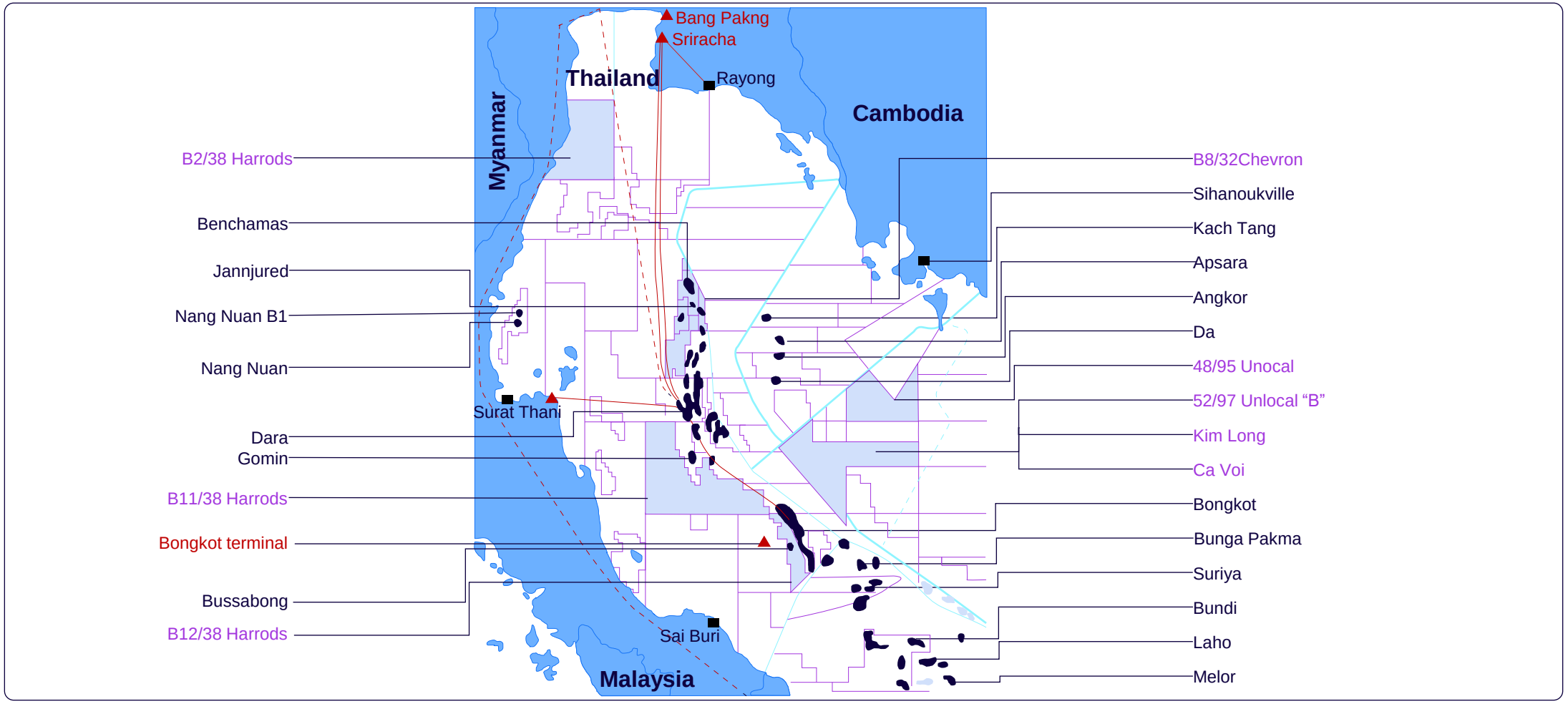
北部のMae Moh石炭は褐炭生産の大半を占め、EGATがオーナー兼オペレーターを実施

Description

- Thailand has only **1 mine** as of 2020, which accounts for all its domestic lignite production of 14.2 Mt in 2021, up 7.3% from 2020 production value of 13.3 Mt
- Despite plans to decommission the mine in 2019, state-run Electricity Generating Authority of Thailand (EGAT) which is the owner and operator have yet to do so
- **Key stats:**
  - **Location:** Lampang, Thailand
  - **Status:** Operating
  - **Max production:** 16 Mt/year
  - **2021 Production:** 14.2 Mt
  - **Mineable reserves:** 1,140 Mt
  - **Size:** 135 km^2
  - **# Workers:** 1,464

Source: Energy Policy and Planning Office 2023, Multiple news sources, Arthur D. Little analysis

石油とガスの埋蔵量は、大部分がタイ湾に所在



Note: Map is illustrative and not drawn to scale and is non-exhaustive in nature
Source: Oil and Gas Online 2006 , Arthur D. Little analysis

List of main oil & gas projects in the pipeline – (1/3)

Name	Field name	Companies	Status	Est. peak oil/ liquid range, bpd[1]	Est. peak gas output, bcm[2]	Fuel source
Block 12/27, Pailin Basin	Contract 4 (Ubon)	Chevron (35%). PTT Exploration and Production - PTTEP (60%) Mitsui (5%)	Appraisal	30,000	1.2	Gas & Condensate
Block Banya	Block Banya	China National Petroleum Corporation (100%)	Appraisal	-	-	Oil & Gas
Block BYW-NS	Block BYW-NS	China National Petroleum Corporation (100%)	Appraisal	-	-	Oil & Gas
Concession G6/48, Karawake Basin	Rossukon	Northern Gulf Petroleum (40%), Valeura Energy (30%), Mubadala Petroleum (30%)	Appraisal	-	-	Oil
Concession L53	Concession L53	Pan Orient Energy (50%)	Appraisal	-	-	Oil & Gas
Block B15, B16, B17 and G12/48	Greater Bongkot North	PTT Exploration and Production - PTTEP (66.67%), Total (33.33%)	Expansion	18,000	6	Gas & Condensate
Block G10/48, Pattani Basin	Block G10/48	Palang Sophon Ltd (11%), KrisEnergy (89%)	Exploration	-	-	Oil & Gas
Block L21/43	Block L21/43	China National Petroleum Corporation (100%)	Exploration	-	-	Oil & Gas
Block 10. 10A, 11, 11A	Platong II	Chevron (69.9%), Mitsui (27.4%), PTT Exploration and Production Public Company - PTTEP (2.7%)	Production	18,000	3.4	Gas & Condensate
BlockA-18	Cakerawala	Hess Corporation (50%), Petronas (50%)	Production	10,000	7.9	Gas & Condensate
Block B14A B15A, B16A, G8/50, Malay Basin	Arthit	PTT Exploration and Production Public Company - PTTEP (80%), Chevron (16%), Mitsui (4%)	Production	19,800	3.7	Gas & Condensate

Note: 1) Barrels per day; 2) Billion cubic metres
Source: Fitch Solutions Oil & Gas Report 2023

List of main oil & gas projects in the pipeline – (2/3)

Name	Field name	Companies	Status	Est. peak oil/ liquid range, bpd[1]	Est. peak gas output, bcm[2]	Fuel source
Block B15, B16, B17and G12/48	Greater Bongkot South	PTT Exploration and Production Public Company - PTTEP (66.67%) Total (33.33%)	Production	15,000	3.6	Gas & Condensate
Block B-17 & C-19 and B-17-01 (MTJA)	Block B-17 & C-19 and B-17-01	Petronas (50%), PTT Exploration and Production Public Company - PTTEP (50%)	Production	-	-	Oil & Gas
Block B5/27	Jasmine, Ban Yen	Mubadala Petroleum (100%)	Production	28,000	-	Oil
Block B8/32	Benchamas	KrisEnergy (4.63%), Mitsui (16.71%) PTT Exploration Production - PTTEP (25%), Palang Sophon (2%), Chevron (51.66%)	Production	50,000	0.8	Oil & Gas
Block ESN & EU-1	Sinphuhorm	ExxonMobil (10%), PTT Exploration and Production - PTTEP (55%), Apico LLC (35%)	Production	-	1.3	Gas & Condensate
Block G10/48, Pattani Basin	Wassana	Palang Sophon (11%), Valeura Energy (89%)	Production	12,800		Oil
Block G7/50, B12/27	Contract 4	Chevron (35%), PTT Exploration and Production - PTTEP (60%) Mitsui (5%)	Production	20,000	4.2	Gas & Condensate
Concession G11/48	Nong Yao	Mubadala Petroleum (67.5%), Palang Sophon (10%), KrisEnergy (22.5%)	Production	11,400		Oil
Block G1/61 Erawan, Pattani Basin	Erawan	PTTEP	Production	50,500	6.5	Gas & Condensate
Block G1/61	Bangkot	PTTEP	Production	20,780	11	Gas & Condensate
G1/48 Concession, Kra Basin	Manora	Northern Gulf Petroleum (10%), Tap Oil (30%), Mubadala Petroleum (60%)	Production	15,000	-	Oil

Note: 1) Barrels per day; 2) Billion cubic metres
Source: Fitch Solutions Oil & Gas Report 2023

List of main oil & gas projects in the pipeline – (3/3)

Name	Field name	Companies	Status	Est. peak oil/ liquid range, bpd[1]	Est. peak gas output, bcm[2]	Fuel source
L33/43, L44/43 and SW1, Phetchabun Basin	L33/43, L44/43 and SW1	Loyz Energy (20%), ECO Orient (60%), Berlanga Holding (20%)	Production	6,000	-	Oil
Plamuk	Plamuk	PTT Exploration and Production - PTTEP (5%), Moeco Oil & Gas (23.75%), Chevron (71.25%)	Production	18,000	-	Oil
Block 7	Block 7	Shell (66.67%), Chevron (33.33%)	Suspended	-	-	Oil & Gas
Block 8	Block 8	Shell (66.67%), Chevron (33.33%)	Suspended	-	-	Oil & Gas
Block 9	Block 9	Shell (66.67%), Chevron (33.33%)	Suspended	-	-	Oil & Gas
Licence G4/50	Licence G4/50	Government of Thailand	Suspended	-	-	Oil & Gas
Block B8/38	Bualuang	Ophir Energy (100%)	Upgrade/EOR	17000	-	Oil
Block S1	Sirikit, Sirikit West, Pru Krathiam, Wat Taen, Thap Raet, Pratu Tao, Nong Tum, Sirikit East, Nong Makham	PTT Exploration and production PTTEP (100%)	Upgrade/EOR	27000	-	Oil & Gas
Block G1/65	Block G1/65	PTT Exploration and production PTTEP (100%)	Exploration	-	-	Oil & Gas
Block G3/65	Block G3/65	PTT Exploration and production PTTEP (100%)	Exploration	-	-	Oil & Gas
Block G2/65	Block G2/65	Chevron (100%)	Exploration	-	-	Oil & Gas

Note: 1) Barrels per day; 2) Billion cubic metres
Source: Fitch Solutions Oil & Gas Report 2023

List of oil refineries

Location	Province	Capacity, '000s bpd[1]	Owner
Map Ta Phut	Rayong	280	PTTAR/PTTGC
Map Ta Phut	Rayong	175	Star Petroleum
Mueang Rayong	Rayong	215	IRPC
Phra Khanong	Bangkok	120	Bangchak Petroleum
Sriracha	Chon Buri	177	ESSA
Sriracha	Chon Buri	275	Thai Oil

Note: 1) Barrels per day
Source: Fitch Solutions Oil & Gas Report 2023

List of LNG import terminals

Name	Capacity, mtpa[1]	Capacity, bcm[2]	Status	Owner (s)	Start-up year
Map Ta Phut Phase I	5	6.8	Online	PTT	2012
Map Ta Phut Phase II	6.5	8.8	Online	PTT	2017
Nong Fab LNG	7.5	10.2	Online	PTT	2022
Map Ta Phut Phase III	5	6.8	Under Construction	PTT, Gulf Energy Development	2025
Surat Thani FSRU	5	6.8	Planned	PTT, EGAT	2027-2029

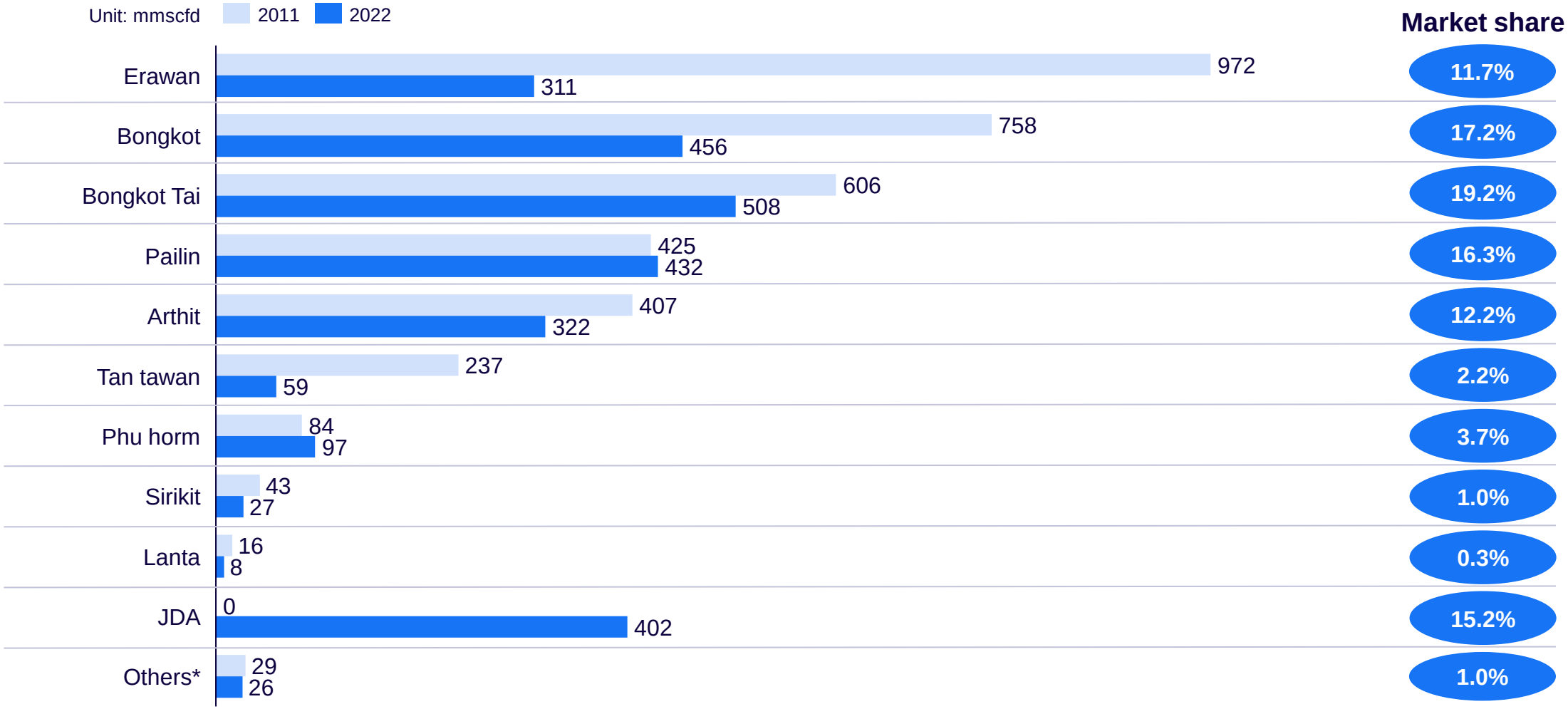
Note: 1) Million tons per year; 2) Billion cubic metres
Source: Fitch Solutions Oil & Gas Report 2023

List of gas separation plants

Location	GSP #	Capacity, mmscfd[1]	Owner
Tambon Map Ta Phut	GSP-1	420	PTT PCL
Amphoe Mueang	GSP-2&3	820	PTT PCL
Amphoe Khanom	GSP-4	230	PTT PCL
Rayong	GSP-5	530	PTT PCL
Rayong	GSP-6	880	PTT PCL
Rayong	GSP-7	460	PTT PCL
Rayong	GSP-8	n.a	PTT PCL

Note: 1) Million standard cubic feet per day
Source: Fitch Solutions Oil & Gas Report 2023

天然ガスの埋蔵量は全般的に枯渇しており、特にエラワンが深刻



Note: *Inclusive of Nam Phong, Jasmin, Yoong Thong, etc
Source: Energy Policy and Planning Office 2023, Arthur D. Little analysis

Natural gas assets owned by PTTEP in Thailand

Natural gas reserves, by region			
Name	**Phase**	**2021**	**Unit**
Main Bongkot	Operating	5,422.00	bcf[1]
South Bongkot	Operating	1,105.00	bcf[1]
Arthit	Operating	1,375.00	bcf[1]
G8/50	Operating	0.76	bcf[1]
G12/48	Operating	18.21	bcf[1]
MTJDA	Operating	170.00	mmscfd[2]

Note: 1) Billion cubic feet; 2) Million standard cubic feet per day
Source: Fitch Solutions Oil & Gas Report 2023

EGATはMae Moh発電計画で既存の設備をアップグレードする政府承認を取得

Mae Moh PP[1] replacement project timeline

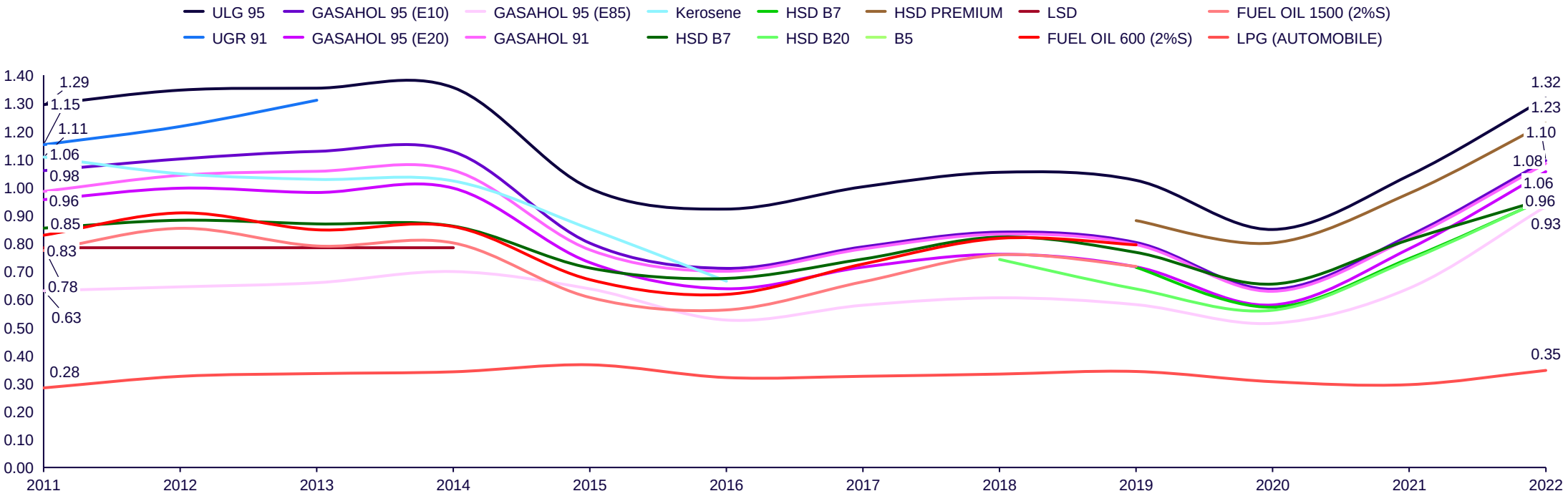
- **Mar 2023:** Thai Cabinet acknowledged the National Environment Board's resolution of the Environmental Impact Assessment Report done in Sep 2021
  - This report highlighted the need for a **600 MW replacement project for the existing units 8-9 in the Mae Moh power plant**
- **May 2022:** The Prime Minister's office confirmed the replacement project, with expectations to start operations in 2026. This is included in the planned additional capacity of 1,200 MW of coal/lignite power plants during 2018 - 2037
- **Dec 2022:** EGAT started a feasibility study to convert Unit 8 to be biomass-fired, whilst consulting Drax Global. Should it pass, it will result in 1.3 Mt of annual biomass purchase from the communities around the power plant
- **May 2023:** Transmission lines were included
- **Jun 2023:** USD 1.4 bn project is under revision, with funds disbursed, whilst the government stays on track with the 2070 zero carbon goal

Note: 1) Power plant
Source: Power Development Plan 2018 (Revision 1), Government press release 2022, Multiple news sources, Arthur D. Little analysis

2014年から2020年にかけては低下したものの、石油製品の小売価格は11年間安定

Retail petroleum products

2011 – 2022, USD/litre



More premium grade products like **ULG 95 and HSD** saw **greater price volatility,** in comparison to the cheaper and more stable **LPG** option for automobiles

Note: Exchange rate is 1 THB = 0.029 USD (2022 2 d.p. average)
Source: Energy Policy and Planning Office 2023, Arthur D. Little analysis

以下がタイのエネルギー関連の関連プレイヤー

Entity	Department	Responsibilities
Ministry of Energy	Department of Mineral Fuels (DMF)	• Encourage exploration, production and integrated management of natural fuel resources using modern and environmentally friendly technologies • Manage petroleum contracts or concessions, exploration, production, storage, transportation, sale and distribution of petroleum, including the demolition of installations used in the petroleum business • Set guidelines for procurement, development and management of petroleum resources • Analyze, research and assess potential and reserves and development of natural fuel sources
	Department of Energy Business (DOEB)	• Set, manage, and develop the standards of fuel quality and supervise the fuel trade and stockpile • Set, manage, and develop the environmental and safety standards of the fuel business • Supervise oil refineries and ensure their operation based on agreed-upon terms and conditions
	Energy Policy and Planning Office (EPPO)	• Recommend energy policies and integrate/review energy management plans of the country, alongside national strategies for energy conservation and alternative energy promotion • Recommend measures to solve and prevent oil shortage in both the short and long term • Supervise, monitor and evaluate the implementation of national energy policies and energy management plans
Electricity Generating Authority of Thailand (EGAT)		• State-owned EGAT acts as both a producer and a purchaser of energy, purchasing power from overseas sources and private-sector IPPs and SPPs, before distribution. Also has a monopoly over the transmission of electricity in Thailand
PTT Public Company Limited (PTT)		• A state-owned fully-integrated energy company, with a leading position in exploration and production, transmission, refining, marketing, and trading of petroleum and petrochemical products • The exploration and production business is conducted through the subsidiary - PTT Exploration and Production Public Company Limited (PTTEP)

Source: Various government sources 2023, Electricity Generating Authority of Thailand 2023, PTT Public Company Limited 2023

3 パイプライン（ガス・石油）

国営PTTグループはタイの天然ガス送電市場を独占

Regulatory overview of the natural gas transmission market

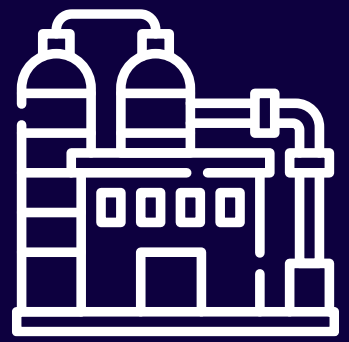
Energy Industry Act and Energy Regulatory Commission, Thailand

Firm	Details
PTT Public Company Limited Majority owned by the Thailand Ministry of Finance	• The construction, ownership, and interconnection of natural gas transportation pipelines are governed by the Energy Industry Act (EIA) • The EIA empowers the Energy Regulatory Commission to approve the construction of all transmission pipelines • The administration of natural gas pipeline transmission derives given state-specified rates of return
	• PTT owns the natural gas pipeline system and has a monopoly over the national pipeline business in Thailand, with >4,500km in total length • Other than the pipelines connecting the gas fields in the Thai-Malaysian Joint Development Area and some pipelines located in and around industrial estates, PTT is the sole owner of natural gas distribution infrastructure in Thailand

Source: Lexology 2023, PTT Public Company Limited 2023, Arthur D. Little analysis

2022年、PTTグループが独占する天然ガス送電パイプラインの総延長は4,500kmを超過

GAS TRANSPOR PIPELINE CAPACITY



- Natural Gas Field
- Power Plant
- Gas Separation Plant Unit 1,2,3,5,6 in Rayong
- Gas Separation Plant Unit 4 in Nakhon Si Thammarat
- Block Valve / Important Node in Pipeline Network
- Map Ta Phut LNG Terminal (T-1)
- LNG Receiving Terminal (T-2): Future
- Existing Pipeline
- Future Pipeline
- Industrial Estate

Gas Separation Plant Capacity	
Unit 1	420 mmcf/d
Unit 2 and 3	820 mmcf/d
Unit 4	170 mmcf/d
Unit 5	580 mmcf/d
Unit 6	880 mmcf/d

Note: Map is illustrative and not drawn to scale. Figures for total length include both onshore and offshore pipelines
Source: PTT Public Company Limited annual report 2022, Arthur D. Little analysis

List of observed PTT Group natural gas transmission pipelines in Thailand – Offshore

#	Name	Length, km	Start-up year
1	Erawan - Rayong Gas Separation Plant (1st Principal Pipeline)	415	1981
2	Bongkot - Erawan (1st Principal Pipeline)	171	1996
3	Erawan - Rayong Gas Separation Plant (Parallel Pipeline)	413	1996-1997
4	Erawan - Khanom Power Plant	161	1996
5	Arthit - Rayong Gas Separation Plant (3rd Pipeline)	610	2007
6	JDA - Arthit	95	2008
7	Chevron Platform Extension (Platong 2) - 3rd Offshore Pipeline	48	2011
8	South Bongkot - 3rd Offshore Pipeline	38	2012

Source: PTT Public Company Limited annual report 2022

List of observed PTT Group natural gas transmission pipelines in Thailand – Onshore (1/2)

#	Name	Length, km	Start-up year
1	Rayong Gas Separation Plant - Bang Pakong Power Plant (2nd Principal Pipeline)	107	1981
2	Bang Pakong Power Plant - South Bangkok Power Plant (1st Principal Pipeline)	57	1981
3	Bang Phli - Saraburi (Principal Pipeline)	99	1981
4	Nam Phong - Nam Phong Power Plant	3	1990
5	Rayong Gas Separation Plant - Bang Pakong Power Plant (Parallel Pipeline)	105	1996
6	Bang Pakong - Wang Noi Power Plant (Parallel Pipeline)	101	1996
7	Transmission Pipeline From Thai-Myanmar Border To Ratchaburi Power Plant	238	1998
8	Ratchaburi - Wang Noi	154	2000
9	Rayong Gas Separation Plant - Bang Pakong Power Plant (3rd Pipeline)	110	2006
10	Wang Noi Power Plant - Kaeng Khoi Power Plant	72	2006
11	Transmission Pipeline From The Pressure Control Station RA#6 - South Bangkok Power Plant	67	2007
12	Offshore - Chana Power Plant	8	2007
13	Transmission Pipeline To North Bangkok Power Plant	7	2009

Source: PTT Public Company Limited annual report 2022

List of observed PTT Group natural gas transmission pipelines in Thailand – Onshore (2/2)

#	Name	Length, km	Start-up year
14	Onshore Pipeline Along The Thai-Myanmar Border - BVW#1	0.59	2014
15	Rayong - Kaeng Khoi (4th Pipeline)	298	2015
16	Nakhon Sawan	192	2015
17	Nakhon Ratchasima	145	2018
18	5th Onshore Pipeline (GDF4 - BV5.4)	72	2021
19	Transmission System From The 6th Gas Compression Station Ratchaburi - Wang Noi To Ratchaburi Province	119	2021
20	The 5th Onshore Gas Pipeline Transmission Project (BV5.6 - BP4)	57	2021
21	The 5th Onshore Gas Pipeline Transmission Project (BV5.4 - BV5.8)	74	2021
22	The 5th Onshore Gas Pipeline Transmission Project (GDF4 - TP5MX)	5	2021
23	The 5th Onshore Gas Pipeline Transmission Project (GDF5 - TP5MX)	7	2022

Source: PTT Public Company Limited annual report 2022

2020年現在、タイの石油パイプラインはバンコク首都圏に近い中部地域に集中

COMMENTS

- Thailand's onshore oil pipelines are observed to primarily serve **major consumption and production centres**
- Pipeline connections to Rayong are likely due to the presence of **oil refineries** in the coastal port region, such as
  - Rayong II refinery, run by PTT Global Chemical Public

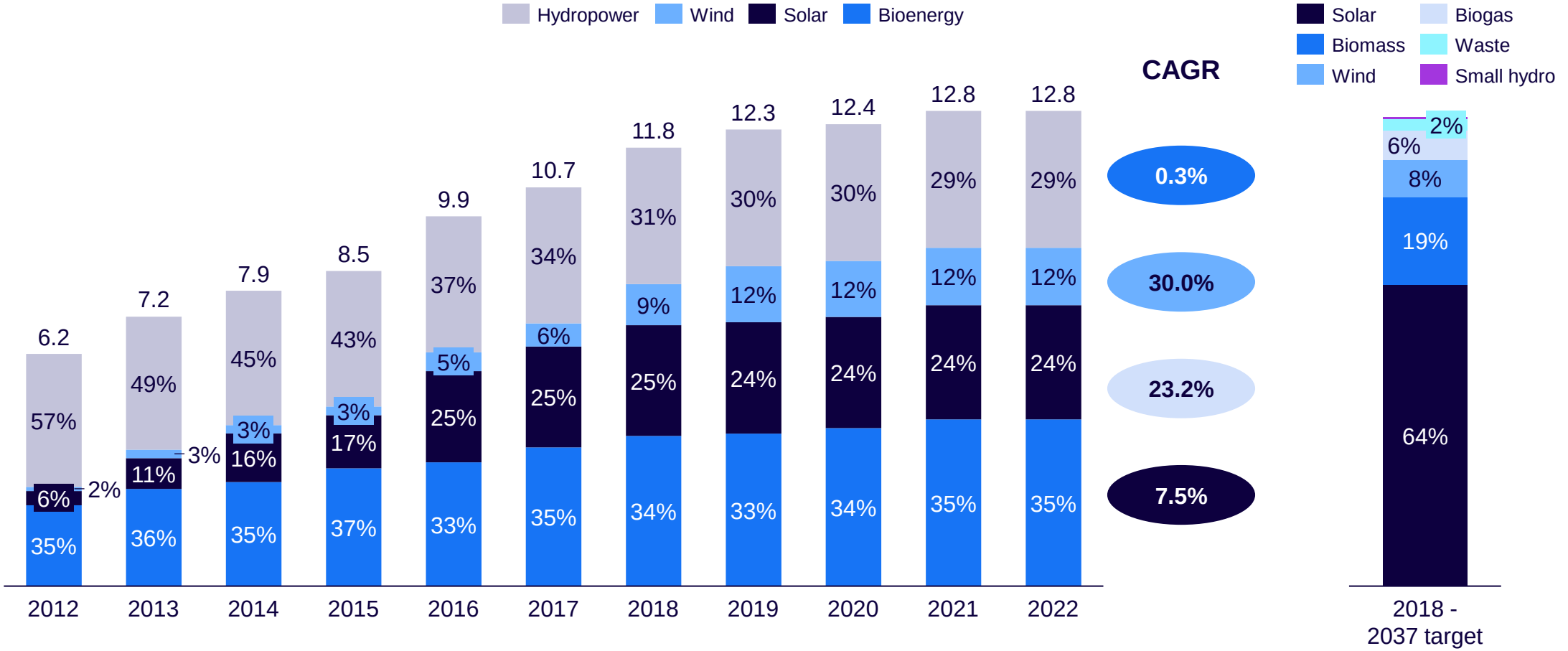
Note: Map is illustrative and not drawn to scale
Source: Modern Diplomacy 2020

4 次世代・再生可能エネルギー

現在は、バイオエネルギーと太陽光が再エネの中心、
2037年に向けて今後は太陽光をドライバーとして再生可能エネルギーが増加する

Renewable energy capacity[1]

2012 – 2022 & target, GW



Note: * Exclusive of hydropower, small hydro has contribution of <1% contribution; 1) Geothermal contributions are significantly lower, hence excluded in database
Source: International Renewable Energy Agency 2023, Arthur D. Little analysis

タイの省エネルギー（ENCON）基金は、エネルギー効率、省エネルギー、再生可能エネルギープロジェクトを支援

ENCON

- Established in 1992, it's the government's main financial mechanism to support energy efficiency (EE) and RE projects.
- USD 160 mn budget in 2020, and supported 1,035 projects
- The source of funds comes from a sales tax of USD 0.1/kL on petroleum products[1]
- The main source of financial support is provided to factories and buildings for investment in energy conservation projects
  - The fund can also be tapped by other agencies for investments
- The two main funds under ENCON are the Energy Service Company (ESCO) Fund (USD 37.76 mn) and Energy Efficiency Revolving Fund (EERF)

EERF

- Objectives:
  - Stimulate and leverage commercial funding for EE projects for industrial and commercial facility owners, ESCOs and project developers
  - Help commercial Thai banks streamline internal processes for project appraisal and loan disbursement
- Provides credit lines to 11 participating Thai banks as of 2020 with 0% interest rate to banks, with repayment period of <7 years
  - Max loan/project: USD 1.25 mn
- Phase 1: USD 100 mn
- Phase 2: USD 66 mn
- Phase 3: USD 65 mn (incl. RE)
- Phase 4: USD 13 mn
- Phase 5: USD 17 mn

ESCO

- Objectives:
  - Encourage >10 ktoe/year energy saving USD 7.25 mn/year[2]
  - Promote private investments in RE
  - Assist entrepreneurs in minimizing their energy cost, and achieving revenues from carbon credit
  - Provide start up capital for energy efficiency and RE companies
- Investment types include equity, equipment leasing, venture capital, GHG, project facilities, credit guarantee facilities
- Phase 1: 6 equity, 9 equipment leasing
- Phase 2: 5 equity, 43 equipment leasing
- Phase 3: 19 equipment leasing
- Phase 4: 1 equity, 9 equipment leasing

Note: 1) Gasoline, diesel, fuel oil and kerosene; 2) Exchange rate is 1 THB = 0.029 USD (2022 2 d.p. average)
Source: World bank 2023, International Energy Agency 2023, Multiple new sources, Arthur D. Little analysis

Very small[1] hydropower projects in the pipeline

Hydropower projects, by region

2023

#	Project	Location			Capacity, kW	Start-up year
		Sub-district	District	Province		
1	Mae Nawang	Royal House[2]	Mother shy	Chiang Mai	52	2022
2	Mae Kongka	Guests[2]	Mae Chaem	Chiang Mai	35	2022
3	Por Kro, Mae	Second Mother[2]	Tha Song Yang	Dry[2]	52	2023
4	Rameng, Mae	Second Mother[2]	Tha Song Yang	Dry[2]	47	2023
5	Amlong, Huai	House[2]	Mae Sariang	Mae Hong Son	65	2024
6	Raphring	Phawo	Mae Sot	Dry[2]	32	2024
7	Mae Yang Min	Sri Thoi	Mae Suai	Chiang Rai	54	2025
8	Huai Mae Ning	Guests[2]	Mae Chaem	Chiang Mai	27	2025
9	Huai Kong Paegro	Mae Waluang	Tha Song Yang	Dry[2]	29	2026
10	Huay Pong Saen Pik	Na Pu	Pang Mapha	Mae Hong Son	26	2026
Total capacity of 10 community hydroelectric power plant projects					**419**	

Note: 1) <200 kW; 2) Due to translation, some names might not be accurately reflected
Source: Alternative Energy Development Plan 2018, Arthur D. Little analysis

Small[1] hydropower projects in the pipeline (1/3)

Hydropower projects, by region

2023

#	Project	Location			Capacity, kW	Start-up year
		Sub-district	District	Province		
1	Nam Max Navng	Ban Luang	Mother Shy[2]	Chiang Mal	719	2018
2	Hual Nam Kham	Huay Hla	Nakon Thal	Phltsanulok	798	2018
3	Mae Mong Kham	Guests[2]	*Unknown*	Chiang Mal	739	2019
4	Huay Yal 5	Wang Nok Aon	Wong Thong	Phltsanulok	1,328	2020
5	Nan River	Ngop	Thung	Nan	988	2020
6	Mae Sarlang	Forest[2]	Chang, Mee Areng	Mae Hong Son	929	2020
7	Mother's Aunt[2]	Young Mother[2]	Mother Shy[2]	Chiang Nal	831	2021
8	Mae Sa	Be Happy[2]	Wlang Sa	Nan	792	2021
9	Huay Lal Ya Nol	Mae Lamung, Umphang, Mae	*Unknown*	Dry[2]	672	2021
10	Mae Tho River-Wlang Pa Pao	Chedi Mal, Wlang Pa Pae	*Unknown*	Chiang Ral	430	2021
11	Mae Tho River-Wlang Pa Pao	*Unknown*	Mae La No	Mae Hong Son	426	2021

Note: 1) >200 kW; 2) Due to translation, some names might not be accurately reflected
Source: Alternative Energy Development Plan 2018, Arthur D. Little analysis

Small[1] hydropower projects in the pipeline (2/3)

Hydropower projects, by region

2023

#	Project	Location			Capacity, kW	Start-up year
		Sub-district	District	Province		
12	Mae Salong River	Mae Salong	*Unknown*	Chiang Ral	527	2022
13	Pong Nam Ron Canal 14	Hot Water Pong[2]	Hot Water Pong[2]	Chanthabur	6,200	2022
14	Thung Plain Canal 15 Hual	Andmory[2]	Khichaku	Chanthabur	2,800	2022
15	Mae Mae Paeng Sal	Mother[2]	Chiang Dao	Chiang Mal	453	2023
16	Mother Taman	Kid Chang[2]	Mee Teng	Chiang Mal	408	2024
17	Mother Secretly	Tease House[2]	Chiang Saen	Chiang Ral	409	2025
18	Pha Nol House	Mae Salong	*Unknown*	Chiang Ral	314	2025
19	Mother Laka	Pon City[2]	Khun Yum	Mae Hong Son	369	2026
20	Hus Mekong	*Unknown*	Sop Moel	Mae Hong Son	345	2026
21	Hua Tha Kuay 1	Temple[2]	*Unknown*	Uthal Thanl	424	2027
22	Hua Tha Kuay 2	Temple[2]	*Unknown*	Uthai Thanl	328	2028
23	Hua Kaeng Pantao	Mother[2]	Chiang Dao	Chiang Mal	224	2028

Note: 1) >200 kW; 2) Due to translation, some names might not be accurately reflected
Source: Alternative Energy Development Plan 2018, Arthur D. Little analysis

Small[1] hydropower projects in the pipeline (3/3)

Hydropower projects, by region

2023

#	Project	Location			Capacity, kW	Start-up year
		Sub-district	District	Province		
24	Khlong Ra	Phang Nga City	*Unknown*	*Unknown*	2,961	2029
25	Ban Bang Kum	Kapong	Kapong	*Unknown*	987	2029
26	Kapong Canal	Kapong	Kapong	*Unknown*	886	2030
27	Klongmen	Middle Elephant [2]	Nakhon Si Thammarat	*Unknown*	561	2030
28	Lamphun Canal 29	Lamphun	Nasam	Surat Thani	707	2031
29	Duan Canal	Ashamed[2]	*Unknown*	Nakhon Si Thammarat	493	2031
30	Nang Yon Canal	Kura	Kuraburi	*Unknown*	447	2031
31	Khlong Ranae	*Unknown*	*Unknown*	Nakhon Si Thammarat	436	2032
32	Tha Phae Canal	Middle Elephant[2]	Nakhon Si Thammarat	*Unknown*	386	2575
Total capacity of small hydroelectric power 32 projects					**29,317**	

Note: 1) >200 kW; 2) Due to translation, some names might not be accurately reflected
Source: Alternative Energy Development Plan 2018, Arthur D. Little analysis

List of hydropower projects in operation[1]

NON-EXHAUSTIVE

Hydropower projects located in dams, by region

2023

#	Name	Reservoir capacity, bcm[2]	# of generators	Generator capabilities, MW/unit[2]	Contracted capacity, MW[2]	Annual Capacity, mn kWh[2]
1	Srinagarind (Kanchanaburi)	17.75	5	120 (Units 1-3), 180 (Units 4-5)	720	1,250
2	Bhumibol (Tak)	13.46	8	82 (Units 1-6), 115 (Unit 7), 171 (Unit 8)	779	1,062
3	Sirkit (Uttaradit)	9.51	4	125	500	1,000
4	Ubol Ratana (Khon Kaen)	2.43	-	-	25	56
5	Vajiralongkorn (Kanchanaburi)	8.86	-	-	300	777
6	Sirindhorn (Ubon Ratchathani)	1.97	-	-	36	52
7	Chulabhorn (Chaiyaphum)	0.16	2	20	40	57
8	Nam Pung (Sakon Nakhon)[3]	0.17	2	3	6	1,250
9	Pak Mun (Ubon Ratchathani)	-	4	34 (Units 1-4)	136	280
10	Rajjaprabha (Surat Thani)	5.64	3	80 (Units 1-3)	240	554
11	Bang Lang Dam (Yala)	1,42	3	-	84	289
12	Kang Krachan (Phetchaburi)	0.71	-	-	19	70
13	Tha Thung Na (Kanchanaburi)	0.05	-	-	39	170
14	Mae Ngat Somboon Chon (Chiang Mai)	0.27	2	5 (Units 1-2)	9	29

Note: 1) Only encompasses EGAT dams and power plants; 2) Values are rounded up; 3) Possible errors in reported values
Source: Electricity Generating Authority of Thailand 2023, Arthur D. Little analysis

List of hydropower projects in operation[1]

NON-EXHAUSTIVE

Hydropower projects located downstream, by region

2023

#	Name	Reservoir capacity, mcm[2]	# of generators	Installed capacity, MW/unit[2]	Annual Capacity, mn kWh[2]	Transmission line
1	Mae Klong Mini Hydro PP	8.20	2	6	74	22 kV
2	Khun Dan Prakan Chon Mini Hydro PP	224.00	1	11	28	22 kV
3	Naresuan Mini Hydro PP	8.20	1	-	43	22 kV
4	Chao Phraya Mini Hydro PP	144.70	2	6	62	22 kV
5	Kwae Noi Bumrung Dan Mini Hydro PP	769.00	2	15	147	22 kV
6	Kiew Kho Ma Mini Hydro PP	170.00	3	2	69	22 kV
7	Pha Chuk Mini Hydro PP	-	2	7	74	-
8	Khlong Tron Mini Hydro PP	-	2	1	12	22 kV
9	Pasak Jolasid Mini Hydro PP	785.00	1	7	35	22 kV
10	Chulabhorn Mini Hydro	-	1	1	6	22 kV

Note: 1) Only encompasses EGAT dams and power plants; 2) Values are rounded up
Source: Electricity Generating Authority of Thailand 2023, Arthur D. Little analysis

Floating solar efficiency improvement projects in the pipeline

Solar power projects, by region

2023

Efficiency improvement/increase in profit plan production capacity with floating solar energy

#	Name	Province	District	Sub-district	Solarp floating from minimum water level, MW
1	Ban Phiuang Dam	Chantaburi	Kitchanakut	antimony	44
2	Kirthan Dam	Chanthabur	tamarind	Pataw	218
3	Hual Pra Thao Dam - Lower Dam	Chaiyaphum	Kaeng Khro	Tha Hin Ngom	5.35
4	Hual Pra Thao Dam-Top Dam Mae	Chaiyaphum	Kaeng Khro	Na Nong Thum	61
5	Mao Dam Mae	Chiang Ma	Fang	Mon Pin	3
6	Sap Dam Mae	Chiang Mai	Samoeng	South Siemong	2.1
7	Sa Nga Dam	Mae Hong Son City		fog	1
8	Nam Wa	Nan	Wlang Sa	Lanna, Nong Mal,	1.8
9	Dam Mae Phong Dam	Phayao	Dok Kham Tal	Ban Tham	0.18
Total					**336.43**

Source: Alternative Energy Development Plan 2018, Arthur D. Little analysis

List of solar projects in operation (1/2)

NON-EXHAUSTIVE

Solar power projects, by region

2023

#	Province	Name	Capacity[1]	Developer	Status	Start-up year
1	Sa Kaeo	BSP Saen Phu Dat-Ban Phoe	1.6	Bangkok Solar Power	Operating	2007
2	Udon Thani	BSP Na Phu-Phen	1.8	Bangkok Solar Power	Operating	2009
3	Nakhon Ratchasima	Korat-I	7.1	SPCG	Operating	2010
4	Saraburi	Kengkoi-III	6.0	Infinite Green	Operating	2010
5	Phra Nakhon Si Ayutthaya	Bang Pa-In 1	12.0	BCPG	Operating	2011
6	Chonburi	Kabinburi	9.6	Loxley	Operating	2011
7	Nakhon Phanom	Nakhon Phanom-I	7.1	SPCG	Operating	2011
8	Nakhon Ratchasima	Korat-II	7.1	SPCG	Operating	2011
9	Phra Nakhon Si Ayutthaya	Bang Pa-In 2	41.0	BCPG	Operating	2012
10	Saraburi	Bang Len-I / Sai Thong	9.9	Yanhee Solar	Operating	2012
11	Chonburi	Huai Yai	9.6	Xeon Top	Operating	2012
12	Lopburi	Phatthana Nikhom	9.6	EA Solar	Operating	2012
13	Roi Et	SPP5 Roi Et	9.6	EGCO	Operating	2012
14	Saraburi	SPP2 Saraburi	9.6	EGCO	Operating	2012
15	Sisaket	SPP3 Sisaket	9.6	EGCO	Operating	2012
16	Nakhon Pathom	Sai Prapa	8.7	Yanhee Solar	Operating	2012
17	Chai Nat	Dong korn	7.8	G-Power Source	Operating	2012

Note: 1) DC capacity
Source: Rystad Energy 2023

List of solar projects in operation (2/2)

NON-EXHAUSTIVE

Solar power projects, by region

2023

#	Province	Name	Capacity[1]	Developer	Status	Start-up year
18	Kanchanaburi	Coop Kanchanaburi	4.7	BCPG	Operating	2018
19	Samut Prakan	Chachoengsao - WVO	4.3	B.Grimm	Operating	2018
20	Phetchabun	Chon Daen - Agricultural Coop	2.8	B.Grimm	Operating	2018
21	Phetchabun	Phukham	2.1	United Power	Operating	2018
22	Nakhon Si Thammarat	Kathun	1.4	United Power	Operating	2018
23	Udon Thani	BSP Udon Thani	0.3	Bangkok Solar Power	Operating	2018
24	Chaiyaphum	Udon Thani	6.0	Unknown	Operating	2019
25	Krabi	Kabri - PS&S	6.0	PS&S	Operating	2019
26	Rayong	IRPC Floating Solar Farm	15.0	Unknown	Operating	2020
27	Ratchaburi	SPM group floating PV	2.4	Greenyellow	Operating	2021
28	Rayong	U-Tapao - Solar	18.0	Unknown	Operating	2022
29	Nakhon Ratchasima	Smart Energy Floating Solar	5.2	CHPP	Operating	2022
30	Ubon Ratchathani	UBE Ubon Ratchathani	2.8	BayWa r.e.	Operating	2022
31	Nakhon Ratchasima	Smart Energy Rooftop Solar	2.1	CHPP	Operating	2022
32	Saraburi	CP-Meji Floating Solar	2.0	KP Greenery	Operating	2022
33	Prachinburi	NPS Green Lake	60.0	National Power Supply Co	Operating	2023
34	Sa Kaeo	Sa Kaeo Super Solar Hybrid PV	49.0	Super Solar Hybrid	Operating	2023

Note: 1) DC capacity
Source: Rystad Energy 2023

List of solar projects in the pipeline (1/2)

NON-EXHAUSTIVE

Solar power projects, by region

2023

#	Province	Name	Capacity[1]	Developer	Status	Start-up year
1	Suphan Buri	Blue Solar SPP Hybird PV	40.8	Essential Power	Construction	2023
2	Nong Bua Lamphu	Ubol Ratana Dam Hydro-Floating Solar Hybrid	28.8	EGAT	Financial Close	2023
3	Suphan Buri	Breeze and Shine Power - PV	90.0	Gulf	Approved	2024
4	Kanchanaburi	Pattana Solar - PV	72.0	Gulf	Approved	2024
5	Kanchanaburi	Sky Power	57.6	Sky Power	Approved	2024
6	Phetchabun	Energy First - PV	73.2	Gulf	Approved	2025
7	Mae Hong Son	Duangtawan Energy - PV	72.0	Gulf	Approved	2025
8	Surin	Thaipat Solar	61.2	Thaipat Solar	Approved	2025
9	Sukhothai	Suriyapat	57.6	Suriyapat	Approved	2025
10	Buriram	Racha Solar	45.4	Racha Solar	Approved	2025
11	Tak	Bhumibol Hydro-Floating Solar Hybrid	189.6	EGAT	Concept	2026
12	Kanchanaburi	Srinagarind Hydro-Floating Solar Hybrid	168.0	EGAT	Concept	2026
13	Phetchaburi	Saengdee Clean Energy - PV	70.8	Gulf	Approved	2026
14	Kamphaeng Phet	Power CE 1	109.2	Power CE	Approved	2026
15	Chonburi	NP Watt	89.8	NP Watt	Approved	2027
16	Kanchanaburi	Vajiralongkorn Hydro-Floating Solar Hybrid	60.0	EGAT	Concept	2027
17	Suphan Buri	Anurak Green Power - PV	55.2	Gulf	Approved	2027

Note: 1) DC capacity
Source: Rystad Energy 2023

List of solar projects in the pipeline (2/2)

NON-EXHAUSTIVE

Solar power projects, by region

2023

#	Province	Name	Capacity[1]	Developer	Status	Start-up year
18	Suphan Buri	Blue Wave Power - PV	87.8	Gulf	Approved	2028
19	Phetchabun	Saeng Arun Clean Energy - PV	78.0	Gulf	Approved	2028
20	Ratchaburi	Solar For All	69.6	Solar For All	Approved	2028
21	Phetchabun	Sang Siam	66.0	Sang Siam	Approved	2028
22	Phichit	Sunray Renewable Energy - PV	54.0	Gulf	Approved	2028
23	Nakhon Sawan	Ruang Siam - PV	51.6	Gulf	Approved	2028
24	Nakhon Sawan	Double Clean Energy - PV	55.2	Gulf	Approved	2029
25	Ubon Ratchathani	WHA Solar - PV	34.7	WHA Group	Approved	2029
26	Lopburi	Wang Khon Khwang Solar Energy - PV	27.6	Super Energy	Approved	2029
27	Kanchanaburi	Kanchanaburi Solar - PV	25.2	Super Energy	Approved	2029
28	Ratchaburi	Banpong Solar Energy - PV	21.6	Super Energy	Approved	2029
29	Narathiwat	Gunkul One Energy 2 - PV	21.1	Gunkul	Approved	2029
30	Lopburi	Nongkhaem Solar Energy - PV	19.2	Super Energy	Approved	2029
31	Kanchanaburi	PR Chiang Mai - PV	61.7	Prime Road	Approved	2030
32	Nong Khai	Gunkul One Energy 9 - PV	39.6	Gunkul	Approved	2030
33	Songkhla	Gunkul Solar Powergen - PV	39.6	Gunkul	Approved	2030
34	Khon Kaen	WH Solar Two - PV	36.0	WHA Group	Approved	2030

Note: 1) DC capacity
Source: Rystad Energy 2023

List of wind[1] projects in operation (1/2)

NON-EXHAUSTIVE

Wind power projects, by region

2023

#	Province	Name	Capacity[1]	Developer	Status	Start-up year
1	Nakhon Ratchasima	Khlong Phai- Lam Takhong	2.5	Gunkul	Operating	2009
2	Nakhon Si Thammarat	Nakhon Si Thammarat - IV	1.5	DEDE	Operating	2009
3	Songkhla	Sathing Phra	1.5	PEA	Operating	2010
4	Nakhon Ratchasima	Huaybong - II (KR 1)	103.5	Wind Energy	Operating	2012
5	Chaiyaphum	Chaiyaphum - II	6.9	EGCO	Operating	2013
6	Nakhon Ratchasima	Huaybong - III (KR Two)	103.5	Wind Energy	Operating	2013
7	Nakhon Si Thammarat	Southern Thailand Wind Power	10.0	Lomligor	Operating	2015
8	Chaiyaphum	Chaiyaphum - I	80.0	EGCO	Operating	2016
9	Chaiyaphum	Watabak Wind Farm	60.0	Wind Energy	Operating	2016
10	Nakhon Ratchasima	Huaybong - IV	10.0	Gunkul	Operating	2016
11	Nakhon Ratchasima	Huaybong - V	2.5	Gunkul	Operating	2016
12	Nakhon Ratchasima	Huaybong (Wayu Wind Farm)	50.0	Gunkul	Operating	2016
13	Phetchabun	Khao Kor	60.0	Ratch Energy	Operating	2016
14	Nakhon Ratchasima	Khlong Phai- Lam Takhong 2	24.0	EGAT	Operating	2017
15	Nakhon Si Thammarat	Hadkunghan 2	45.0	Energy Absolute	Operating	2017
16	Nakhon Si Thammarat	Hadkunghan 3	45.0	Energy Absolute	Operating	2017
17	Songkhla	Hadkunghan 1	36.0	Energy Absolute	Operating	2017

Note: 1) Onshore wind
Source: Rystad Energy 2023

List of wind[1] projects in operation (2/2)

NON-EXHAUSTIVE

Wind power projects, by region

2023

#	Province	Name	Capacity[1]	Developer	Status	Start-up year
17	Chaiyaphum	Theparak 4	90.0	Wind Energy	Operating	2018
18	Chaiyaphum	Tropical wind	90.0	Wind Energy	Operating	2018
19	Nakhon Ratchasima	K.R.S Three	90.0	Wind Energy	Operating	2018
20	Nakhon Ratchasima	Krissana Wind NKS	90.0	Wind Energy	Operating	2018
21	Nakhon Ratchasima	Mittraphap	52.5	Gunkul	Operating	2018
22	Nakhon Ratchasima	Sarahnlom	67.5	Gunkul	Operating	2018
23	Chaiyaphum	Hanuman Wind Project-1	45.0	Energy Absolute	Operating	2019
24	Chaiyaphum	Hanuman Wind Project-10	80.0	Energy Absolute	Operating	2019
25	Chaiyaphum	Hanuman Wind Project-5	48.0	Energy Absolute	Operating	2019
26	Chaiyaphum	Hanuman Wind Project-8	45.0	Energy Absolute	Operating	2019
27	Chaiyaphum	Hanuman Wind Project-9	42.0	Energy Absolute	Operating	2019
28	Chaiyaphum	Theparak	90.0	Wind Energy	Operating	2019
29	Mukdahan	Rom Klao	45.0	Alpha Energy	Operating	2019
30	Nakhon Si Thammarat	Lomligor	9.0	BCPG	Operating	2019
31	Mukdahan	Bo Thong 1	8.0	B.Grimm	Operating	2021
32	Mukdahan	Bo Thong 2	8.0	B.Grimm	Operating	2021

Note: 1) Onshore wind
Source: Rystad Energy 2023

List of wind[1] projects in the pipeline (1/2)

NON-EXHAUSTIVE

Wind power projects, by region

2023

#	Province	Name	Capacity[1]	Developer	Status	Start-up year
1	Chumphon	Alpha One Project	48.0	Gulf	Approved	2025
2	Khon Kaen	Wind Mahasarakham 1	90.0	Energy Absolute	Approved	2025
3	Mukdahan	Isaan Clean Energy	90.0	Gulf	Approved	2025
4	Prachuap Khiri Khan	Alpha Two Project	70.0	Gulf	Approved	2025
5	Nakhon Ratchasima	Dan Khun Thot Wind One	89.7	Wind Energy Holding	Approved	2026
6	Ubon Ratchathani	Blue Sky Wind Power 31	90.0	The Blue Circle	Approved	2026
7	Ubon Ratchathani	Lemon Gold Farm	40.0	Super Energy	Approved	2026
8	Chaiyaphum	Lom Plearn	90.0	Gulf	Approved	2027
9	Chaiyaphum	Wayu Power	78.0	Gulf	Approved	2027
10	Chaiyaphum	Wind Two Power	90.0	Gulf	Approved	2027
11	Kalasin	Wayo Power	36.0	Gulf	Approved	2028
12	Lopburi	Lonrak Green Energy 1	60.0	Gulf	Approved	2028
13	Lopburi	Lonrak Green Energy 2	60.0	Gulf	Approved	2028
14	Ubon Ratchathani	Blue Sky Wind Power 36	90.0	The Blue Circle	Approved	2028
15	Amnat Charoen	Blue Sky Wind Power 39	90.0	The Blue Circle	Approved	2029
16	Amnat Charoen	Blue Sky Wind Power 52	90.0	The Blue Circle	Approved	2029

Note: 1) Onshore wind
Source: Rystad Energy 2023

List of wind[1] projects in the pipeline (2/2)

NON-EXHAUSTIVE

Wind power projects, by region

2023

#	Province	Name	Capacity[1]	Developer	Status	Start-up year
17	Amnat Charoen	Gunkul Wind Power 5	90.0	Gunkul	Approved	2029
18	Chaiyaphum	Blue Sky Wind Power 3	76.5	The Blue Circle	Approved	2030
19	Chaiyaphum	Smart Clean System 1	16.0	B Grimm	Approved	2030
20	Nakhon Ratchasima	Gunkul Wind Power 3	90.0	Gunkul	Approved	2030
21	Prachuap Khiri Khan	Lom Singkhon 1	8.0	Sermsang	Approved	2030
22	Prachuap Khiri Khan	Lom Singkhon 2	8.0	Sermsang	Approved	2030

Note: 1) Onshore wind
Source: Rystad Energy 2023

There is currently only 1 biomass project in Thailand that has begun operations earlier in June 2023, with no other projects in the horizon

Biomass power plants

No	Project	Province	District/City	Capacity, MW	Owner	Start-up year
1	Pracharat Biomass Mae Lan PP	Pattani	Mae Lan	2.85[1]	TCPH	2023

Note: 1) Based on power purchase contract
Source: Power Development Plan 2018 (Revision 1), Bioenergy 2023, Arthur D. Little analysis

都市ゴミはエネルギー生成の潜在的な供給源とみなされ、プロジェクトが進行中(1/5)

Waste-to-energy power projects, totalling 400 MW

#	Name	Province	Quantity offered sell electricity, MW
1. 1 project approved by the cabinet and private sector 20 MW			
1	Waste disposal project for electricity generation Nonthaburi Provincial Administrative Organization (Selected SPP Sic Co., Ltd. and Super Earth Energy Co., Ltd.) 2. Projects approved by	Nonthaburi	20.0
The Minister of Interior and in the process of selecting private sector 12 projects 131.4 MW			
1	Electricity generation project in kiln-type kiln technology Ban Phru Municipality Gas	Songkhla	4.9
2	Plasma technology power generation project Cification, Phan Thong Subdistrict Administrative Organization,	Kamphaeng Phet	6.0
3	RDF Waste-to-energy Power Plant Project, Phan Thong Subdistrict Administrative Organization Phraeksa Mai (PTS 424 feeder line)	Samut Prakan	9.9
4	RDF waste-to-energy power plant project, Provincial Administrative Organization Phraeksa Mai (BTR 416 feeder line)	Samut Prakan	3.0
5	RDF waste-to-energy power plant project, Provincial Administrative Organization Phraeksa Mai (BTR 426 feeder cable)	Samut Prakan	3.0
6	Waste disposal project with an incinerator system of not less than 1,000 tons per day at Nong Khaem Waste Management Center Bangkok Waste	Bangkok	30.0
7	Disposal project with an incinerator system of not less than 1,000 tons per day at On Nut Waste Disposal Center. Bangkok System construction	Bangkok	30.0

Source: Power Development Plan 2018 (Revision 1), Arthur D. Little analysis

都市ゴミはエネルギー生成の潜在的な供給源とみなされ、プロジェクトが進行中(2/5)

Waste-to-energy power projects, totalling 400 MW

#	Name	Province	Quantity offered sell electricity, MW
8	Project Solid waste disposal phase 2, Nakhon Ratchasima municipality Gasification technology	Nakhon Ratchasima	9.9
9	Power generation project Sawankhalok Municipality	Sukhothai.	2.0
10	Project to generate electricity from solid waste Nakhon Si Thammarat Municipality construction and management project municipal solid waste disposal	Nakhon Si Thammarat	19.8
11	Yala City Municipality	Yala	3.0
12	Waste to electricity project, size 9.9 megawatts of Maha Sarakham Municipality Maha Sarakham Province	Maha Sarakham	9.9
3. Projects under consideration by the screening committee and the Central Committee, 4 projects, 30.3 MW			
1	Garbage disposal project to generate electricity, Nong Ma Mong Municipality Project of	Chai Nat	5.0
2	Waste-to-fueled power plant, Watthana Nakhon Sub-district Municipality	Sa Kaeo	6.0
3	Technology Power Generation Project MBT Biological Treatment Technology Bang Sao Thong Subdistrict Administrative Organization	Samut Prakan	9.8
4	Solid Waste Management Project for RDF and Electricity Generation Chiang Mai Provincial Administrative Organization	Chiang Mai	9.5

Source: Power Development Plan 2018 (Revision 1), Arthur D. Little analysis

都市ゴミはエネルギー生成の潜在的な供給源とみなされ、プロジェクトが進行中(3/5)

Waste-to-energy power projects, totalling 400 MW

#	Name	Province	Quantity offered sell electricity, MW
4. Projects under preparation Proposal for 39 projects/plans 218.3 MW			
4.1 Central region: 13 projects, 92.2 MW			
1	Garbage disposal project to generate electricity, Tha Tako Subdistrict Municipality	Nakhon Sawan	0.5
2	Garbage disposal project to generate electricity, Hankha Subdistrict Municipality	Chai Nat	1.0
3	Garbage disposal project to generate electricity, Ban Mi Subdistrict Municipality	Lop Buri	0.5
4	Garbage disposal project to generate electricity Tha Chin Municipality Garbage disposal	Samut Sakhon	3.9
5	Project to generate electricity Nadi Sub-district Municipality Garbage disposal	Samut Sakhon	1.5
6	Project to generate electricity Subdistrict Administrative Organization Klong Madua Sub-district, solid	Samut Sakhon	1.0
7	Waste disposal project to generate electricity Phitsanulok City Municipality Waste	Phitsnulok	10.0
8	Disposal project to generate electricity Chiang Rak Yai Subdistrict Administrative	Pathum	30.0
9	Organization, waste disposal project to generate electricity Sukhothai Municipality	Thai	3.0
10	Garbage disposal project to generate electricity Tha Sadet Municipality Garbage disposal	Sukhothai, Suphanbun	9.9
11	Project to generate electricity Subdistrict Administrative Organization Phiapphlachal Subdistrict	Suphan Buri	20.0
12	Waste disposal project to generate electricity Phetchabun Municipality 13. Garbage disposal	Phetchabun	3.0
13	Project for electricity generation	Phetchaburi	7.9

Source: Power Development Plan 2018 (Revision 1), Arthur D. Little analysis

都市ゴミはエネルギー生成の潜在的な供給源とみなされ、プロジェクトが進行中(4/5)

Waste-to-energy power projects, totalling 400 MW

#	Name	Province	Quantity offered sell electricity, MW
4.2 Northern region: 6 projects, 51 MW			
14	Waste disposal project for electricity generation, Si Pho Sri Ngoen Subdistrict Municipality	Chiang Rai	9.8
15	Waste disposal project for electricity generation Chiang Rai City Municipality Solid waste	Chiang Rai	9.8
16	Disposal project to generate electricity Lamphun Provincial Administrative Organization	Lamphun	10.0
17	Solid waste disposal project to generate electricity Wiang Fang Municipality	Chiang Mai	10.6
18	Solid waste disposal project to generate electricity Ban Luang Subdistrict Municipality	Chiang Mai	1.0
19	Solid waste disposal project to generate electricity Phayaman Subdistrict Administrative Organization	Uttaradit	9.8
4.3 Northeastern region, 14 projects, 21.2 MW			
20	Waste disposal project to generate electricity Kut Khao Subdistrict Administrative Organization	Khon Kaen	1.0
21	Solid waste disposal project to generate electricity, Ubonrat Subdistrict Municipality	Roi Et	0.5
22	Solid waste disposal project to generate electricity Roi Et Municipality	Roi Et	1.5
23	Solid waste disposal project to generate electricity Phon Thong Municipality	Roi Et	3.0
24	Solid waste disposal project to generate electricity Ummao Municipality	Roi Et	5.0
25	Solid waste disposal project to generate electricity Electricity Generating Kaset Wisai Municipality	Nong Khai	6.2
26	Waste disposal project to generate electricity Nong Khai Municipality	Nong Khai	0.5
27	Solid waste disposal project to generate electricity. Tha Bo Municipality	Nong Khai	0.5

Source: Power Development Plan 2018 (Revision 1), Arthur D. Little analysis

都市ゴミはエネルギー生成の潜在的な供給源とみなされ、プロジェクトが進行中(5/5)

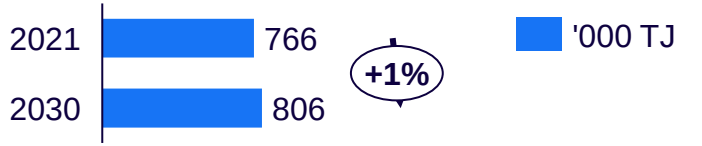
Waste-to-energy power projects, totalling 400 MW

#	Name	Province	Quantity offered sell electricity, MW
28	Garbage disposal project to generate electricity Si Chiang Mai Municipality	Nong Khai	0.5
29	Garbage disposal project to generate electricity Soem Sub-district Municipality	Nong Khai	0.5
30	Garbage disposal project to generate electricity Electricity Chumphon Sub-district Municipality	Nong Khai	0.5
31	Garbage disposal project to generate electricity Kut Bong Sub-district Municipality	Nong Khai	0.5
32	Garbage disposal project to generate electricity Pak municipality	Nong Khai	0.5
33	Solid waste disposal project to generate electricity	Nakhon Ratchasima	0.5
4.4 Eastern region: 2 projects, 31.4 MW			
34	Waste disposal project to generate electricity Si Racha Municipality	Chonburi	7.4
35	Solid waste disposal project to generate electricity. Pattaya Municipality	Chonburi	24.0
4.5 Southern region: 4 projects, 22.5 MW			
36	Waste disposal project to generate electricity Songkhla City Municipality	Songkhla	4.6
37	Solid waste disposal project to generate electricity Chumphon Municipality		3.0
38	Solid waste disposal project to generate electricity. Pattani Municipality	Chumphon Pattani	5.0
39	Solid waste disposal project to generate electricity. Phatthalung Municipality	Phatthalung	9.9

Source: Power Development Plan 2018 (Revision 1), Arthur D. Little analysis

タイのバイオマス市場のエネルギーポテンシャルは約80万TJに達し、木材残渣、サトウキビバガス、もみ殻が現在の主たるエネルギー原料

Market size and forecast (energy potential)



Major biomass players

- Major wood pellet companies: Asia Biomass public, Biomass fuel pellets

Government direction

- BOI[1] provides waiver of income and import taxes for maximum of 8 years for firms which invest in renewable energy (RE)
- EERF[2] & local financial institutions (FIs) total spending of ~USD 98mn since 2003 on RE projects
- Generally support the use of biomass feedstocks for power generation

Key highlights

- Biomasses like rice husk, sugar bagasse, wood chips, PKS are mostly being used in power generation and partially in industrial heating
- Relatively high competition in feedstock sourcing for power plants across different feedstocks.
- Wood residues from rubber mostly uncertified while face sourcing competition with plywood production

Major biomass feedstock overview[1]

Supply biomass	Energy potential (2021)	Biomass form	Demand (use cases / applications)
▪ Wood timber	53 '000 TJ	▪ Briquette / pellet ▪ Woodchips	▪ Wood pellet: 63% export + 37% domestic consumptions for industrial heating at pharma/ food companies ▪ Wood chips: Power generation
▪ Sugarcane bagasse	94	▪ Bale	▪ Power generation or boiler heating at sugar mill
▪ Rice husk	133	▪ Briquette	▪ Power generation or boiler heating at rice mill

Note: 1. Bank of Investment – Thailand. 2. Energy Efficiency Revolving Fund. 3. Department of Alternative Energy Development and Efficiency – Thailand
Source: Arthur D. Little analysis

ADEP2018では、バイオ燃料の目標値が引き下げられた

Biofuel provisions for transportation sector

2015 & 2018

Fuel type	AEDP 2015 plan		AEDP 2018 plan	
	mn liters/day	ktoe[1]	mn liters/day	Ktoe[1]
1. Ethanol	11.30	2,104	7.50	1,396
2. Biodiesel	14.00	4,405	8.00	2,517
3. Pyrolysis oil	0.53	171	0.53	171
4. Biomethane	4,800 tons/day	2,023	-	-
5. Other alternative fuels		10	-	-
Total		**8,713**		**4,085**
Transport sector demand for fuel		34,798		40,890
Biofuels against fuel consumption in the transport sector (%)		25.04		9.99
Biofuels per final energy demand (%)		6.65		3.22

COMMENTS

- Targets in the AEDP 2018 were revised lower after taking into consideration the following:
  - The transportation system development plan from the Ministry of Transport
  - Energy conservation plan in the transport sector
  - Development of electric vehicle technology (which the government is pursuing aggressively)
  - Limitations of current automotive technology to support the use of biofuels
- Fund Act 2562 (2019) further reduced subsidies available for biofuels

Note: 1) Thousand tons of oil equivalent
Source: USDA GAIN Thailand Biofuel Annual Report 2022, Arthur D. Little analysis

一方で、政府はバイオエタノール製造の原料となるキャッサバやサトウキビの増産を狙っている

Potential of cassava and molasses for bioethanol production

2017 – 2019 & 2026

Potential of cassava and molasses	2017	2018	2019	2026
Cassava				
• Target planting area (mn rai)	8.911	8.321	8.721	8.52
• Cassava production (Mt/year)[2]	30.491	29.371	31.551	59.52
• Consumption consumption (Mt/year)[2]	8.331	10.881	12.272	18.062
• Remaining cassava for ethanol production (Mt/year)[2]	3.27	2.72	2.932	5.712
• Ethanol used produce (mn liters/day)	1.43	1.19	1.28	2.50
Molasses				
• Target planting area (mn rai)	9.863	11.183	11.463	164
• Sugar cane yield (Mt/year)[1]	92.953	134.923	130.983	1824
• Molasses for consumption (Mt/year)[2]	1.003	1.003	1.003	1.003
• Remaining molasses for ethanol production (Mt/year)[2]	2.89	4.48	4.875	7.195
• Ethanol produced (mn liters/day)	2.57	2.87	3.19	4.72
Total ethanol produced (mn litres/day)	4.00	4.06	4.47	**7.22**

COMMENTS

- Ministry of Energy is pushing to use excess cassava and molasses[1] as a raw material for commercial bioethanol production via the following plans:
- Cassava strategy 2015 – 2026
  - Maintain plantation area while increasing productivity to reach 8.52 mn rai in 2026, an increase in productivity from 3.5 tons/rai/year in 2014 to 5 tons/rai/year in 2019 and 7 tons/rai/year in 2026
- Sugarcane and sugar factory strategy 2015 -2026
  - Expected yield of 182 Mt[3] of sugarcane in 2026 from the planting of 10-16 mn rai, where the leftover juice or syrup will be used as bioethanol raw material

Note: 1) Preferred over cassava; 2) Million tons per year; 3) Million tons
Source: USDA GAIN Thailand Biofuel Annual Report 2023, Arthur D. Little analysis

バイオディーゼルの消費が進む

Biodiesel[1] key metrics

2013 – 2022, mn litres

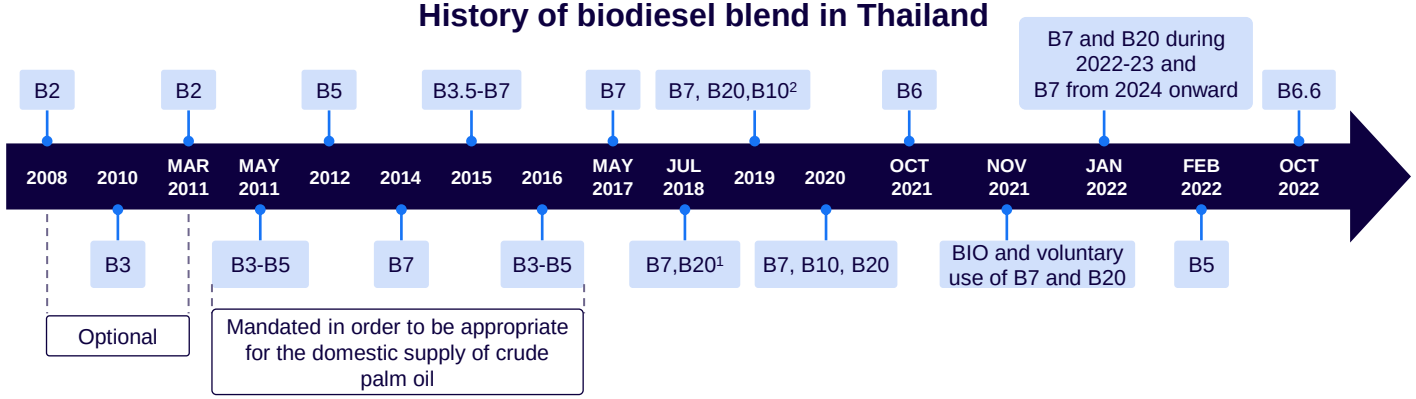
	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023f
Beginning stocks	20	18	24	20	50	50	86	56	35	36
Production	1,170	1,250	1,240	1,427	1,567	1,845	1,843	1,658	1,391	1,660
Imports	12	2	5	2	2	2	1	0	0	0
Exports	4	3	16	4	1	21	3	7	9	10
Consumption	1,180	1,243	1,233	1,395	1,568	1,790	1,871	1,672	1,381	1,645
Ending stocks	18	24	20	50	50	86	56	35	36	41

Note: f = forecast; 1) Including ethanol used as fuel and other industrial chemicals but excluding beverage ethanol
Source: USDA GAIN Thailand Biofuel Annual Report 2023, Arthur D. Little analysis

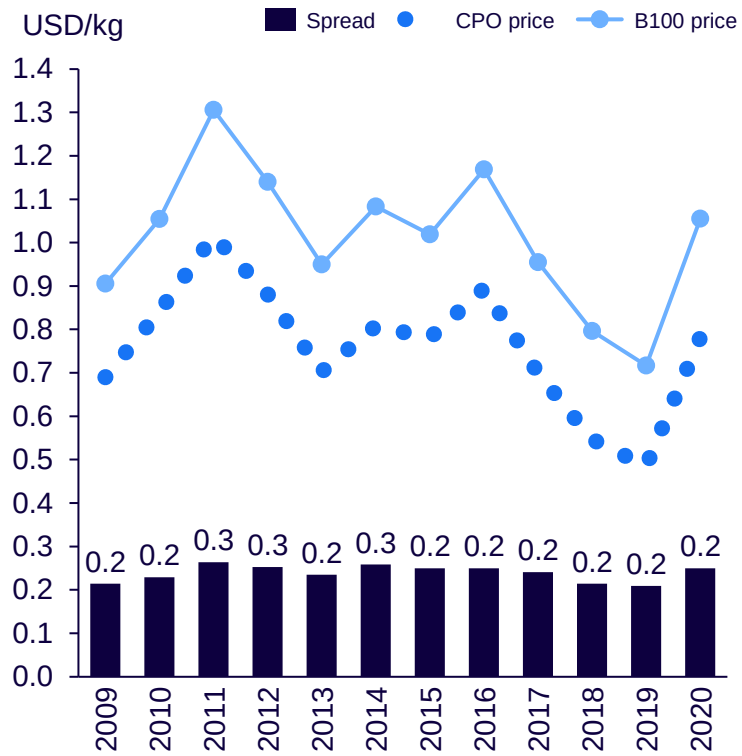
パーム油の価格に連動して、価格が大きく変動

Biodiesel landscape

History of biodiesel blend in Thailand



Price and spread



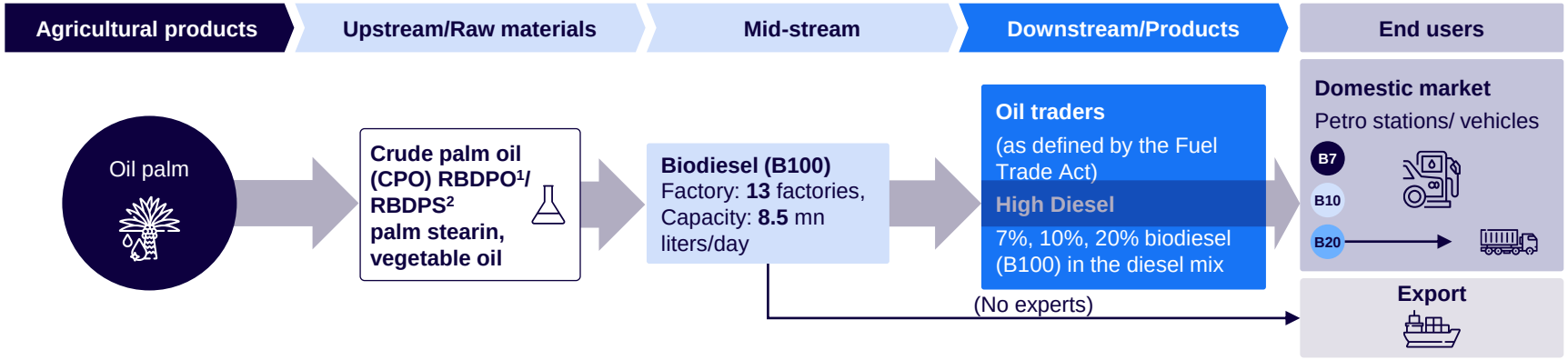
- Thailand is the 5th largest producer of biodiesel as of 2019 coming in at 1.8 bn litres, largely consisting of crude palm oil (CPO)
- The Thai government routinely changes the required blends in accordance with fluctuations in palm oil prices, reducing when price increases and reverting when supply catches up
  - A drought in the first half of 2020 severely impacted CPO yields resulting in supply shortages and causing CPO price to spike, and as a result, the price of biodiesel
- Blending rate dropped from B10 to B5 in 2022, with new mandatory blending rates ranging from B7 – B20 in 2022 and 2023, with B7 being the only mandatory blend rate 2024 onwards

Note: 1) On July 2018, B20 is used for large trucks and public buses which can absorb the surplus of crude palm oil; 2) DOEB announced a pilot program for the distribution of B10 beginning in June 2019. Then from January 1, 2020, B10 has replaced B7 as the standard diesel
Source: Energy Policy and Planning Office 2023, Department of Internal Trade 2021, Department of Energy Business Krungsri 2021, Arthur D. Little analysis

バイオディーゼルとしては、上位4社が全生産量の50%以上を占有

Biodiesel landscape

Biodiesel supply chain



- Market structure: 13 registered biodiesel producers as of Dec 2020, with a majority in downstream companies belonging to palm oil, petrochemicals or oil refinery firms
- Production cost: CPO (7-70%), chemical inputs (~20%), operating expenditure (~10%)

	Company	Capacity, liter/day
1	Patum Vegetable Oil	1,800,000
2	Global Green Chemicals	1,722,242
3	New Biodiesel	1,000,000
4	Bangchak Biofuel[3]	1,000,000
5	Energy Absolute[4]	650,000
6	PPP Green Complex	630,000
7	AI Energy	600,000

	Company	Capacity, liter/day
8	Suksomboon Energy*	450,000
9	GI Green Power	200,000
10	Verasuwan	200,000
11	Global Bio Power	150,000
12	Trang Palm Oil	100,000
13	Bio synergy	30,000
Total		**8,532,242**

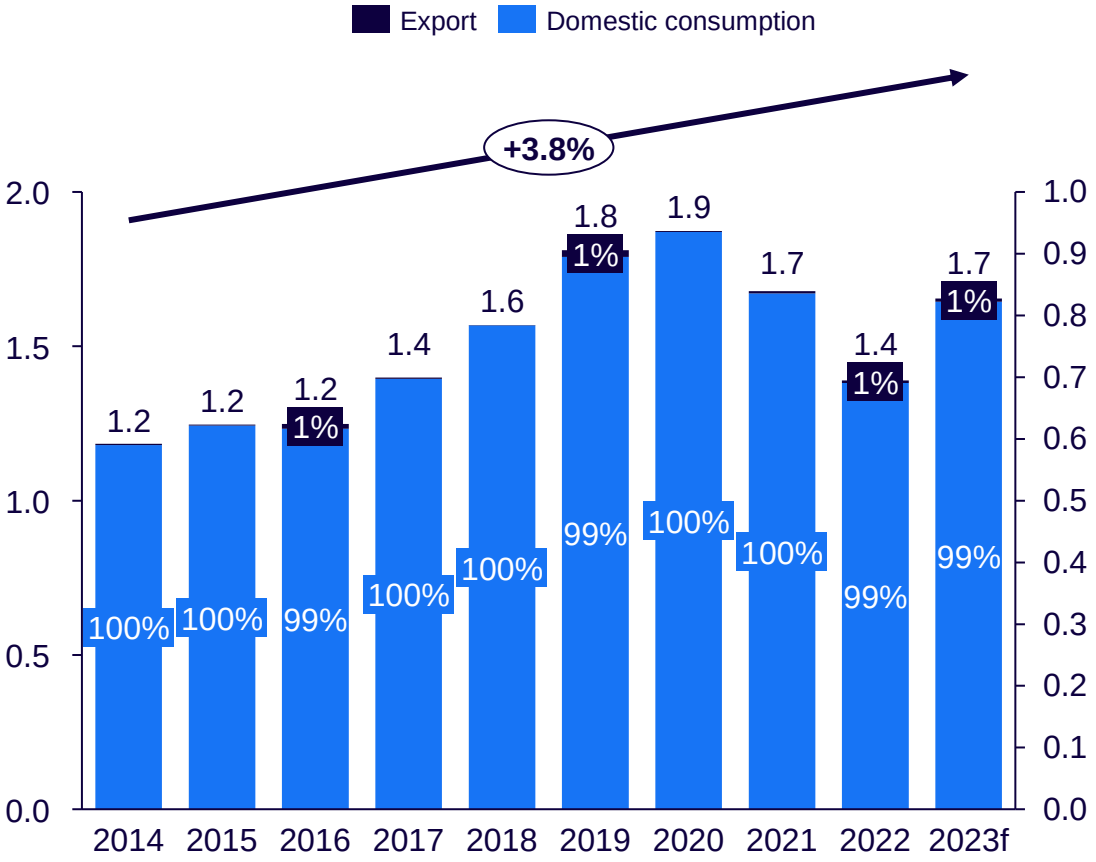
Maximum possible output	2018-2022	2023-2027	2028-2032	2033-2037
CPO used to produce biodiesel (Mt/year)[5]	1.55-2.36	2.45-3.07	3.10-3.12	3.32-3.48
Biodiesel (mn liters/day)	**4.88-7.44**	**7.72-9.67**	**9.77-9.83**	**10.46-10.96**

Note: 1) Refined bleached and deodorized palm oil; 2) Refined bleached and deodorized palm stearin; 3) Expand production capacity; 4) Reduce production capacity; 5) Million tons per year
Source: Department of alternative energy development and efficiency (DEDE)

2011年から2023年までのバイオディーゼル消費量は、政府の介入を背景に変動が激しい

Biodiesel key metrics and comments

2011 – 2021, Bn tons



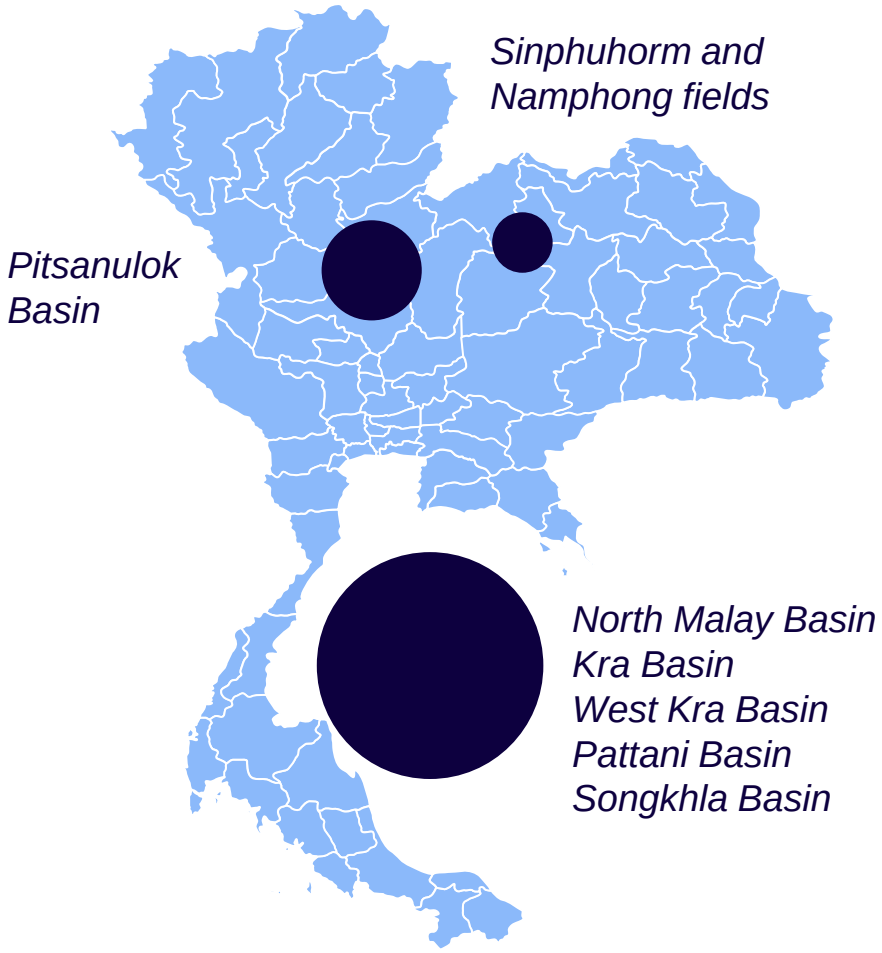
- Despite the slight increase of 3.8% YOY from 2011 – 2023, biodiesel consumption fell by ~17% in 2022 despite a 16% increase in diesel fuel demand
- This largely stemmed from the drop-in blending rate from B10 to B5 in 2022
  - Automotive manufacturers are complying by machine engines that specifically efficiently run on B7
- Blending rate range as of Feb 2022:
  - B7: 5 – 7%
  - HSD: 5 – 10%
  - B20: 5 – 20%
- The higher blending rate is set to increase demand in 2023

Type of Diesel	2018	2019	2020	2021	2022	January-March		% Change
						2022	2023	
B7[1]	23,089	21,852	16,033	14,543	23,317	5,826	5,999	3.0
B10[1]	-	34	5,935	7,028	834	314	97	-69.1
B20[1]	19	1,631	1,269	360	68	19	15	-24.9
Other[1]	478	1,062	683	1,075	2,444	704	765	8.8
Total[1]	**23,587**	**24,579**	**23,920**	**23,005**	**26,863**	**6,863**	**6,876**	**0.2**

Note: 1) Values in million litres
Source: USDA GAIN Thailand Biofuel Annual Report 2022, Arthur D. Little analysis

タイのCO2総貯留容量は約2.69GtCO21で、主にタイ湾に集中

Carbon Capture & Storage (CCS) Potential in Thailand



COMMENTS

- Approximately 90% of Thailand's total current CCS potential is located within the **Gulf of Thailand**

Note: Map is illustrative and not drawn to scale; 1) Billion tons of CO2
Source: Asia CCUS Network 2023, Asia Clean Energy Forum 2020

タイでは、CCUSの政策状況は比較的新しく、ほとんどの政策メカニズムはまだ発展途上

NON-EXHAUSTIVE

Overview of the CCUS policy landscape

Category	Details	Status
National Committee on Climate Change Policy	• Approved the establishment of the Greenhouse Gas Reduction Steering Subcommittee at the 1/2022 meeting, which will steer technology applications for the country's carbon capture, utilization and storage	Established
5-Year Plan (2022-2027)	• Focusing on CCUS deployment and development in both upstream and downstream industry • The Ministry of Energy will oversee the involvement of national oil companies, utilities, and the private sector in developing a comprehensive CCUS Roadmap	In development
CCUS business and revenue model	• Expected to be completed by 2026 • Business models are expected to include CCUS installations retrofitted in existing coal-fired power plants and CO2 sinks in depleted reservoirs	In development

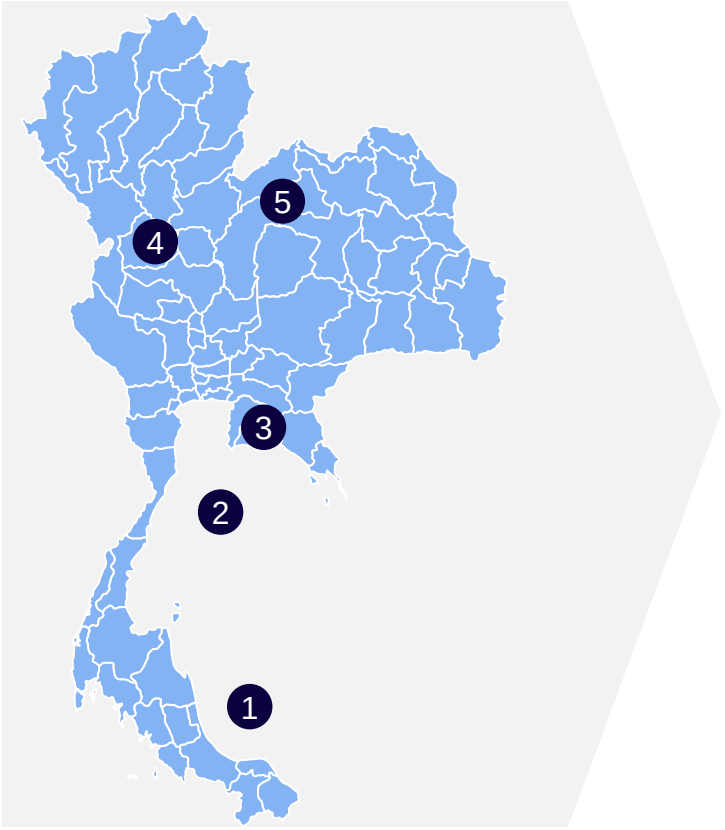
Policy drivers and incentives to drive CCUS deployment in Thailand are currently nascent, but are expected to develop progressively over the next few years

Source: Asia CCUS Network 2023, PTT Exploration and Production 2023

現在タイで観測されているCCUSプロジェクトは5件のみで、大半は「サンドボックス」段階

Observed CCUS projects

As of June 2023

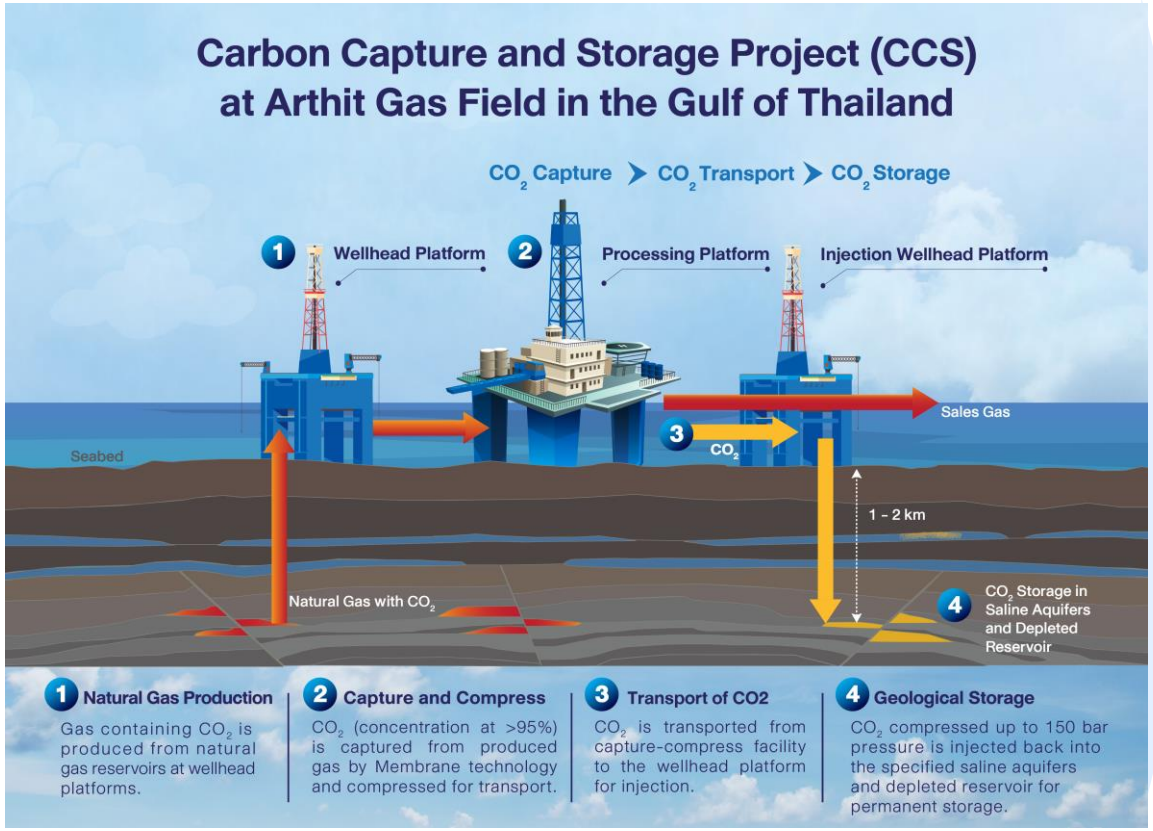


#	Name	Details	Status
1	Arthit Gas Field Pilot Project	• Preliminary assessment of carbon storage capacity and corresponding development plan completed, alongside the preliminary front-end engineering and design (Pre-FEED) • The FEED is underway and PTTEP expects to execute CCS technology at Arthit Field around 2026	Front-end engineering and design in development
2	Kra Basin Pilot Project	• Unknown	Unknown
3	BLCP Pilot Project	• Still under its initial phase of development • The Thai government is collaborating with the Japanese government to scale up methane production	Under discussion
4	S1 Pilot Project	• Under discussion with EGAT and PTTEP on potential collaboration	Under discussion
5	Phu Horm Pilot Project	• Final investment decision expected in late-2023	Under discussion

Note: Map is illustrative and not drawn to scale
Source: Asia CCUS Network 2023, PTT Exploration and Production 2023, Energy Voice 2022

Case study:PTTグループ傘下のPTTEPが、タイ初の炭素回収・貯留（CCS）プロジェクトを2021年に開始

Arthit Gas Field CCS pilot project



Background

Initiated in 2021, to reduce PTTEP's emissions from its petroleum production process in the Gulf of Thailand

Current status

Feasibility studies completed, with front-end engineering and design underway. Technology deployment is presently expected around 2026

Targets

Targeted reduction in carbon dioxide emissions by approximately 700,000 to 1,000,000 tons per annum

Source: PTT Exploration and Production 2023

PTTEPは、タイにおけるCCSの分野で、いくつかの共同研究やパートナーシップを実施

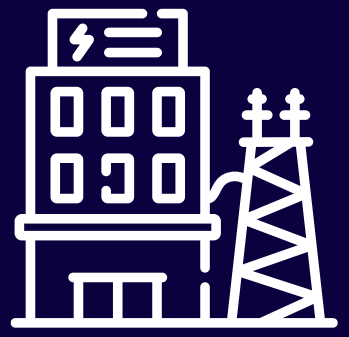
Observed PTTEP CCS collaborations

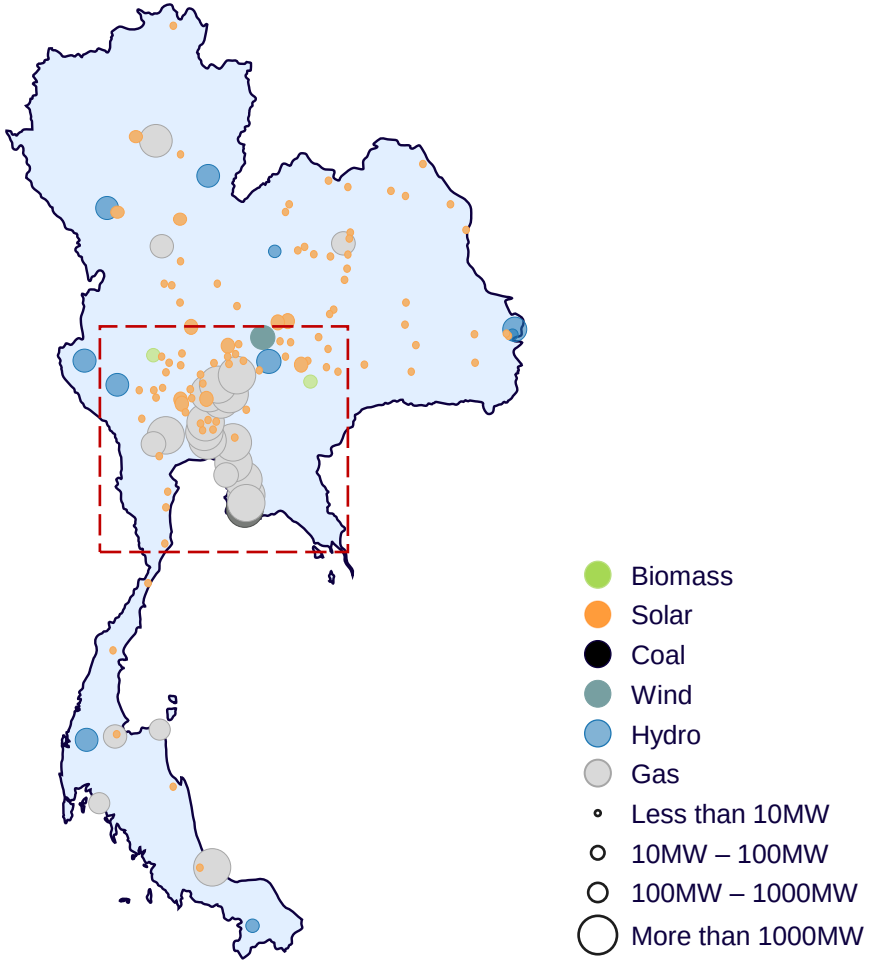
July 2022	**CCUS Technology Development Consortium**	• PTTEP jointly announced the establishment of Thailand's CCUS Technology Development Consortium led by the Bio-Circular-Green economy Technology & Engineering Center (BCGeTEC), Faculty of Engineering, Chulalongkorn University • The consortium will build a collaborative network for the **study and development, and utilization of CCUS technology** in Thailand
June 2022	**PTT Group CCS Partnership**	• PTTEP announced a partnership with companies in the PTT Group to conduct a **feasibility study on the application of CCS** under the concept of CCS Hub Model • The study started off in PTT Group's nearshore operational sites in **Rayong and Chonburi provinces**, targeted to reduce the emissions of the Group and nearby industries
April 2022	**International CCS Partnership**	• PTTEP announced a CCS partnership with **INPEX CORPORATION and JGC Holdings Corporation** from Japan, who have experience in CCS project development • The partnership will **explore the potential development of a CCS project** in other areas of Thailand that will help reduce greenhouse gas emissions emitted by other industries

Source: PTT Exploration and Production 2023

Emission source – Coal-fired power generation / Natural gas-fired power generation

POWER PLANTS IN THAILAND





COMMENTS

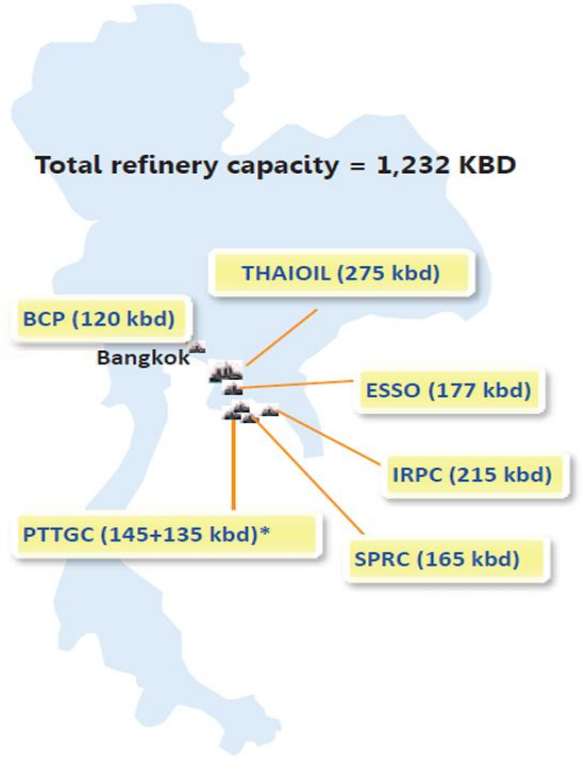
- Higher-capacity coal and natural gas power plants appear concentrated within **Central Thailand** – such as the Bangkok Metropolitan Area and Chonburi/Rayong Provinces
- This is likely due to the proximity to **dense population centers** and nearby industrial estates

Note: Map is illustrative and not drawn to scale
Source: Greening the Grid 2018, World Resources Institute 2018

Emission source – Refinery/Steel plants

Oil refineries and key steel producing regions in Thailand

Oil refineries



Steel producing regions

COMMENTS

- Oil refineries and steel producers/mills also appear concentrated within **Central Thailand** – such as the Bangkok Metropolitan Area and Chonburi/Rayong Provinces
- This is likely due to the presence of **well-developed port infrastructure** in the region, with a number of commercial and industrial ports, such as:
  - Bangkok Port
  - Laem Chabang Port
  - Map Ta Phut Industrial Port

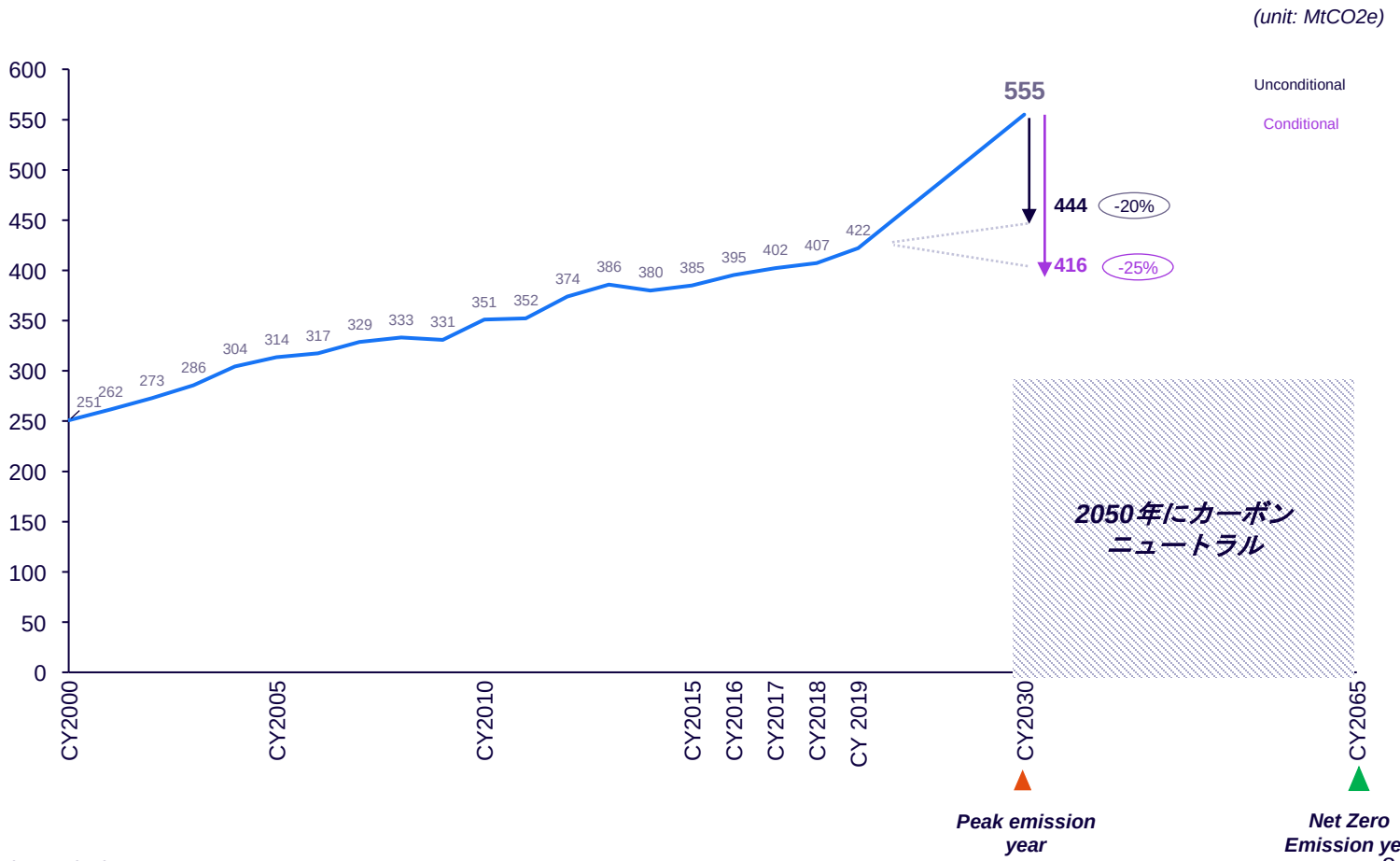
Note: Maps are illustrative and not drawn to scale
Source: DBS 2020, Thai Energy Academy 2020, Arthur D. Little analysis

タイは現在、2065年をネットゼロの確定年とし、条件付きで2030年の排出量を25%削減すると発表しており、GHG排出のピーク

GHG Emission Trends

- **Update:** From 2021, Thailand has announced a **definitive CN year of 2050 and GHG zero emission of 2065** compared to previously giving a year range of 2065-2070
- Peak emission year remains **2030** at **444 Mt CO2e**
- **Update:** Peak emission year value may be further reduced by **5% (25% in total)** provided conditional support is extended
- Conditional support relates to access to technology development, transfer, financial resources, and capability building support by developed market
- **No official GHG reduction schedule beyond 2030 up to net zero year**
- As a result**, ambiguity remains** about the seriousness and **position of Government**

GHG Emission Levels



Source: Public News, World Bank Emission Indicator, Arthur D. Little Analysis

補助金や税制優遇措置で代替エネルギーの利用を増やし、規制でエネルギー効率を高める政策

	GHG Target Action		Detail
アメの政策	助成金	• Subsidy is provided to alternative energy (biofuel and solar PV) to boost alternative energy adoption	■ Biofuel subsidy – Price subsidy for Gasohol (E20, E85) and biodiesel (B10, B20), allocated and managed by oil fuel fund committee ■ Feed in Tariff for C&I solar prosumer
	税制優遇措置	• Mainly for transport sector, via tax incentives for EV production and consumption	■ Production: Up to 13 years tax holidays for EV producer under board of investment scheme ■ Consumption: Special excise tax for xEV and government EV fleet purchase
ムチの政策	排出権取引制度 (ETS)	■ Initiated in 2007, carbon credit trading is currently under pilot program which participation is voluntary basis ■ ETS policy development is commerce	• With the government's promotion of the establishment of carbon credit-related laws and regulations, Thailand V-ETS is now managed by the Thailand Green House Management Organization (TGO), an independent administrative agency.
	罰則	• No carbon pricing regulation, current program is for voluntary basis	• -
	規制	■ Mandates to increase renewable energy in power generation and limit new coal fire power plant ■ Regulates new building and machinery/ transport equipment with higher energy standard	■ Increase renewable energy up to 30% of power generation by 2037, and limits new coal fire plant ■ Energy efficiency code – a guideline for building and factory design to optimize energy consumption ■ Machinery equipment energy standard ■ Progressive vehicle tax based on GHG emission level ■ Set biofuel (E20 and B10) as national fuel standard

Source: Multiple news sources, Expert Interviews, Arthur D. Little Analysis

発電では2040年約68%の再エネ比率、輸送では、生産の約30%をZEV化と野心的な目標を掲げる(産業に関してのアクションへの言及は限定的)

More detail in following page

Industry		CN Target	Detail
Electricity/ Heat		• 72 MT-CO2e reduction in 2030	• 発電（電気と熱）における再生可能エネルギーの比率を高め、2037年に総発電容量の30%を目指していたが、総発電に占める再エネ比率を68%とさらにアグレッシブな目標に引き上げ • エネルギー最適化目標（建物・工場設計、機械設備）の設定を実施
Transportation		• 41 MT-CO2e reduction in 2030	• 炭素排出量に基づく自動車税の設定 • 2030年にゼロエミッション車（ZEV）の生産台数を全自動車生産台数の30%と設定（FCV何パーセントとの記載は無し)
Industry	Cement	N/A	• **CCUSや再生可能エネルギー**を採用するセメント会社に対する輸入関税の免除 • セメント製造におけるクリンカ使用量の削減
	Steel	N/A	• タイは、鉄鉱石からの鋼板製造プロセスがない • BCG政策による再利用、リサイクルの奨励
	Chemical	N/A	• 税制優遇、研究開発プロジェクトへの資金提供など、バイオケミカル製品の普及促進 • 税制優遇措置により再生プラスチックペレットの利用促進
Other		N/A	• 産業全体として、熱利用においてはバイオ燃料や電化＋再エネが重要と想定 • 炭素クレジット市場（タイ自主排出削減プログラム（T-VER））の試行実施 ✓ 2022年、タイで炭素税を導入するための調査を物品税局が開始

1 – Energy usage includes energy generation and consumption e.g. from manufacturing industry
出所： Ministry of Natural Resources and Environment, Department of Alternative Energy Development and Efficiency

特に国家エネルギー計画は、タイがクリーンエネルギーに移行し、二酸化炭素排出量を削減することを支援する政策で、RE/ZEVの導入を掲げている

National Energy Plan (NEP) Framework

NEP covers targets and actions to reduce GHG emission in energy sector, ranging from electricity sources to fuel for vehicles

RE >50% with ESS

More than half of electricity generated to be from **renewable energy which will be used together with battery. There are 4 key actions:**

- **Lower RE price**
- **Lower ESS cost**
- **Smart Grid development**
- **Distributed energy resource**

EV 30@30

Drive EV industry by:

- Increasing production of ZEVs to at least 30% by 2030
- Developing infrastructure including charging stations and battery

EE >30%

Increase energy efficiency (EE) to >30% by using energy efficient technology. Focus on 5 key sectors:

- Industrial
- Commercial
- Residential
- Agriculture
- Logistics

4D1E

Policy which involves

- Decarbonization
- Digitalization
- Decentralization
- De-regulation
- Electrification

出所： Ministry of Energy Thailand, EPPO

CNソリューションとしては発電において再エネ比率が68%(2040年時点) と注力度が高く、産業の熱利用においてはバイオ燃料と電化への注力度が高い

Long-term mitigation actions in key sectors

SELECTED

Carbon Neutrality | Net Zero

	2025	2030	2035	2040	2045	2050	2055	2060	2065
Power generation	• Efficiency improvement in powerplants • Use of RE • Phase out of oil powerplant	• Solar/ wind with battery storage		• Phase down of coal plants • **68% share of RE electricity** • CCS, CCU and BECCS		• Combined cycle NG • **74% share of RE electricity** • Phase out of coal plants	Not specified yet		
Transport	• Efficient engine vehicle (gasoline/ diesel) • RE (E10, E20, E85, B10, B20) • Electric train	• Phase down of ICE • **EV 30@30**			• Most efficient ICE with biofuels • High share of EV • **FCEV**	• Combined cycle NG • 74% share of RE electricity • Phase out of coal plants			
Mfg. industries/ IPPU	• Efficient boiler/ utility tech • RE (bioenergy) • Clinker substitution • Substitution of refrigerant	• Most efficient boiler/ utility tech • **RE (bioenergy)**	• **Electric heating tech**	• CCS in cement industry	• **Green hydrogen fuel** (to replace fossil fuel for hard to abate sectors such as steel, cement, etc.)	• Most efficient electrical devices/ boiler • RE (bioenergy)			

IPPU – Industrial Processes and Product Use, RE – Renewable Energy

出所：Thailand's Long-Term Low Greenhouse Gas Emission Development Strategy (Revised) as of November 2022

Actions involving hydrogen are highlighted in **blue**

一方で脱炭素の文脈では種々アクションが定義されており、REの文脈で水素にも注目され始めている

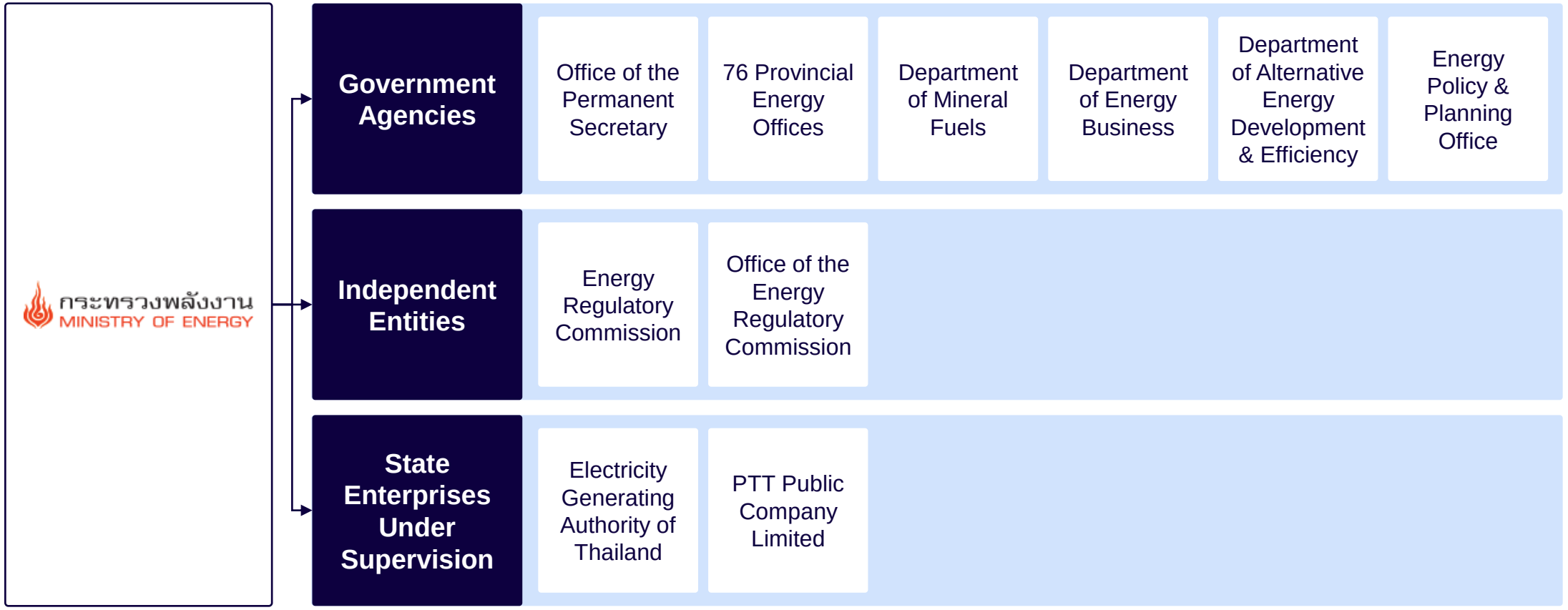
	Decarbonization	Digitalization	Decentralization	Deregulation	Electrification
Electricity	• Build new clean fuel plant • Retire fossil fuel power plant • Develop CCUS • Increase power generation efficiency • Reduce share of coal • Promote RE/Clean energy • Promote power trading with neighboring countries	• Develop Grid Modernization • Develop Smart Grid (Energy Management System and Smart Meter) • Develop Virtual Power Plant e.g. Demand Respond and V2G • Develop load forecasting for power system planning	• Develop flexible IPS management system • Develop Smart Micro Grid • Develop Grid Modernization • Develop Smart Grid RE+ESS • Develop power infrastructure	• Promote Peer-to-Peer and Net Metering • Electricity market Liberalization • Power trading with neighboring countries • Restructure electricity pricing • Third Party Access in power sector • Promote Wheeling Charge system	• Promote EV/EV Charging Station • Promote ESS • Electricity management to support EV
Oil & Gas	• LNG management • Promote the use of LNG in Industry and transportation • Upgrading refinery standard EURO 5-6 • Management of LPG and NGV • Promoting the proper use of Biofuel in the transport sector	• Develop a system for evaluating potential and regulating petroleum resources. • Develop a system to control, supervise and collect fuel information.	• Develop Gas Infrastructure (Piping and rail system, LNG receiving terminal) • Develop Oil Infrastructure (Oil depots, oil pipelines, rail transport)	• Gas market liberalization • Efficient management of offshore and onshore gas • Restructure gas pricing • Regulate pipe safety • Restructure oil pricing • Biofuel Cost Management • Regulate pipe safety	• Management of the fuel industry to support Evs • Change the use of LPG stoves to electric stoves.
RE	• Manage electricity generation from RE • **R&D Hydrogen** • Promote investment in RE technology market	• Set up a Data Platform and develop a RE Control Center data center.	• Develop Microgrid • Develop RE at the community level to improve farmers' lives and the basic economy	• Promote RE trading and P2P • Develop carbon credit mechanism • Determine RE purchase price • Develop biomass market for electricity and heat generation	None
EE	• Evaluate new potential, increase EE targets • Green Industry • Increase EE in homes, buildings and industrial plants. • Promote investment in EE technology market	• Promote Smart Energy Management system • Develop Digital Platform for energy conservation • Develop EV Data Platform	• Develop Infrastructure (Charging station) to support the use of EV	• Determine the government's ESCO measures • Establish compulsory measures • Use market mechanisms to promote energy conservation • Enforce energy conservation benchmarks for energy producers	None

出所： Ministry of Energy Thailand, EPPO

5 発電事業者

タイでは、エネルギー省がエネルギー部門の総督であり、政策立案者

Organizational structure of the Ministry of Energy



Source: Thailand Ministry of Energy 2023, Arthur D. Little Analysis

一方、独立したエネルギー規制委員会（ERC）は、発電、送電、配電の規制を担当

NON-EXHAUSTIVE

Mandate of the Energy Regulatory Commission

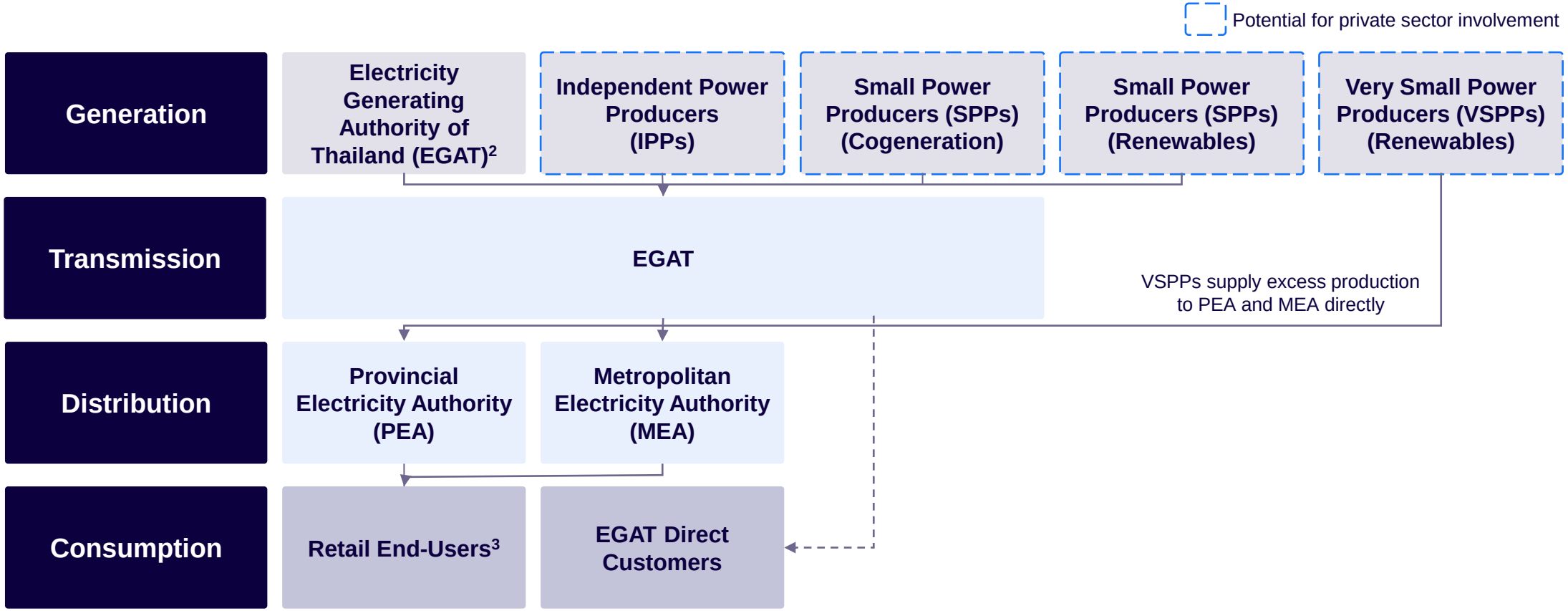
Energy Regulatory Commission
established by the Energy Industry Act 2007

Category	Details
Consumer protection	• Regulated primarily through the **Power Development Fund** (PDF). The PDF is funded by mandatory contributions of licensees operating in the energy industry, such as IPPs[1] and SPPs[2] • Disbursements from the PDF can occur when there is a natural disaster, or when electricity generators or distributors overcharge
Setting of licensing requirements for generation	• An **electricity generation license** must be obtained for an electricity generation plant to operate. This must be obtained from the ERC if the plant has a total capacity of 1,000 kW or more • Most generation plants must also obtain a **factory operation license** from the ERC, except rooftop solar photovoltaic installations up to 1,000 kWh, wind farms, and hydropower
Electricity supply and transmission	• Electricity Generating Authority of Thailand (EGAT) is the **single buyer of bulk electricity**, under **ERC-set regulations**. Electricity is then sold to: – The **Metropolitan Electricity Authority**, for the Bangkok metropolitan area and the provinces of Nonthaburi and Samutprakan – The **Provincial Electricity Authority**, for the remaining provinces – Various direct consumers and neighboring countries

Note: 1) Independent power producers; 2) Small power producers
Source: Thailand Ministry of Energy 2023, Thomson Reuters Practical Law 2020, Arthur D. Little Analysis

タイの電力生産は自由化済みだが、送電と配電チャンネルは依然としてEGAT.PEA.MEAの占有

Domestic electricity supply chain[1]



Note: 1) The generation, transmission, and distribution phases are highly regulated by the Government; 2) Includes imports of electricity purchased by EGAT, from overseas supply sources; 3) SPPs and VSPPs can generate electricity for their own consumption too
Source: Krungsri 2021, Arthur D. Little Analysis

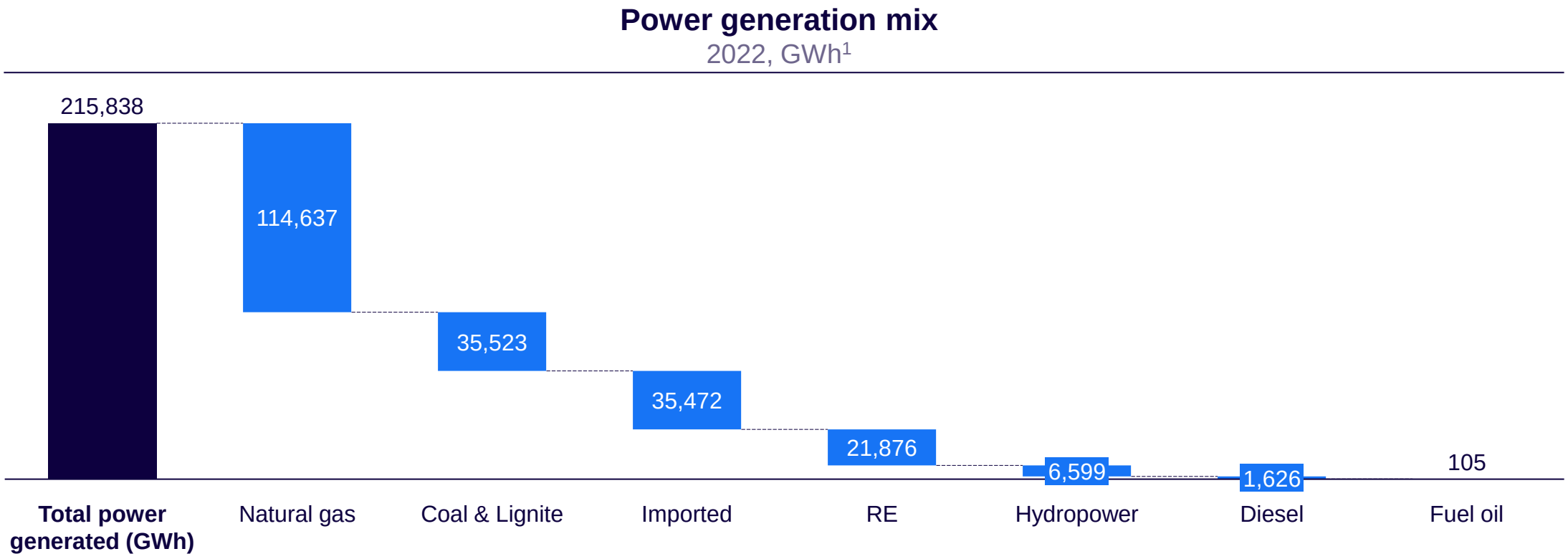
発電能力は、国営のEGAT、さまざまなカテゴリーの発電事業者、輸入に分離

Power generation capacity, by categories

1	Electricity Generating Authority of Thailand (EGAT)	• State-owned EGAT acts as both a **producer and a purchaser of energy** • Purchases power from overseas sources and private-sector IPPs and SPPs, before distribution • Has a monopoly over the transmission of electricity in Thailand
2	Independent Power Producers (IPPs)	• **Total installed generating capacity to qualify: Over 90 MW** • Mainly use **natural gas and coal** to fuel power stations, signing **long-term power supply contracts** with EGAT • Major players include Ratchaburi Electricity Generating Holdings, Gulf JP NS, and Gulf Power Generation
3	Small Power Producers (SPPs)	• **Total installed generating capacity to qualify: 10-90 MW** • (i) **'Firm'-type SPPs** have a 20-25-year EGAT contract and are normally fueled by **natural gas or coal** • (ii) **'Non-firm' SPPs** have 5-year extendable contracts and are normally fueled by **renewables**
4	Very Small Power Producers (VSPPs)	• **Total installed generating capacity to qualify: Under 10 MW** • Typically generate electricity from renewables (including solar, wind, hydropower, biomass, biogas and waste) • Mainly for self-consumption, with **surplus production sold** to MEA[1] or PEA[1] at feed-in tariff (FiT) rates
5	Energy Imports	• Often from neighboring countries, including Laos, Malaysia, and China

Note: 1) Metropolitan Electricity Authority (MEA) and the Provincial Electricity Authority (PEA), both state-owned and closely linked to EGAT
Source: Energy Policy and Planning Office 2023, Electricity Generating Authority of Thailand 2023, Krungsri 2021, Arthur D. Little Analysis

タイの発電構成は現在、天然ガス、石炭、輸入エネルギーが大半を占めている



Natural gas currently comprises 53.1% of Thailand's power generation mix, with coal & lignite at 16.5%, and imports at 16.4%. **RE[2]** currently comprises **10.1% of all power generated**

Note: 1) Gigawatt per hour; 2) Renewable energy includes solar, wind, and biomass renewable energy sources – and are grouped separately from hydropower in official government reports
Source: Energy Policy and Planning Office 2023, Arthur D. Little Analysis

タイ発電公社（EGAT）の概要

Core business operations

1 Electricity generation

- Electricity is generated from 53 EGAT power plants countrywide, with a total installed capacity of 16,920 MW

2 Electricity purchase

- EGAT also purchases bulk electricity from 12 Independent Power Producers (IPPs), Small Power Producers (SPPs), and several neighboring countries (i.e., Laos and Malaysia)

3 Electricity transmission

- EGAT's transmission lines comprise of different voltages ranging from 500 kV, 230 kV, 132 kV, 115 kV, and 69 kV
- EGAT sells electricity to its direct customers and to MEA and PEA, for nationwide distribution to their own retail customers

EGAT subsidiaries and associated companies

2022

Company	Ownership, %	Status	Summary
RATCH Group Public Company Limited	45.00	Subsidiary Company	Investment in the electricity generation and infrastructure development sphere
EGAT International Company Limited	99.99	Subsidiary Company	Represent EGAT in overseas investment in order to acquire electricity back to Thailand
EGAT Diamond Service Company Limited	45.00	Subsidiary Company	Provide refurbishment work for the hot gas path parts of gas turbine in 18 countries
Electricity Generating Public Company Limited	25.41	Associated Company	Conduct electricity and energy-related generation and business in Thailand and abroad
District Cooling System and Power Plant Company Limited	35.00	Joint Venture	Generate and sell electricity and cooling water to the Suvarnabhumi International Airport
INNOPOWER Company Limited	40.00	Joint Venture	Develop and make commercial use of research and innovations, as well as invest in future energy
InnoSpace (Thailand) Company Limited	13.61	Investment	Promote and develop Thai Start-ups to mobilize domestic economic development

Source: Electricity Generating Authority of Thailand 2023, Arthur D. Little Analysis

ERCによって義務付けられているように、発電事業者や発電会社には通常、タイ資本がマジョリティである必要あり

NON-EXHAUSTIVE

General qualifying criteria for power generation companies

คณะกรรมการกำกับกิจการพลังงาน Energy Regulatory Commission

ERC Regulation on

Qualifications, documents and procedures for obtaining electricity business license

Category	Details
General qualifying criteria	• Applicants must be corporate entities **registered in Thailand** and **foreign shareholding is limited to 49%** • At least half of the applicant company's **directors and shareholders** must be Thai. Directors authorized to bind the company must also be Thai • Power producers must always maintain the above qualifications
Potential exemptions	• Exemptions from the foreign shareholding and director requirements are possible for companies under international agreements or under other law • However, **in practice, the availability of exemptions is likely to be limited**
Minimum capital requirements	• For current power purchase agreements under the FiT scheme, a minimum capital requirement of **USD 58[1] per kW of capacity** is imposed

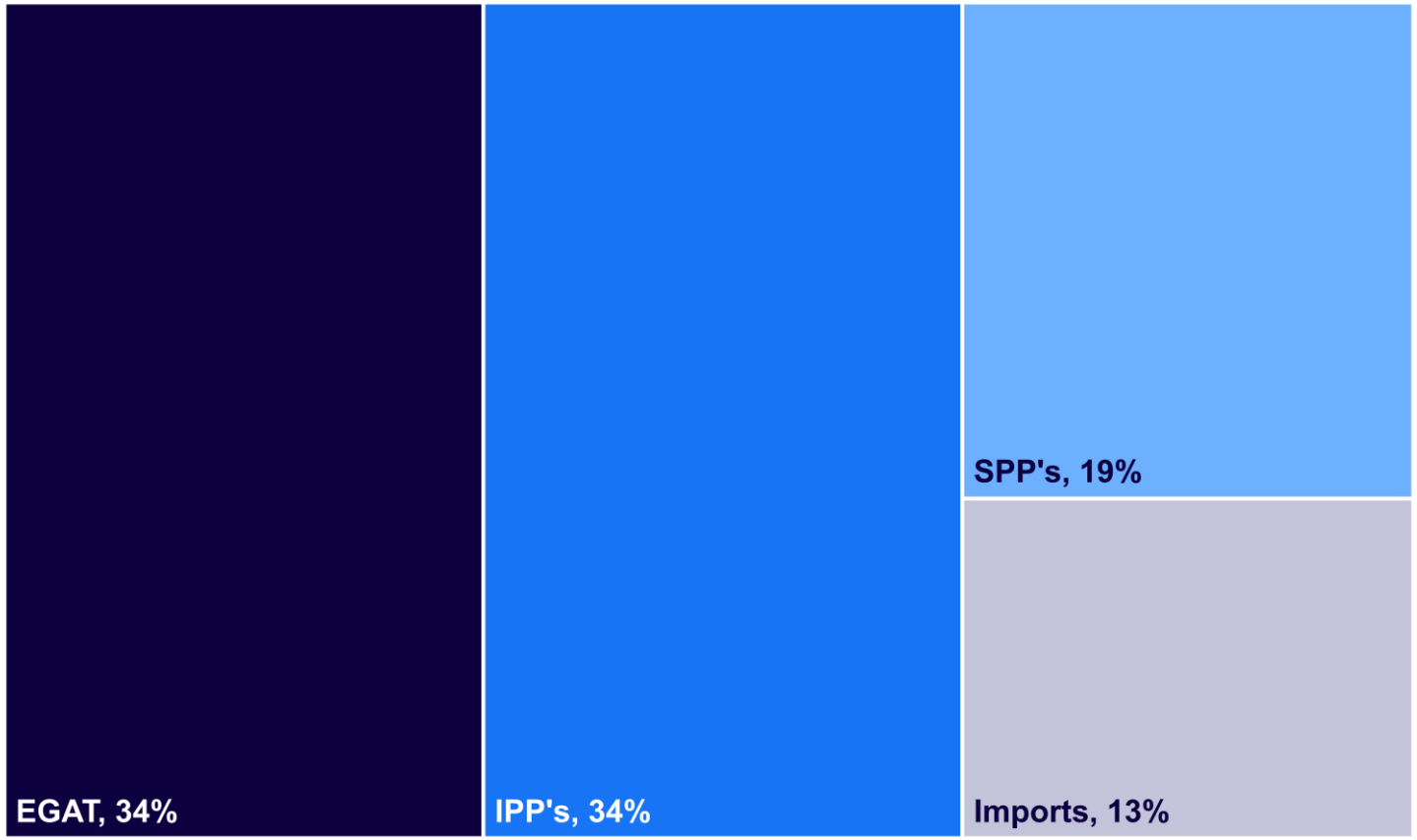
Hence, most power generation firms in Thailand fall under **local-majority ownership and decision-making control**

Note: 1) Exchange rate is 1 THB = 0.029 USD (2022 2 d.p. average)
Source: Norton Rose Fulbright 2022, Watson Farley & Williams 2022, Arthur D. Little Analysis

タイの発電市場は、EGATとIPPで6割を超えるシェアを占める

Market share in terms of installed generating capacity

2022



Description

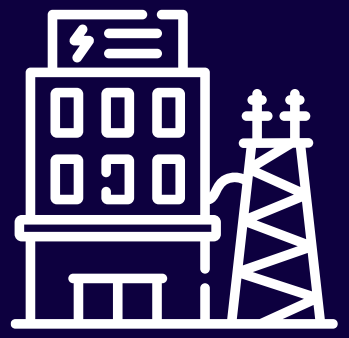
- State-owned EGAT and various Independent Power Producers both have a **roughly equal market share** in terms of installed generating capacity
- Energy imports currently form the smallest proportion of installed generating capacity

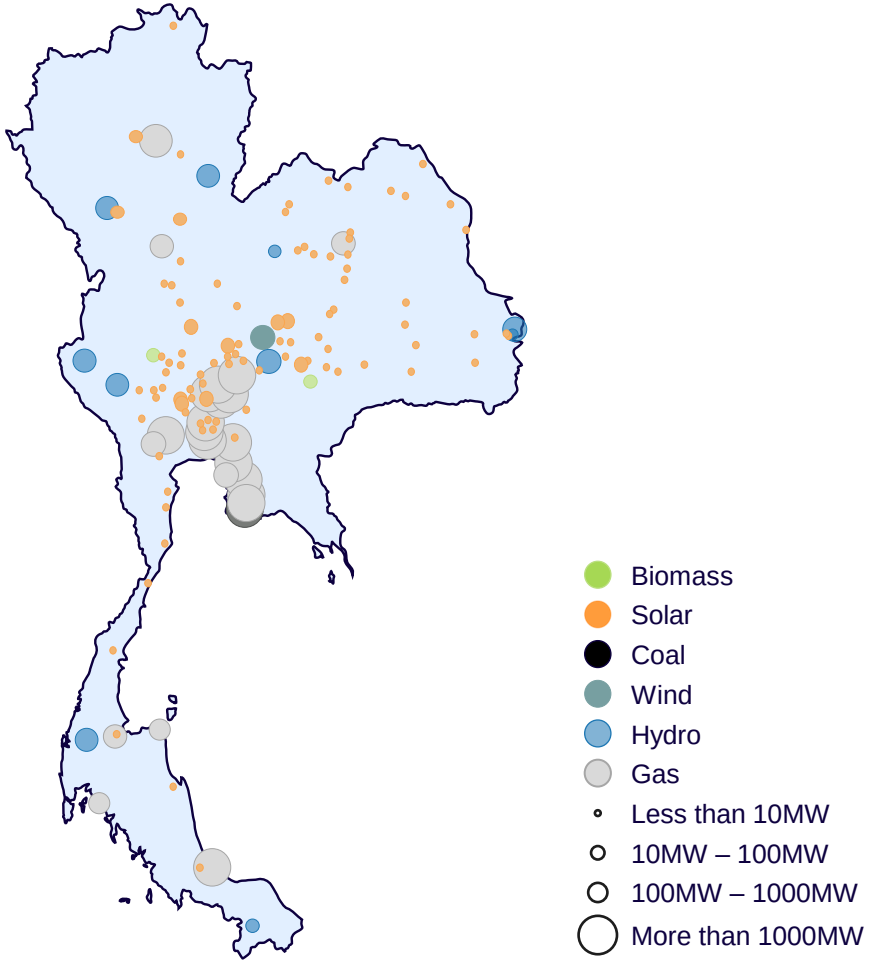
Source: Energy Policy and Planning Office 2023, Arthur D. Little Analysis

6 発電所

Map of power generation plant

POWER PLANTS IN THAILAND





COMMENTS

- The majority of higher capacity power plants in Thailand appear clustered in:
  - The Bangkok Metropolitan area
  - The Chonburi and Rayong provinces
- Solar power plants appear to be relatively more dispersed across Thailand, compared to other energy sources

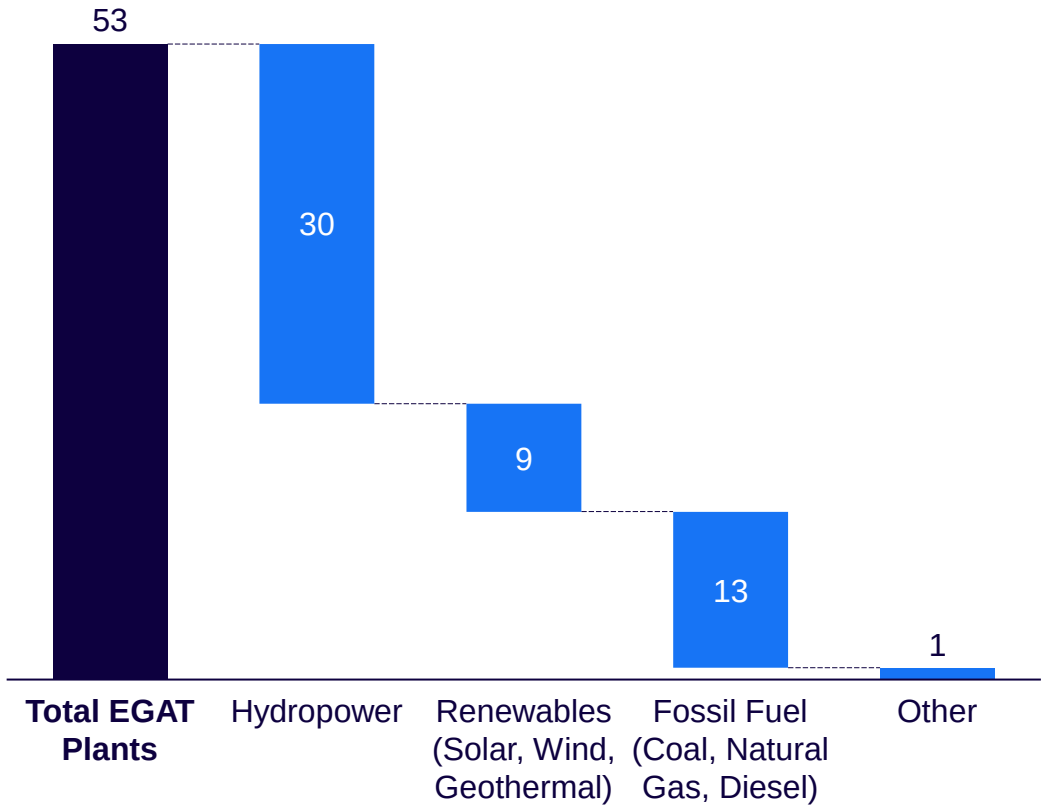
Note: Map is illustrative and not drawn to scale
Source: Greening the Grid 2018, World Resources Institute 2018, Arthur D. Little Analysis

EGATはタイ全土で53の発電所を運営しているが、そのうち13の発電所は化石燃料に依存

NON-EXHAUSTIVE

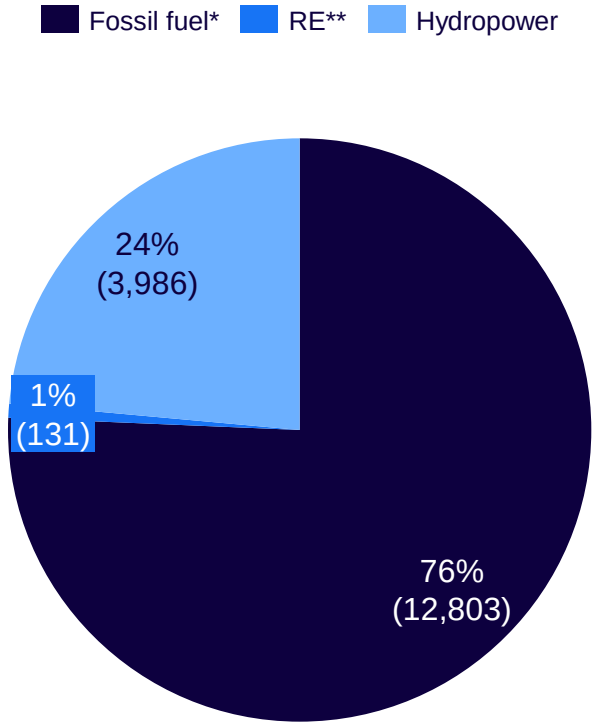
Breakdown of EGAT power plants

2022, Number of plants



Installed capacity in EGAT power plants

2022, MW



Note: Numbers assume that EGAT's combined cycle, thermal, and diesel power plants are fully reliant on fossil fuels; * Fossil fuels includes coal, natural gas and diesel; **RE includes solar, wind and geothermal
Source: Electricity Generating Authority of Thailand 2023, Arthur D. Little Analysis

List of observed Independent Power Producers (IPPs) in Thailand

NON-EXHAUSTIVE

#	Companies	Total contracted capacity, MW	Fuel type
1	Ratchaburi Electricity Generating Holding	3,481	Gas
2	Gulf JP NS	1,600	Gas
3	Gulf JP UT	1,600	Gas
4	Gulf Power Generation	1,468	Gas
5	Ratchaburi Power	1,400	Gas
6	BLCP Power	1,347	Coal
7	Electricity Generating	930	Gas
8	Glow IPP	713	Gas
9	Global Power Synergy	700	Gas
10	Gheco-One	660	Coal
11	Eastern Power & Electric	350	Gas

Major Independent Power Producers in Thailand rely on coal or natural gas fuel for power generation.
Ratchaburi Electricity Generating Holding and **Gulf JP** are the dominant players in the IPP sphere

Source: Krungsri 2021, Arthur D. Little Analysis

List of observed Small Power Producers (SPPs) in Thailand (1/2)

NON-EXHAUSTIVE

SPPs with firm power purchase agreements[1]

#	Companies	Total contracted capacity, MW	Fuel type
1	Amata B. Grimm Power (10 projects)	870	Gas
2	Gulf JP (6 projects)	540	Gas
3	Glow SPP (8 projects)	590	Gas, Coal
4	Gulf TS (4 projects)	360	Gas
5	Rojana Power (2 projects)	180	Gas
6	Glow Energy (3 projects)	194	Gas
7	National Power Supply (2 projects)	180	Coal
8	Ratchaburi World Cogeneration (2 projects)	180	Gas
9	SSUT (2 projects)	180	Gas
10	TOP SPP (2 projects)	180	Gas
11	Bangpa-in Cogeneration (2 projects)	180	Gas
12	B. Grimm BIP Power (2 projects)	180	Gas
13	Banpong Utilities (2 projects)	180	Gas
14	IRPC Clean Power (2 projects)	180	Gas
15	Siam Power Generation (1 project)	90	Gas

Note: 1) Firm PPAs are those with a term designated between 20 to 25 years, in which the project operator is required to provide electricity during peak demand months to EGAT
Source: Krungsri 2021, Arthur D. Little Analysis

List of observed Small Power Producers (SPPs) in Thailand (2/2)

NON-EXHAUSTIVE

SPPs with non-firm power purchase agreements[1]

#	Companies	Total contracted capacity, MW	Fuel type
1	Global Power Synergy (2 projects)	100	Gas
2	PTT Global Chemical	60	Gas
3	DCAP	65	Gas
4	IRPC	45	Gas, Coal

Fossil fuel-based SPPs tend to favor firm power purchase agreements with EGAT, instead of non-firm agreements

Note: 1) Non-firm PPAs have terms that do not exceed five years, during which the project operator would not be required to provide electricity in peak demand months to EGAT
Source: Krungsri 2021, Arthur D. Little Analysis

List of observed power plants – Natural gas (1/2)

NON-EXHAUSTIVE

#	Name	Capacity, MW	Primary fuel	Owner (s)
1	Amata B Grimm	733	Gas	B Grimm Power
2	B Grimm BIP	230	Gas	
3	Bang Bo	350	Gas	Eastern Power and Electric Company
4	Bang Pakong	4,384	Gas	EGAT
5	Bowin Clean Energy	132	Gas	
6	CUP-1	228	Gas	GPSC
7	CUP-2	114	Gas	GPSC
8	Chana	1,531	Gas	EGAT
9	EGCO Cogen	112	Gas	EGCO
10	GSPP 11	272	Gas	GLOW Group
11	Glow Demin	124	Gas	GLOW Group
12	Glow Energy Phase 2 Power Plant	258	Gas	GLOW Group
13	Glow Energy Phase 5 Power Plant	412	Gas	GLOW Group
14	Glow IPP	713	Gas	GLOW Group
15	Kaeng Khoi 2	1,468	Gas	EGCO
16	Khanom	748	Gas	EGCO
17	Krabi	340	Gas	EGAT
18	Laem Chabang	159	Gas	
19	Lan Krabue	150	Gas	EGAT
20	Nam Phom	710	Gas	EGAT
21	Nong Khae	126	Gas	EGCO

Source: World Resources Institute 2021, Arthur D. Little Analysis

List of observed power plants – Natural gas (2/2)

NON-EXHAUSTIVE

#	Name	Capacity, MW	Primary fuel	Owner
22	Nong Saeng	1,600	Gas	J-Power
23	North Bangkok Power Station	704	Gas	EGAT
24	Ratchaburi (RATCHGEN)	3,645	Gas	Ratchaburi Electric Generating Company
25	Ratchaburi Power (RPCL)	1,400	Gas	Ratchaburi Electric Generating Company
26	Rayong	1,232	Gas	EGCO
27	Rojana Power Plant 1	1,600	Gas	J-Power
28	Saha Patana	122	Gas	Sahacogen Co Ltd
29	South Bangkok	1,691	Gas	EGAT
30	Sriracha	700	Gas	GPSC
31	Surat Thani	244	Gas	EGAT
32	Tri Energy Power Plant	700	Gas	Ratchaburi Electric Generating Company
33	Wang Noi	2,027	Gas	EGAT

Source: World Resources Institute 2021, Arthur D. Little Analysis

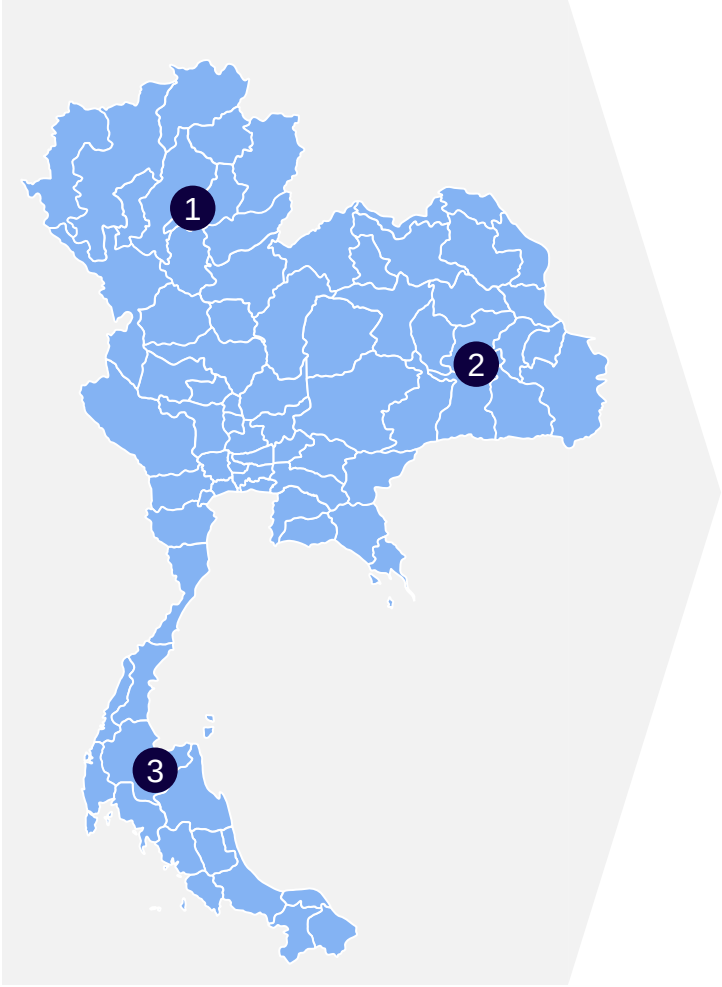
List of observed power plants – Coal and lignite

NON-EXHAUSTIVE

#	Name	Capacity, MW	Primary fuel	Owner
1	BLCP Power	1,347	Coal	EGCO
2	Gheco One Power Station	660	Coal	GLOW Group
3	Glow Energy Power Complex	526	Coal	GLOW Group
4	Mae Mah	2,400	Coal	EGAT
5	Tha Tum Power Station	328	Coal	National Power Supply PCL

Source: World Resources Institute 2021, Arthur D. Little Analysis

Observed power plant projects in development – Coal and lignite



#	Name	Capacity, MW	Primary fuel	Owner	Start-up year
1	Mae Moh 8-9 coal-fired projects	600	Coal	EGAT	2026
2	Not specified, but located in Eastern Thailand	1,000	Coal	EGAT	2033
3	Not specified, but located in Southern Thailand	1,000	Coal	EGAT	2034

Note: Map is illustrative and not drawn to scale
Source: Mongabay 2022, Enerdata 2021, Arthur D. Little Analysis

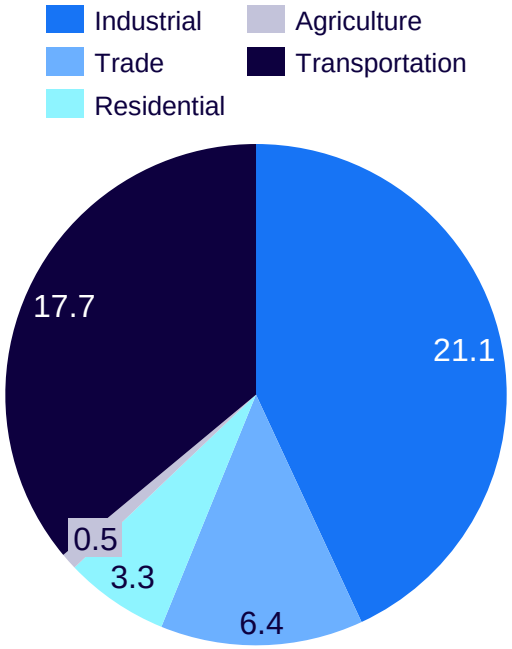
7 電力品質

エネルギー効率化計画は、2037年までにエネルギー原単位を2010年を基準に30%削減することをターゲットと設定

NON-EXHAUSTIVE

Total energy conservation targets by sectors

Mtoe*



Selected enabling mechanisms

Category	Details
Building regulations	• Develop laws specifying types or sizes of factories and buildings • Develop energy conservation criteria for building design, construction, and operation • Conduct enforcement measures, as needed
Labelling	• Create measures to support and incentivize voluntary energy efficiency labeling for equipment and appliances
Tax incentives	• Enforce a new excise tax rate structure in the private transportation sector, according to the amount of carbon dioxide emitted per car
Technology	• Promote the use of smart energy management systems and more energy-efficient technologies

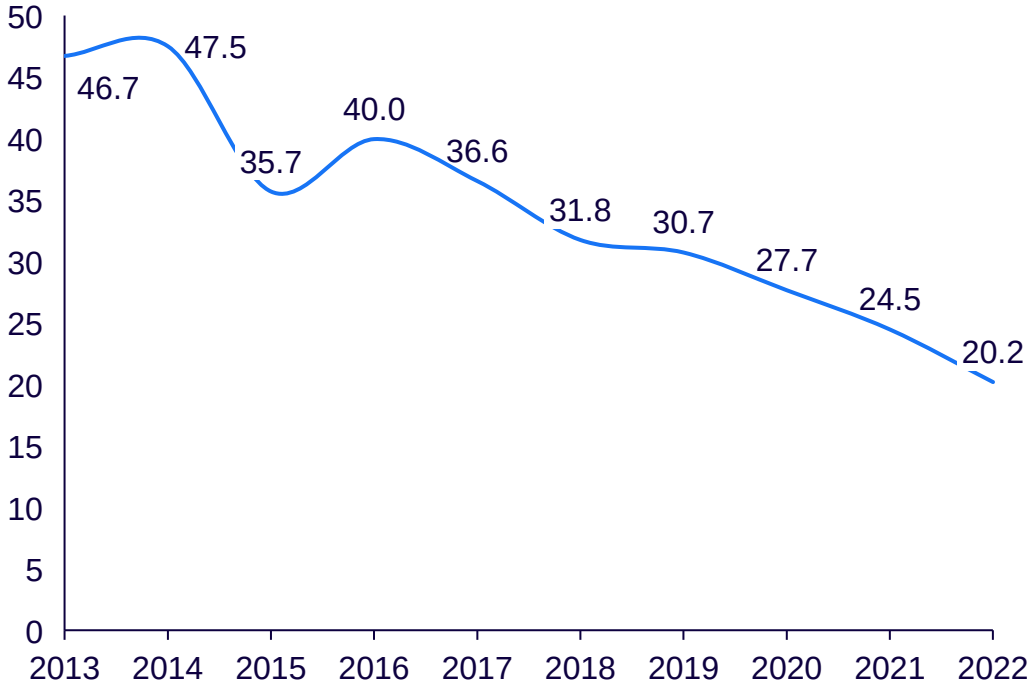
The industrial and transportation sectors form the primary focus of Thailand's energy conservation efforts

Note: * Million tons of oil equivalent
Source: Energy Efficiency Plan 2018, Arthur D. Little Analysis

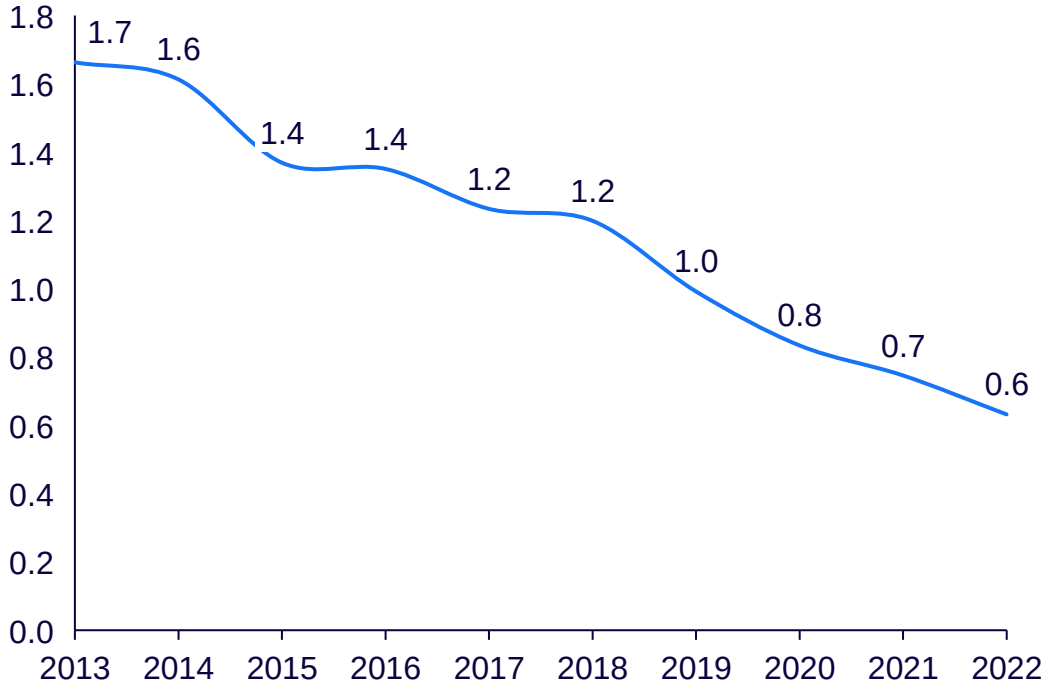
SAIDIとSAIFIの指標としての電力品質は、2013年以降一貫して改善

Electricity Quality Index
2013 - 2022

SAIDI[1]



SAIFI[2]



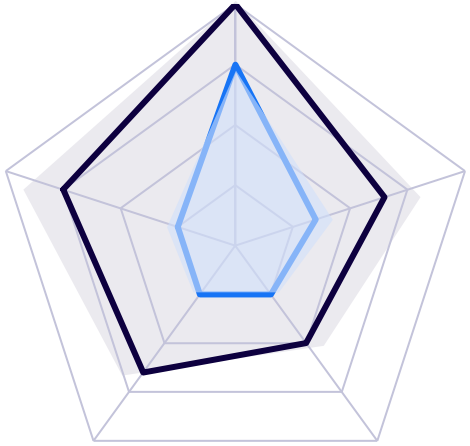
Note: 1) System Average Interruption Duration Index (Minutes/Customer/Year); 2) System Average Interruption Frequency Index (Number of Interruptions/Customer/Year)
Source: Metropolitan Electricity Authority 2023, Arthur D. Little analysis

タイは2030年の温室効果ガス排出目標達成のため、2015年に複数省庁による20年間のスマートグリッド・マスタープランを打ち出し

Overview

Security
Power Reliability and Quality
- Improved Reliability (e.g. SAIDI, SAIFI)
- Improved Power Quality (V, F)

Competitiveness
Economic and Industrial Stimulus
- Human Capacity Building
- Enhanced EMS for Competitiveness
- SG Technology, Product and Service Development & Export

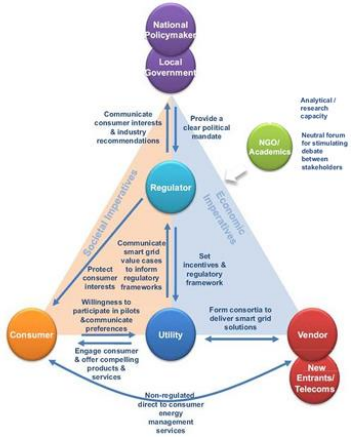


Sufficiency
Energy Sustainability and Efficiency
- RE/Domestic Energy Dependency
- Improved Utility Asset Management
- Primary Energy Efficiency
- Microgrid Development

Awareness
Integration and Interoperability
- Device and ICT Upgrading for Interoperability
- Accessibility and Interchangeability

Efficiency
Utility Operation and Service
- Improved Quality of Services / New Services
- Work Process Efficiency

- The master plan was launched to support the government's goal of reducing GHG by at least 20% by 2030
- This was a multi-agency effort involving EGAT[1], MEA[2] and PEA[3], with different areas of focus for pilot projects
  - EGAT: grid modernization, big data, grid connectivity, demand response and renewable energy forecasting
  - MEA: Distribution system management, smart metering and supporting application for EV transition
  - PEA: Smart Energy, Smart Community, Smart Life



Note: 1) Electricity Generating Authority of Thailand; 2) Metropolitan Electricity Authority; 3) Provincial Electricity Authority
Source: Power Development Plan 2018 (Revision 1), Government press release 2022, Multiple news sources, Arthur D. Little analysis

EGATは現在、バリューチェーン全体に沿った複数のサブプロジェクトとともに、スマートグリッド・パイロット・プロジェクトを実施

Smarter Green Sustainable

EGAT smart grid roadmap

	Preparation	Pilot project	Deployment	Enhancement
	2014-2015	2016-2020	2021-2025	2026-2030
Restructure ICT Org	ICT policy and strategy refinement	Restructuring ICT organization		
QoS-Cyber Integrity	Establishing cyber security standard	ICT infrastructure improvement with QoS and integrity		
Dev-ICT Integration	Establishing device-ICT integration standard	Pilot device-ICT integration	Expanding to all areas of integration	
Standardized ICT	Establishing ICT interconnection standard	Pilot ICT interconnection	Expanding to all areas of interconnection	
TEC61850 SAS	Pilot IEC61850-SASfor WAMS/WAPC	SAS for WAMS/WAPC	Other SAS, including IPP&SPP implementation (if necessary)	
RCC EMS	RCC-EMS design	RCC-EMS with Volt/VAr (Q-V) Control	RCC-EMS & WAMSWAPC integration	RCC-EMS for balancing real-power & islanding operation
Optimized Asset	On-line monitoring & CBM design	PP & 500 kV monitoring & risk analysis-reliability issue	Enhancing SAP for AM with extendedmonitoring & CBM	Risk analysis enhancement-financial & corporate issues
Demand Forecast		Demand monitoring development	Demand forecast & pilot integration to EMS	Full-scale demand forecast integration to EMS
Standardized AMI	Establishing AMI interconnection standard	Pilot AMI interconnection	Establishing ASEAN standard for AMI interconnection	
Demand Response	DR policy development (National agenda)	Pilot DR integration to EMS	Full-scale DR integration to EMS	DR enhancement
Small RE Generation	RE generation (PDP2010 and CPP	RE generation (PDP2010)	RE generation (PDP2010	RE generation (PDP2010
RE Grid Codes	Structural harmonization of RE grid codes	Technical harmonization of RE grid codes		
RE Forecast	RBmonitoring development	RE forecast & pilot integration to EMS	Full-scale RE forecast integration to EMS	
Energy Storage Mgmt	Plot battery energy storage system	Pump-hydro storage in neighboring countries	Full-scale ICT infrastructure for energy storage management	Full-scale energy storage integration to EMS
EV Support	Establishing EV charging standard (National agenda)	Pilot smart charging for load management	Pilot V2G technology	V2G technology deployment
GMS-APGEVA	Human resource enhancement	Establishing oversea business units	Being the leader for Smart Grid within GMS-APG	
WAMS HVDC	Pilot WAMS/WAPC	Full-scale WAMS & readiness for GMS-APG extension	Full-scale WAMS/WAPC integration to EMS	WAMS/WAPC for GMS-APG
	Initiating level	Enabling level	Integrating level	Optimization level

Existing and proposed sub-projects

Existing

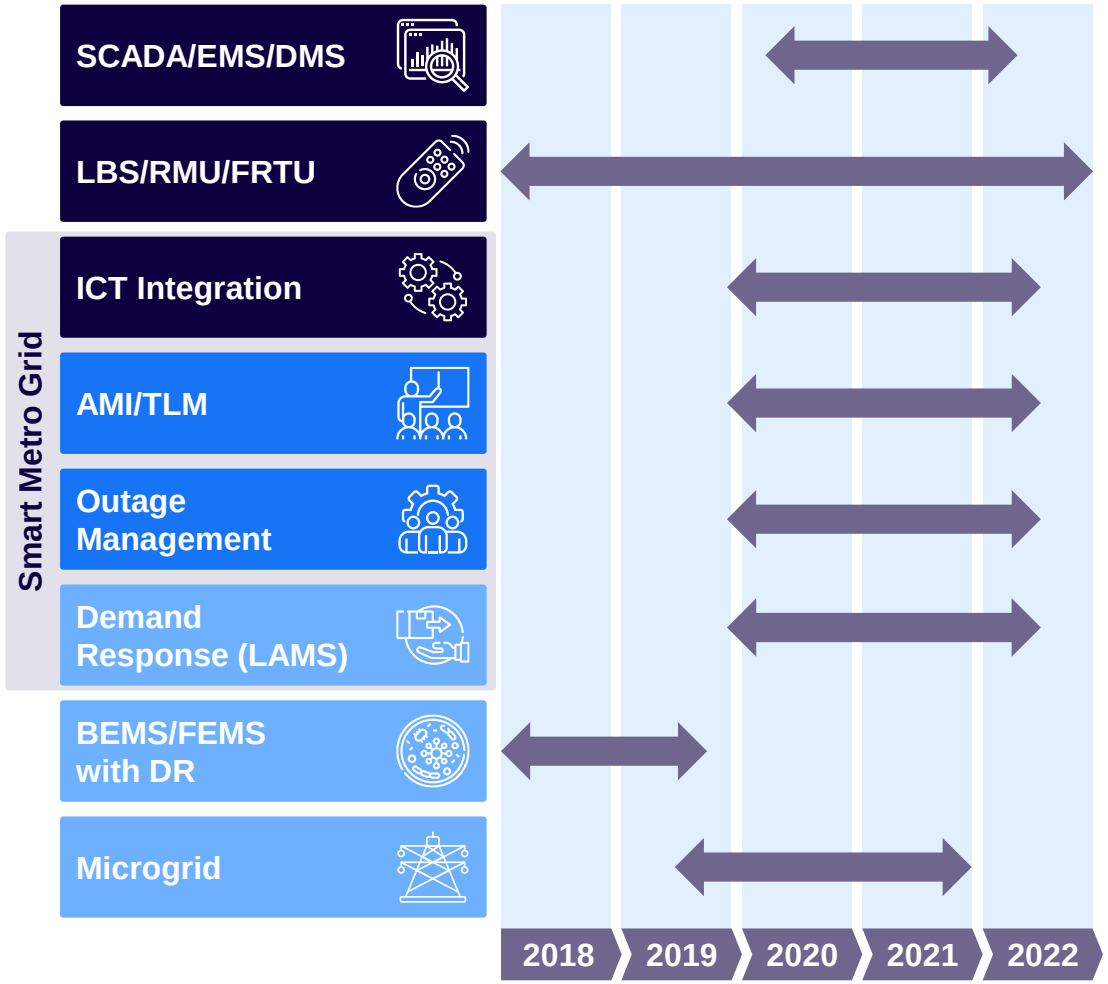
- Mae Hong smart grid project with Italthai Engineering
  - Purchase and construction contract signed in Jun 2022, which will be connected to every power plant in the province via Micro grid Control Center System, adding to green tourism in the province
- Solar power battery storage system
  - 3 MW system developed to combat the many power outage problems occurring in the Mae Hong Son province
- Collaboration with Hitachi and Chulalongkorn University
  - Demand response test to build a system that can support the increased use of renewables

Proposed

- Integrated renewable energy power plant
  - A hydropower plant that includes floating solar, battery storage and hydro pump system all-in-one
- 1 community 1 power plant
  - Initial concept involves the development of a biogas power plant that is run on pig waste, which are fed napier grass that is grown on the same farm

Source: Power Development Plan 2018 (Revision 1), Government press release 2022, Multiple news sources, Arthur D. Little analysis

MEAは、効率を高め、無駄を省くための多方面からのアプローチでスマートグリッドシステムを開発



Existing and proposed sub-projects

Existing

- Replacement of DMS[1]
  - Allows for the increase in control capability of feeder in 12 kV and 24 kV substations and communicates via the RTU[2] for monitoring and control
- Advanced metering infrastructure project
  - Replacement of 33,265 existing meters which would allow customers to manage and receive automatic readings of energy usage
- Expanded power distribution system
  - Via automatic functions like LTO[3], CTO[4], LTF[5] and BTO [6] whilst retaining the total quality management approach
- Household solar scheme purchase of 30 MW total at 0.06 USD/unit[7]
- Electricity purchase from Waste-to-Energy plants with 30.34 MW capacity

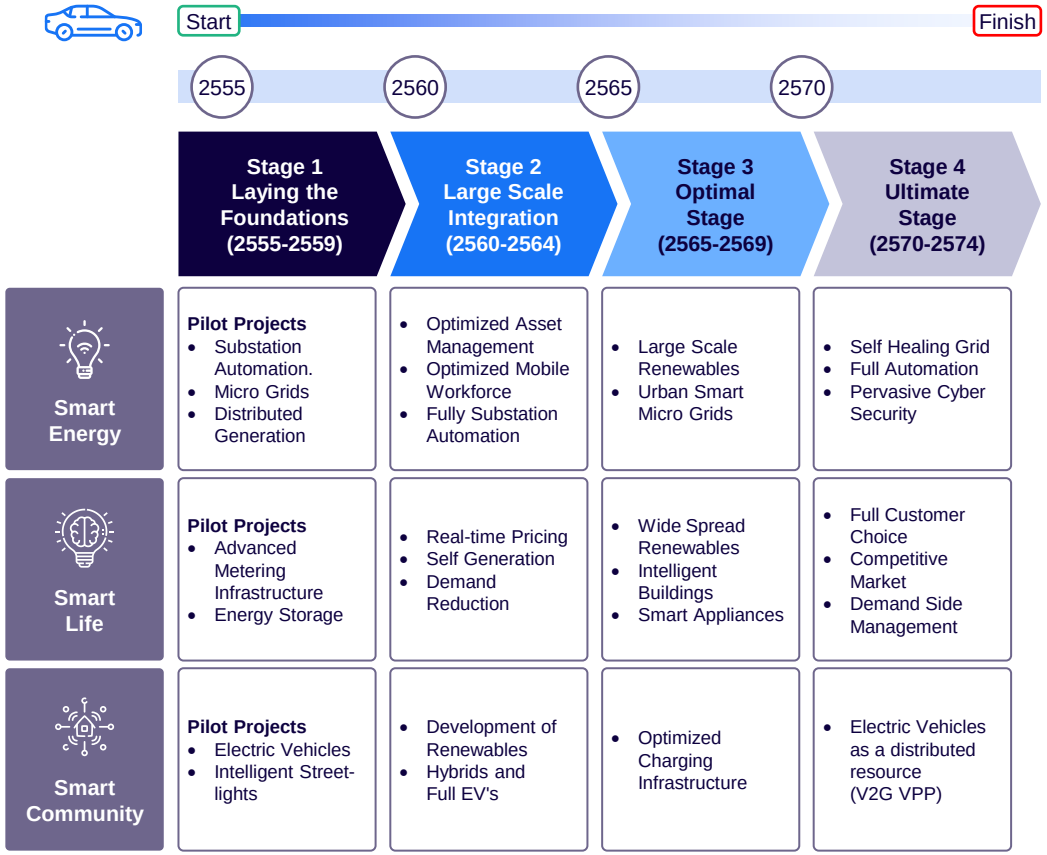
Proposed

- Load aggregator management system project
- MEA microgrid system pilot project
- Energy storage system pilot project
- SENA village renewable energy pilot project

Note: 1) Distribution management system; 2) Remote terminal unit; 3) Line throwover scheme; 4) Couple throwover scheme; 5) Line transfer function; 6) Bus throwover scheme; 7) Exchange rate is 1 THB = 0.029 USD (2022 2 d.p. average)
Source: Power Development Plan 2018 (Revision 1), Government press release 2022, Multiple news sources, Arthur D. Little analysis

PEAは、既存インフラのアップグレードからAI統合アプリ、クリーンエネルギー移行支援まで、複数のイニシアチブを展開

PEA smart grid roadmap *(under revision)*



Existing and proposed sub-projects

Existing

- Collaboration with Huawei
  - Upgrade of wireless communication infrastructure including SCADA1 using Huawei's eLTE-DSA2 solution, resulting in increase speed, capacity, security, and reliability across its services.
- Smart Grid Project in Pattaya
  - Country's first smart grid electricity project costing USD 27.9 mn, to replace smart meters in 0.12 mn houses in the city, and the construction of a data centre to process all forms of communication
- VOLTA charging stations
  - 57/263 EV charging stations completed in 2023 with the goal to have 1 charging station ever 100km

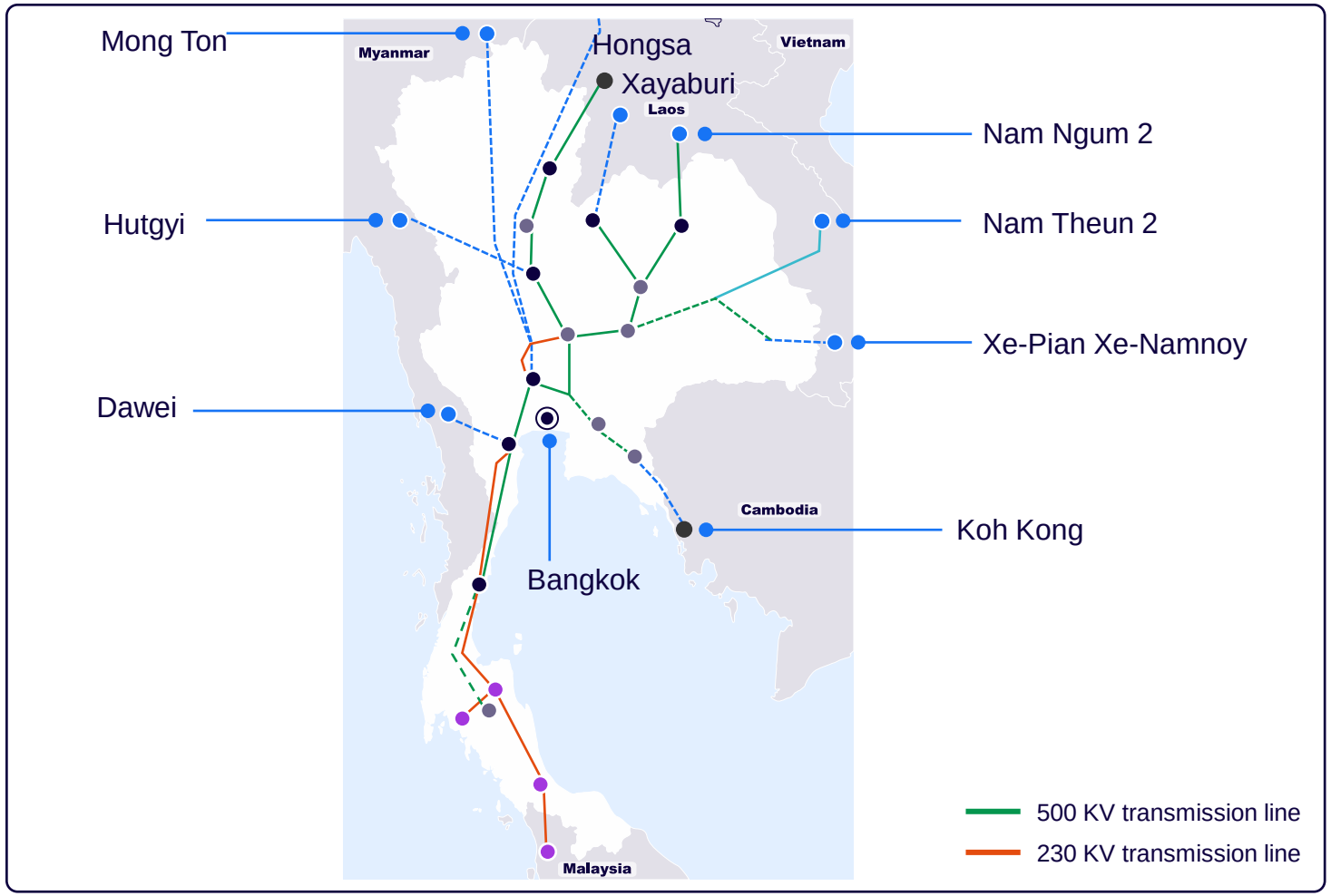
Proposed

- Solar roofs on 204 PEA office building
- Net Zero Energy Building project
- JV with Finland to open a power plant in Rayong
- IHAPM app that allows users to monitor and control their electrical appliances via a phone, together with AI which detect anomalies

Note: 1) Supervisory Control and Data Acquisition (SCADA) system is used to control and monitor power distribution, enabling accurate and rapid fault detection, as well as remote power management and maintenance; 2) eLTE Discrete Spectrum Aggregation (eLTE-DSA)
Source: Power Development Plan 2018 (Revision 1), Government press release 2022, Multiple news sources, Arthur D. Little analysis

8 送電網

タイの送電網は比較的安定



COMMENTS

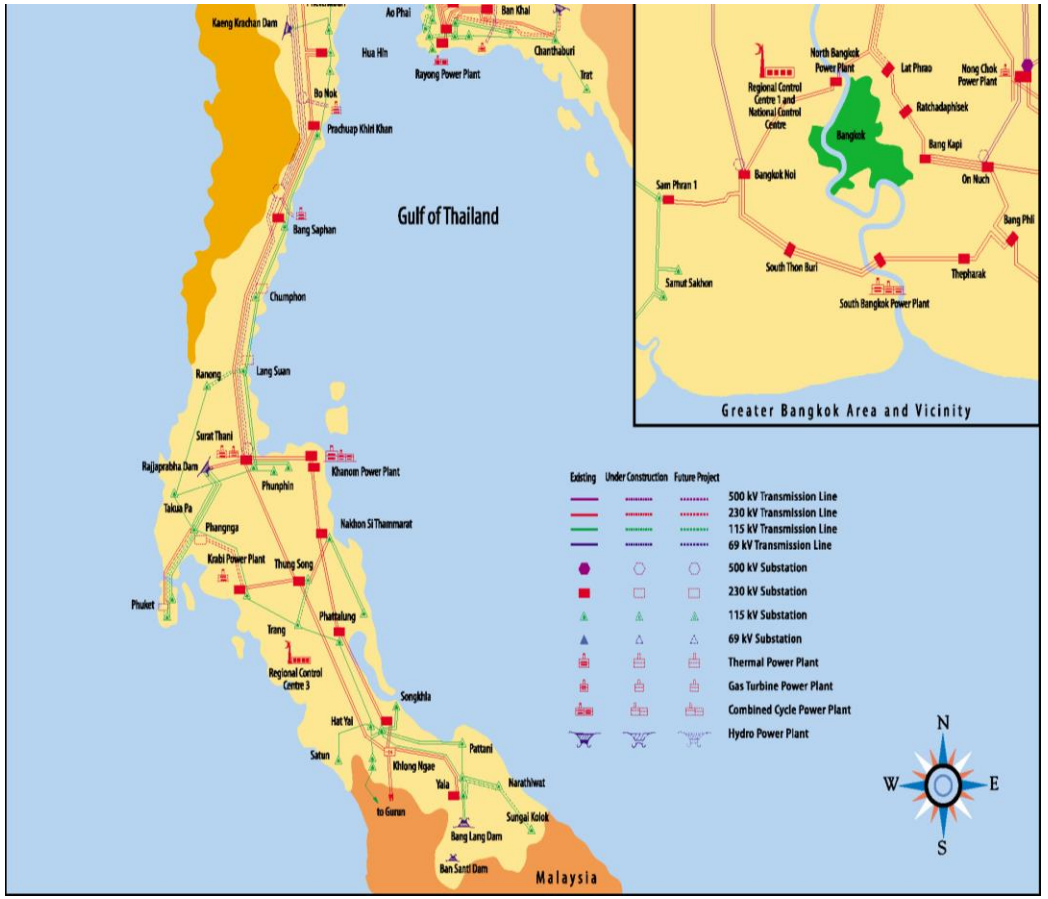
- In general, Thailand's transmission grid appears to be **relatively robust and reliable**
- Multiple transmission circuits supply the major load centers in different regions, particularly in the central and metropolitan areas
- The **southern region of Thailand is perhaps the most challenging region** for maintaining reliable system operation and stability, due to its partly electrically isolated geography. This only allows for radial connections with the central regions **without the possibility to connect to other regions** for enhanced system stability and security

Note: Map is illustrative and not drawn to scale
Source: International Energy Agency 2016, 2018

タイ全国送電網 - 詳細概略図

Central & Northern Thailand

Southern Thailand

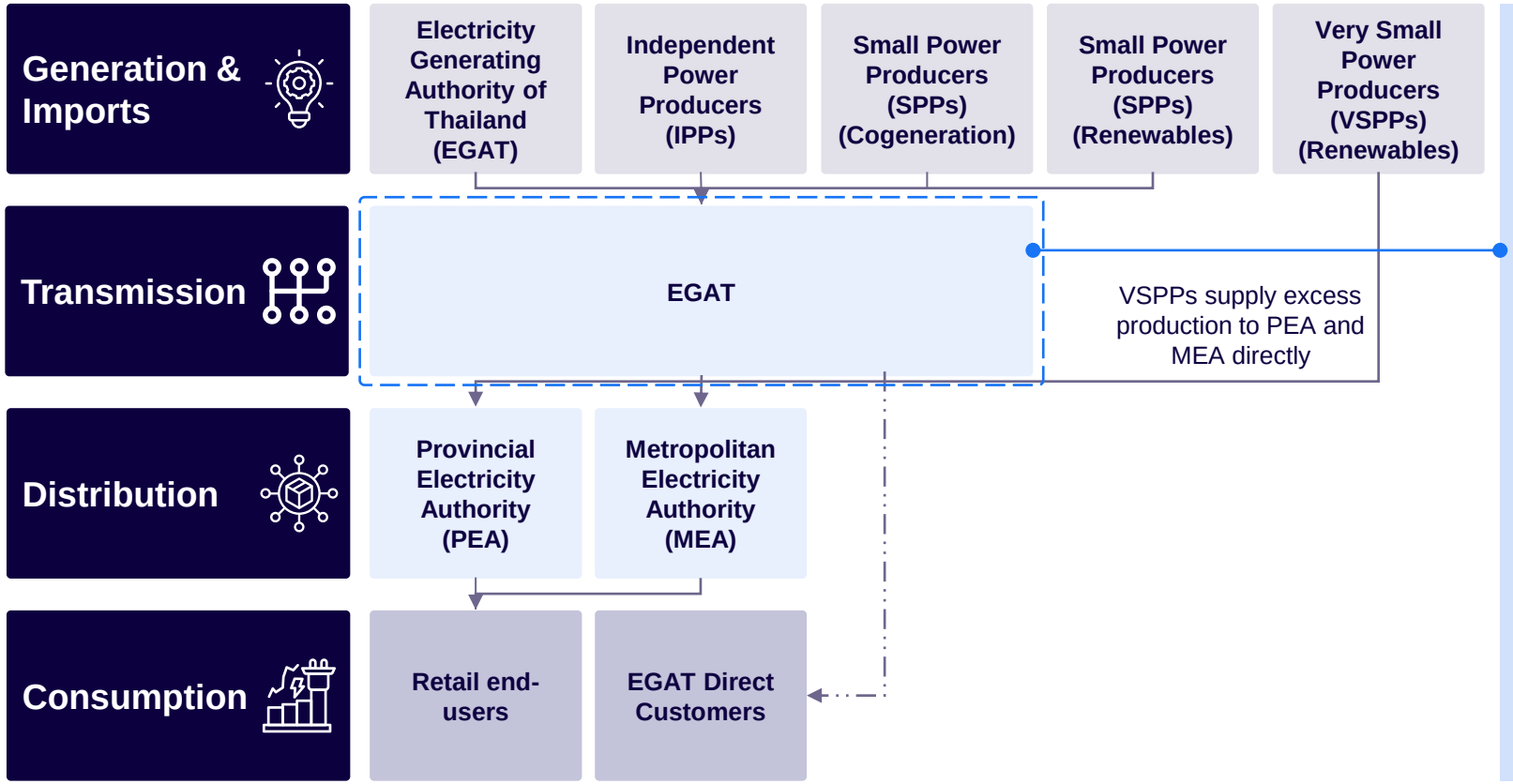


Source: Global Energy Network Institute 2017

タイの送電網は、エネルギー規制委員会（Energy Regulatory Commission）によって許可された唯一のライセンシーであるEGATによって運営

Overview of the electricity transmission sector

2022



คณะกรรมการกำกับกิจการพลังงาน
Energy Regulatory Commission

Energy Regulatory Commission and Energy Industry Act

The EGAT is responsible for:

- The construction of all transmission networks
- Transmitting electricity to the MEA and the PEA, several direct customers prescribed by law, and neighboring countries

The EGAT owns and operates the national transmission network, which includes transmission lines and substations of various high voltage levels

- The **Energy Industry Act theoretically permits other applicants** to obtain an electricity transmission license, but **only EGAT has been awarded this license by the ERC**

Source: Krungsri 2021, Thomson Reuters Practical Law 2020, Arthur D. Little analysis

List of observed EGAT transmission system and substation development projects in Thailand – Approved projects (1/5)

#	Name	Location	Overview	Cost[1,2]	Completion rate (Q4Y22)[3]	Expected completion date
1	Bulk Power Supply for the Greater Bangkok Area Project, Phase 2	Greater Bangkok	Construction of transmission lines of 89.03 circuit-kilometers and **a new substation, expansion of 6 substations**, installation of transformers of 6,800 MVA and capacitor bank of 384 MVAr, and 21 miscellaneous works relating to the transmission system expansion	USD 266 mn	97%	2023
2	Transmission System Development Project for Power Purchase from Independent Power Producers	Eastern Thailand	Construction of transmission lines of 170.2 circuit-kilometers and **2 new substations, expansion of 6 substations**, installation of transformers of 1,000 MVA, and 6 miscellaneous works relating to the transmission system expansion	USD 204 mn	76%	2026
3	Transmission System Renovation and Expansion Project, Phase 1: Substation	Nationwide	The project involves the improvement, replacement, or addition of transmission equipment to the control building of **15 aged substations**	USD 111 mn	88%	2024

Note: 1) Exchange rate is 1 THB = 0.029 USD (2022 2 d.p. average); 2) Rounded to whole numbers; 3) Fourth quarter of 2022
Source: Electricity Generating Authority of Thailand 2023, Arthur D. Little analysis

List of observed EGAT transmission system and substation development projects in Thailand – Approved projects (2/5)

#	Name	Location	Overview	Cost[1,2]	Completion rate (Q4Y22)[3]	Expected completion date
4	Main Transmission System Expansion Project for Power Purchase from SPP Cogeneration Power Plants	Nationwide	Expansion of the main transmission system to accommodate the power purchase from SPP's cogeneration power plants. Comprises the construction of transmission lines of 490 circuit-kilometers and a new substation, expansion and improvement of control and prevention system of **102 substations**, and installation of transformers totaling 2,500 MVA	USD 308 Mn	92%	2025
5	Transmission System Renovation and Expansion Project, Phase 1: Transmission Line	Nationwide	The renovation of aged and deteriorated transmission lines. Comprises the construction of 15 transmission lines of 331 circuit-kilometers and renovation and **expansion of 14 substations**	USD 286 mn	93%	2026
6	Transmission System Development Project in the Area of Loei, Nong Bua Lam Phu, and Khon Kaen Provinces for Power Purchase from Lao PDR	Loei, Nong Bua Lam Phu, and Khon Kaen Provinces	Accommodate power purchase from Xayaburi Hydroelectric Plant in Lao PDR to enhance power system security, comprising the construction of transmission lines of 496.77 circuit-kilometers and **2 new substations, expansion of 4 substations**, and installation of transformers totaling 1,400 MVA	USD 350 mn	98%	2023
7	Transmission System Renovation and Expansion Project, Phase 2	Nationwide	Construction of 11 transmission lines of 1,267 circuit-kilometers as well as construction, renovation, and expansion of **19 substations**	USD 636 mn	82%	2027

Note: 1) Exchange rate is 1 THB = 0.029 USD (2022 2 d.p. average); 2) Rounded to whole numbers; 3) Fourth quarter of 2022
Source: Electricity Generating Authority of Thailand 2023, Arthur D. Little analysis

List of observed EGAT transmission system and substation development projects in Thailand – Approved projects (3/5)

#	Name	Location	Overview	Cost[1,2]	Completion rate (Q4Y22)[3]	Expected completion date
8	Transmission System Improvement Project in Eastern Region for System Security Enhancement	Eastern Thailand	Construction of transmission lines of 469.664 circuit-kilometers and **3 new substations, expansion of a substation**, installation of transformers of 3,000 MVA, and eight miscellaneous works relating to the expansion of the transmission system	USD 349 mn	41%	2027
9	Bulk Power Supply for the Greater Bangkok Area, Phase 3	Greater Bangkok	Construction of transmission lines of 266.91 circuit-kilometers and **2 new substations, expansion of 4 substations**, installation of transformers of 2,425 MVA, and 32 miscellaneous works relating to the expansion of the transmission system	USD 351 mn	68%	2025
10	Transmission System Expansion Project, Phase 12	Nationwide	Construction of transmission lines of 3,427.58 circuit-kilometers and **9 new substations, expansion of 124 substations**, installation of transformers of 26,201.5 MVA, and 215 miscellaneous works relating to the transmission system expansion	USD 1,743 mn	71%	2025
11	Transmission System Improvement Project in the Western and Southern Regions to Enhance System Security	Western and Southern Thailand	Construction of transmission lines of 2,192 circuit-kilometers and a **new substation, expansion of 5 substations**, installation of transformers of 4,000 MVA, and eight miscellaneous works relating to the transmission system expansion	USD 1,836 mn	71%	2026

Note: 1) Exchange rate is 1 THB = 0.029 USD (2022 2 d.p. average); 2) Rounded to whole numbers; 3) Fourth quarter of 2022
Source: Electricity Generating Authority of Thailand 2023, Arthur D. Little analysis

List of observed EGAT transmission system and substation development projects in Thailand – Approved projects (4/5)

#	Name	Location	Overview	Cost[1,2]	Completion rate (Q4Y22)[3]	Expected completion date
12	Transmission System Improvement Project for System Security Enhancement of the Northeast, Lower North, and Central Parts	Northern, North-eastern and Central Thailand	Construction of transmission lines of 1,358 circuit-kilometers, **expansion of 12 substations**, installation of transformers of 10,000 MVA, and eight miscellaneous works relating to the transmission system improvement	USD 2,731 mn	58%	2030
13	Transmission System Improvement Project for the Upper Northern Region for System Security Enhancement	Northern Thailand	Construction of transmission lines of 426.27 circuit-kilometers, **expansion of 3 substations**, and installation of transformers of 2,600 MVA	USD 355 mn	12%	2024
14	Transmission System Project for South Bangkok Power Plant Replacement Project, Phase 1	Bangkok	Construction of 230 kV underground transmission lines of 1.0 circuit-kilometer from the switchyard of South Bangkok Power Plant to its substation and the expansion of South Bangkok Substation	USD 32 mn	88%	2023
15	Transmission System Improvement Project in Lower Southern Region to Enhance System Security	Southern Thailand	Construction of transmission lines of 1,409 circuit-kilometers and **2 new substations, expansion of 9 substations**, and installation of transformers of 4,000 MVA.	USD 1,028 mn	24%	2028

Note: 1) Exchange rate is 1 THB = 0.029 USD (2022 2 d.p. average); 2) Rounded to whole numbers; 3) Fourth quarter of 2022
Source: Electricity Generating Authority of Thailand 2023, Arthur D. Little analysis

List of observed EGAT transmission system and substation development projects in Thailand – Approved projects (5/5)

#	Name	Location	Overview	Cost[1,2]	Completion rate (Q4Y22)[3]	Expected completion date
16	Transmission System Development Project for Power Purchase from Independent Power Producers, Phase 3	Eastern and Central Thailand	Link the power purchase from Independent Power Producers (IPPs) to EGAT's system to cope with the rising demand for electricity in the Eastern and Central parts of the country, increase agility in the control and supply of electricity in the Eastern region, and solve the power shortage when the power plants need to be disconnected from the system and closed for overhaul	*Unknown*	67%	2023
17	Transmission System Development Plan for the Power Plant of Hin Kong Power Co., Ltd	Western and Southern Thailand	Enhance the security of the power system in the Western and Southern parts of the country by construction, expansion, and improvement of the electricity system to support the link with Hin Kong Power Co., Ltd. as assigned by the regulatory body and according to PDP2018 Rev.1	USD 5 mn	21%	2023
18	Transmission System Development Plan for Power Purchase from SPP Firm Cogeneration Power Plants of which the Power Purchase Agreement Expires in 2019-2025	*Unknown*	Accommodate the power purchase from the SPP Firm Cogeneration system to maintain the security and stability of EGAT's power system concerning the operation of the preventive and control system equipment	*Unknown*	48%	2025

Note: 1) Exchange rate is 1 THB = 0.029 USD (2022 2 d.p. average); 2) Rounded to whole numbers; 3) Fourth quarter of 2022
Source: Electricity Generating Authority of Thailand 2023, Arthur D. Little analysis

List of observed EGAT transmission system and substation development projects in Thailand – Projects pending approval

#	Name	Location	Overview
1	Transmission System Development Project for Linking Floating Solar Power Plant with Hydro Power Plant of Ubol Ratana Dam	Ubolratana, Khon Kaen	The objective of the project is to maximize the use of renewable energy, reduce energy import, and maintain the overall generating capacity of renewable power plants according to PDP2018 Rev.1

Source: Electricity Generating Authority of Thailand 2023

9 電力料金

タイのエネルギー市場の価格は高度に規制されており、政府による補助金支出も存在

NON-EXHAUSTIVE

Overview of current energy subsidy schemes in Thailand

2022 to 2023

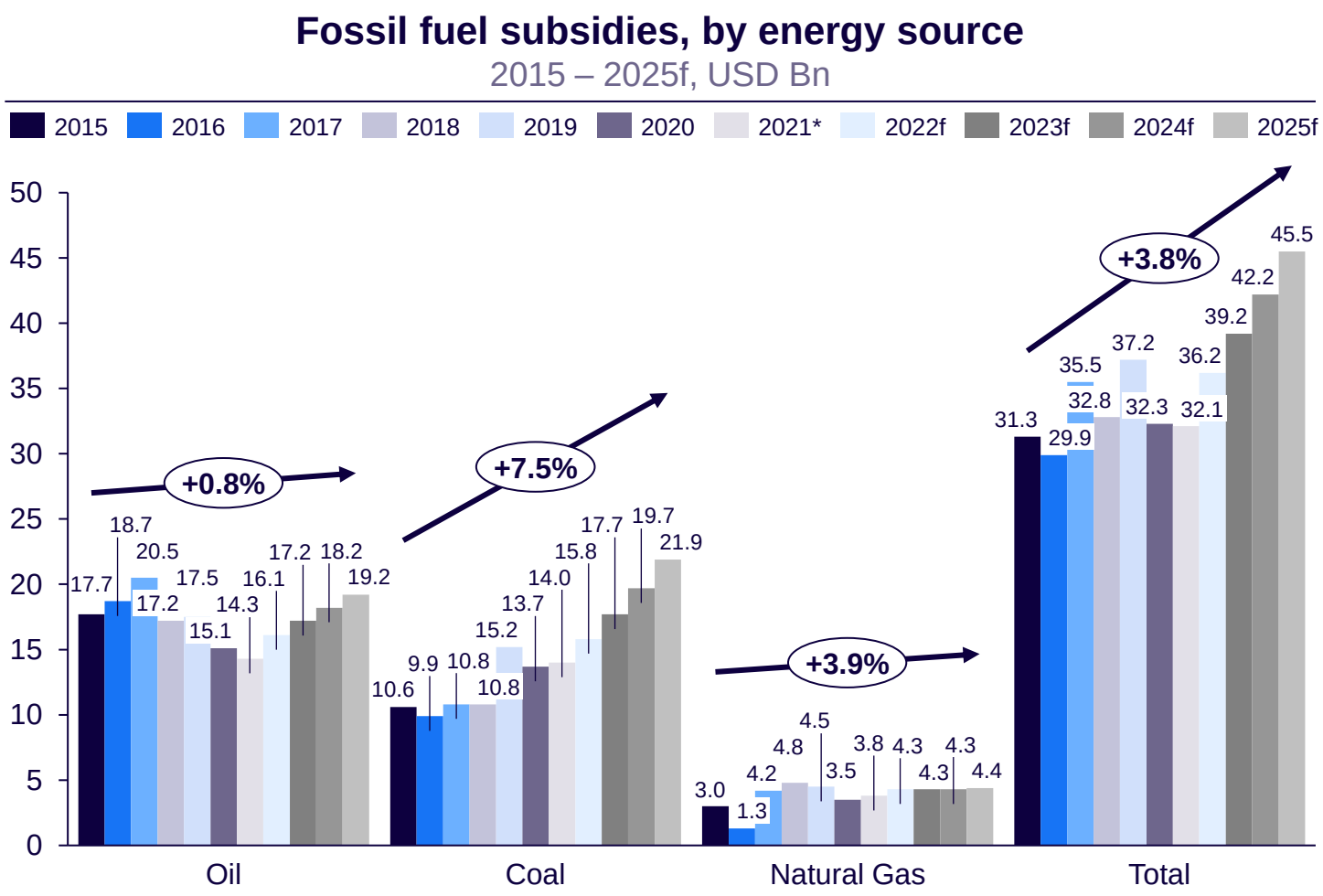
Selected Energy Subsidy Schemes

Category	Details
State fund for the subsidy of fuel costs	• The Oil Fuel Fund Office's borrowing plan of **USD 3.19 bn**[1] in the 2023 fiscal year • Thailand uses the fund to support subsidies and manage oil prices
Excise taxes	• **Elimination of excise tax** on diesel and bunker oil for electricity generation until March 2023 • Excise tax cut of USD 0.15/litre[1] for retail diesel prices was extended till November 2022
Price caps	• In 2022, Thailand introduced a **diesel price cap** of USD 0.87/litre[1] to manage prices for end-consumers

Current deployment of energy subsidies in Thailand appears targeted at **managing cost-of-living concerns**

Note: 1) Exchange rate is 1 THB = 0.029 USD (2022 2 d.p. average)
Source: International Energy Agency 2023, Channel News Asia 2023, Arthur D. Little analysis

補助金は年々伸びてきており特に石炭への補助金額の上昇率が大きい



Comments

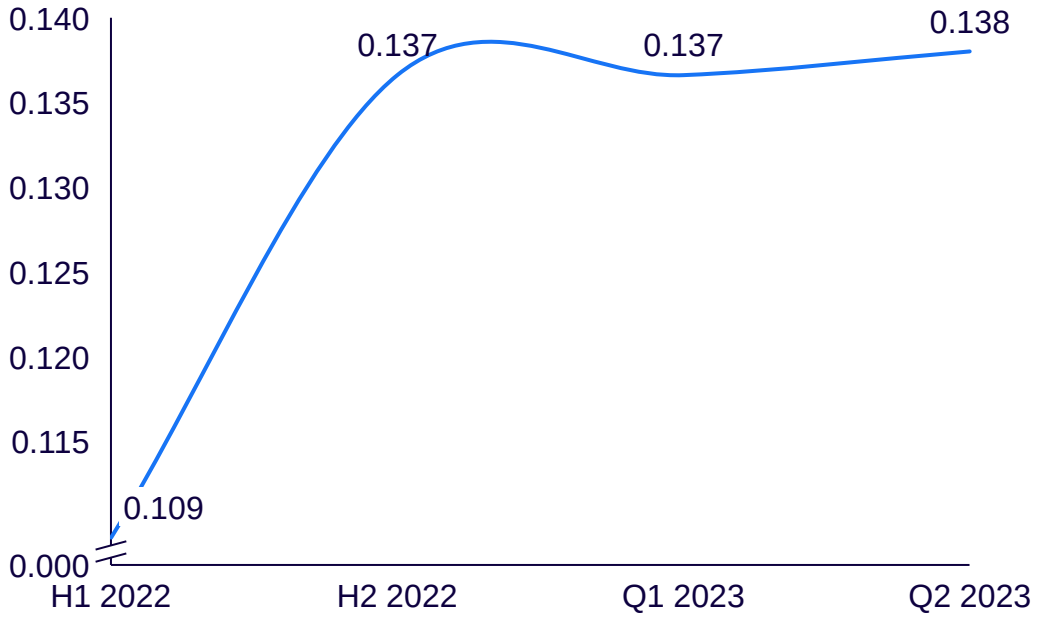
- Coal is largely driving the overall subsidies for the period 2015 – 2025, at a CAGR of 3.8%. However, the increase of USD 10 bn from USD 36.2 in 2021 to 42.2 bn in 2023 was on the back of the fight against inflation
- Despite the lack of dependency on coal as a fuel source, subsidies are estimated to grow almost two-fold at a YOY growth rate of 7.5% from USD 10.6 bn in 2015 to USD 21.9 bn in 2025
  - The increase of ~50% from 2014 to 2025 is largely due to Thailand switching to coal for domestic electricity generation, instead of importing
- Oil & gas saw moderate increases of 0.8% and 3.9% respectively, especially if we look past the inflationary periods. This stems from the government pushing for decreased consumption and reliance on fossil fuels, on top of dwindling reserves

Source: International Monetary Fund 2021, Asian Development Bank 2020, Arthur D. Little analysis

タイの電力料金は現在、国内では記録的な高水準にあるが、他地域の電力料金と比較すると安定価格

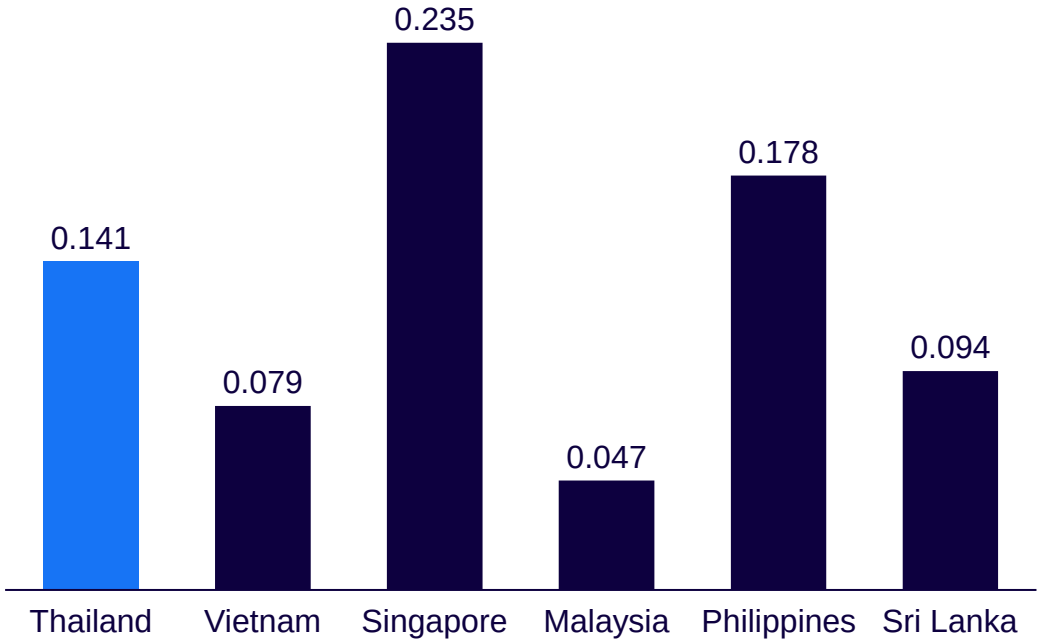
Averaged household electricity retail price[1]

Thailand, USD/kWh



Household electricity retail prices in ASEAN[2]

Dec 2022, USD/kWh



Recent increases in Thailand's electricity retail prices are **in line with the elevated energy prices globally**, partly driven by the rising prices of LNG imports, given bottlenecks in domestic natural gas production

Note: 1) Exchange rate is 1 THB = 0.029 USD (2022 2 d.p. average); 2) Prices for households referenced, for selected ASEAN countries. For households, the displayed number is calculated at the average annual level of household electricity consumption.
Source: Bangkok Post 2023, Thai Enquirer 2022, Global Petrol Prices 2023, Arthur D. Little analysis

タイでは現在、電力小売価格は消費セグメント、消費量、消費期間によって差別化(1/2)

Residential electrical tariffs

As of July 2023

Normal tariff with consumption not exceeding 150 kWh/month[1]		
First 15 kWh (1st – 15th)	0.07	USD/kWh
Next 10 kWh (16th – 25th)	0.09	USD/kWh
Next10 kWh (26th – 35th)	0.09	USD/kWh
Next 65 kWh (36th – 100th)	0.11	USD/kWh
Next 50 kWh (101st – 150th)	0.11	USD/kWh
Next 250 kWh (151st – 400th)	0.12	USD/kWh
Over 400 kWh (up from 401st)	0.13	USD/kWh
Service charge (USD/Month) :	0.24	

Normal tariff with consumption exceeding 150 kWh/month[1]		
First 150 kWh (1st – 150th)	0.09	USD/kWh
Next 250 kWh (151st – 400th)	0.12	USD/kWh
Over 400 kWh (up from 401st)	0.13	USD/kWh
Service charge (USD/Month) :	0.72	

Time of use t ariff[2]			
	Energy charge, USD/kWh[1]		Service charge, USD/month[1]
	On Peak	Off Peak	
12 - 24 kV.	0.15	0.08	9.07
Below 12 kV.	0.17	0.07	0.72

Note: 1) Exchange rate is 1 THB = 0.029 USD (2022 2 d.p. average); 2) On Peak: Monday – Friday from 09.00 AM to 10.00 PM; Off Peak: Monday – Friday from 10.00 PM to 09.00 AM, Saturday – Sunday, and normal public holiday
Source: Metropolitan Electricity Authority of Thailand 2023, Arthur D. Little analysis

タイでは現在、電力小売価格は消費セグメント、消費量、消費期間によって差別化(2/2)

Business electrical tariffs

As of July 2023

Small general service[1]		
Voltage level	Energy charge, USD/kWh[2]	Service charge, USD/month[2]
12 - 24 kV	0.11	9.07
Below 12 kV		0.97
First 150 kWh (1st – 150th)	0.09	
Next 250 kWh (151st – 400th)	0.12	
Over 400 kWh (up from 401st)	0.13	

Medium general service[3]			
Voltage level	Demand charge, USD/kW[2]	Energy charge, USD/kWh[2]	Service charge, USD/month[2]
69 kV and over	5.10	0.09	9.07
12-24 kV	5.70	0.09	9.07
Below 12 kV	6.43	0.09	9.07

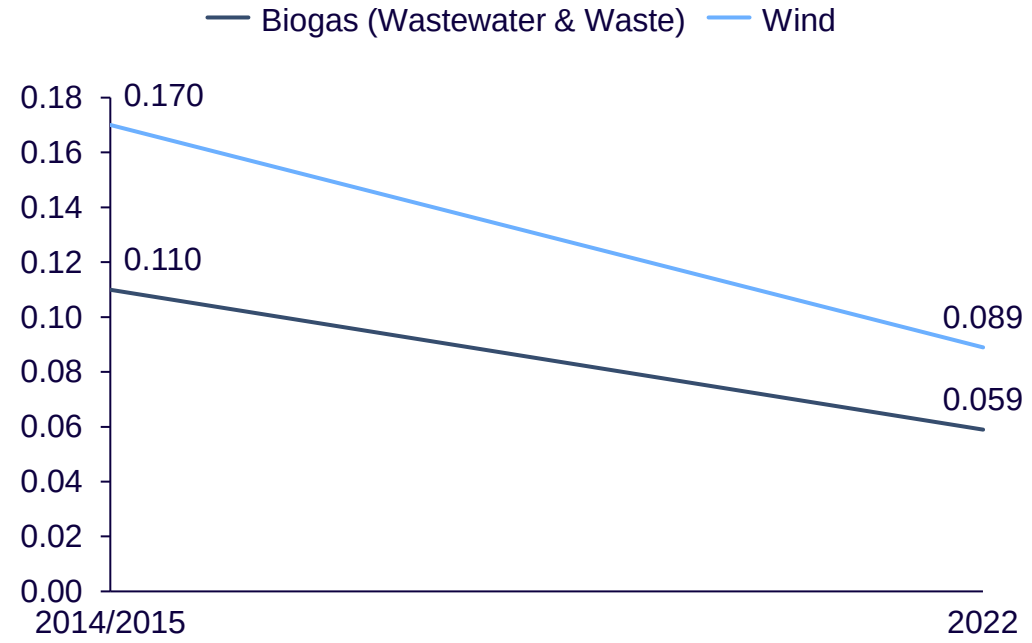
Large general service[4]					
Voltage level	Demand charge, USD/kW[2]			Energy charge, USD/kWh[2]	Service charge, USD/month[2]
	On Peak *06.30 PM to 09.30 PM*	Partial Peak *08.00 AM to 06.30 PM*	Off Peak *09.30 PM to 08.00 AM*	All Times	
69 kV and over	6.51	0.87	0	0.09	9.07
12 - 24 kV	8.28	1.71	0	0.09	9.07
Below 12 kV	9.66	1.98	0	0.09	9.07

Note: 1) A business enterprise with a maximum 15-minute integrated demand of less than 30 kilowatt through a single Watt-hour meter; 2) Exchange rate is 1 THB = 0.029 USD (2022 2 d.p. average); 3) Organizations with a maximum 15-minute integrated demand from 30 to 999 kilowatts; 4) Organizations with a maximum 15-minute integrated demand over 1,000 kilowatts
Source: Metropolitan Electricity Authority of Thailand 2023, Arthur D. Little analysis

再生可能エネルギーの固定価格買取制度（FiT）は、自然エネルギー発電の増加に伴い、タイでは減少傾向

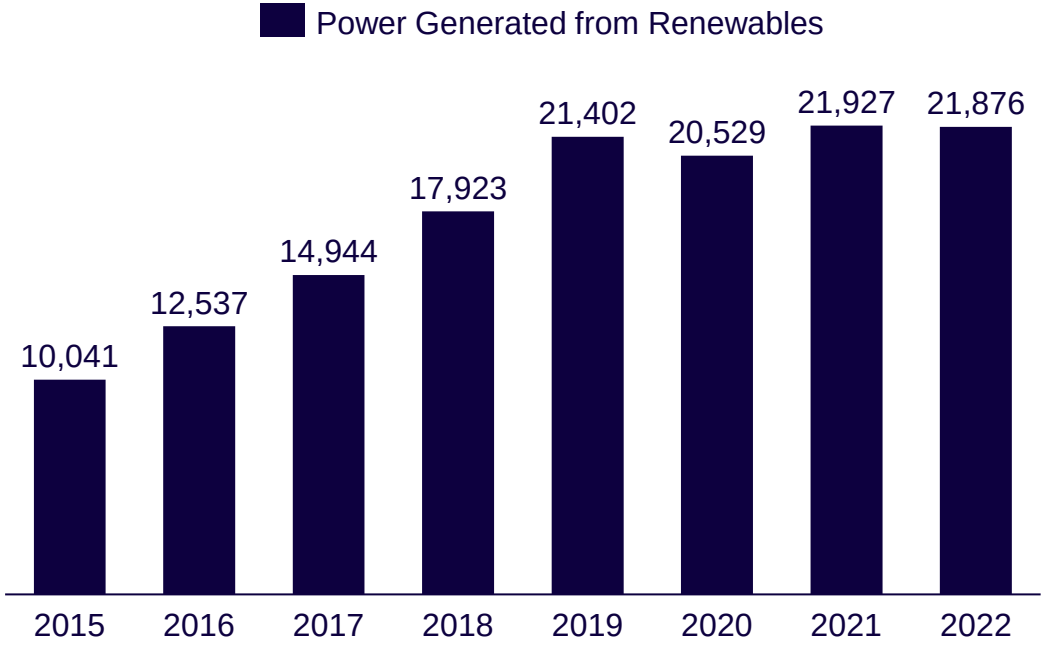
Change in feed-in tariffs, Thailand

For biogas and wind, USD/kWh[1]



Renewables[2] power generation, Thailand

2015 to 2022, GWh

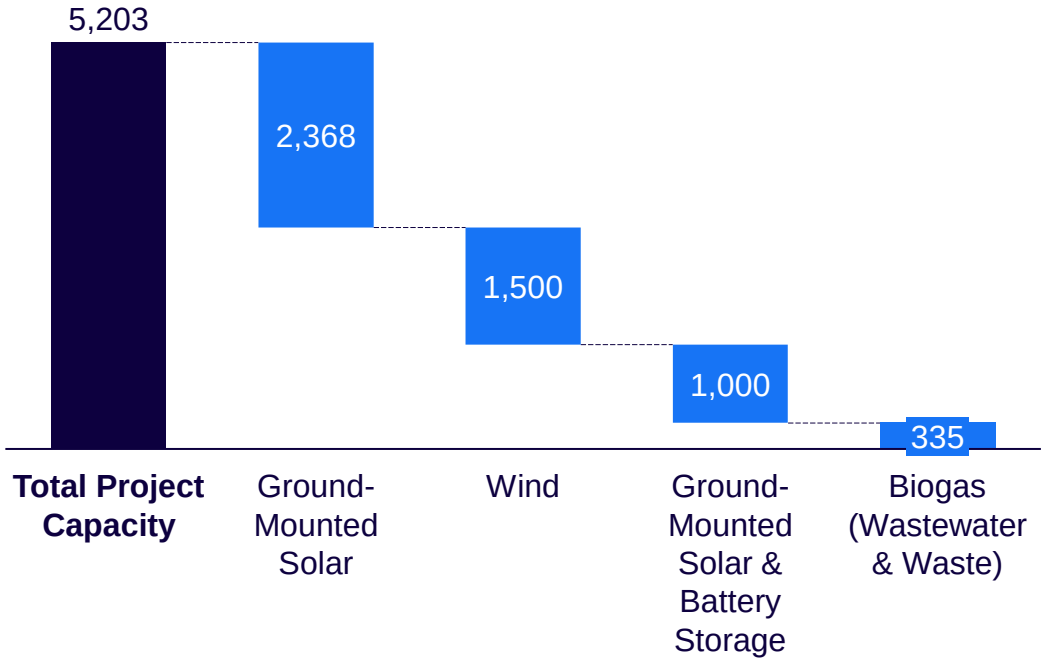


FiT rates often **decline with time** to cater for increased capacity and maturing technology, after attracting initial investment capital. This is likely the case for Thailand, witnessed by the **increased power generation from renewables**

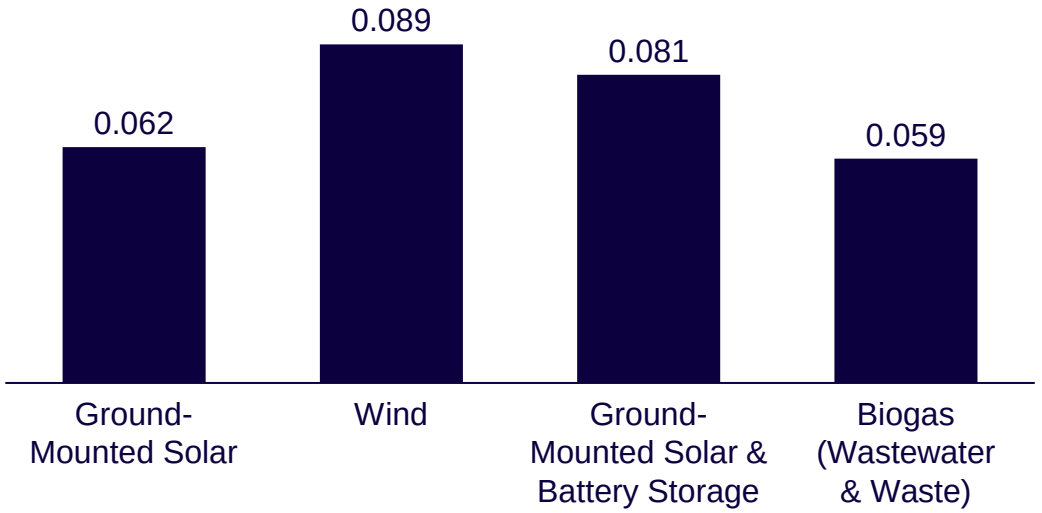
Note: 1) Exchange rate is 1 THB = 0.029 USD (2022 2 d.p. average) and does not include FiT premiums for projects located in the Southern provinces; 2) Renewables include solar, wind, and biomass renewable energy sources – and are grouped separately from hydropower in official government reports
Source: Energy Policy and Planning Office 2023, Watson Farley & Williams 2022, International Energy Agency 2015, Arthur D. Little analysis

2022年、タイの自然エネルギーに対する最近のFiT制度は、太陽エネルギーに焦点を当てているが、風力プロジェクトは相対的に最も高いFiT価格

Total PPA capacity
For 2022-2030 scheme, MW



FiT rates offered[1]
For 2022-2030 scheme, USD/kWh



While **solar energy appears to be the focus for renewables installation**, the higher FiT rates for wind energy and battery storage reflect their relative increased costs of deployment

Note: 1) Exchange rate is 1 THB = 0.029 USD (2022 2 d.p. average) and does not include FiT premiums for projects located in the Southern provinces
Source: Watson Farley & Williams 2022, Arthur D. Little analysis

発電への投資を誘致するために、さまざまな導入可能な技術に対してインセンティブ制度が用意

NON-EXHAUSTIVE

Incentives for renewable energy projects *(Offered by the Thailand Board of Investment)*

Technology	Details of incentive
Solar energy	• Manufacturers of solar cells and/or related raw materials can receive 8 years of corporate income tax exemption, capped at the amount of total investment • Exemption from import duties on machines and raw materials • The same investment promotions are available for the production of electricity from solar energy
Wind energy	• Producers of electricity from wind power can receive 8 years of corporate income tax exemption, capped at the amount of total investment • Exemption from import duties on machines and raw materials
Hydropower	• Producers of electricity from hydropower can receive 8 years of corporate income tax exemption, capped at the amount of total investment • Exemption from import duties on machines and raw materials
Biomass and biogas	• Producers of electricity/fuel from biomass and biogas can receive 8 years of corporate income tax exemption, capped at the amount of total investment, and also receive exemption from import duties on machines and raw materials • Producers of biomass briquettes and pellets receive 5 years of corporate income tax exemption, instead

A **similar range of incentives are broadly offered** to power producers, **regardless of the technology deployed** for renewable energy generation

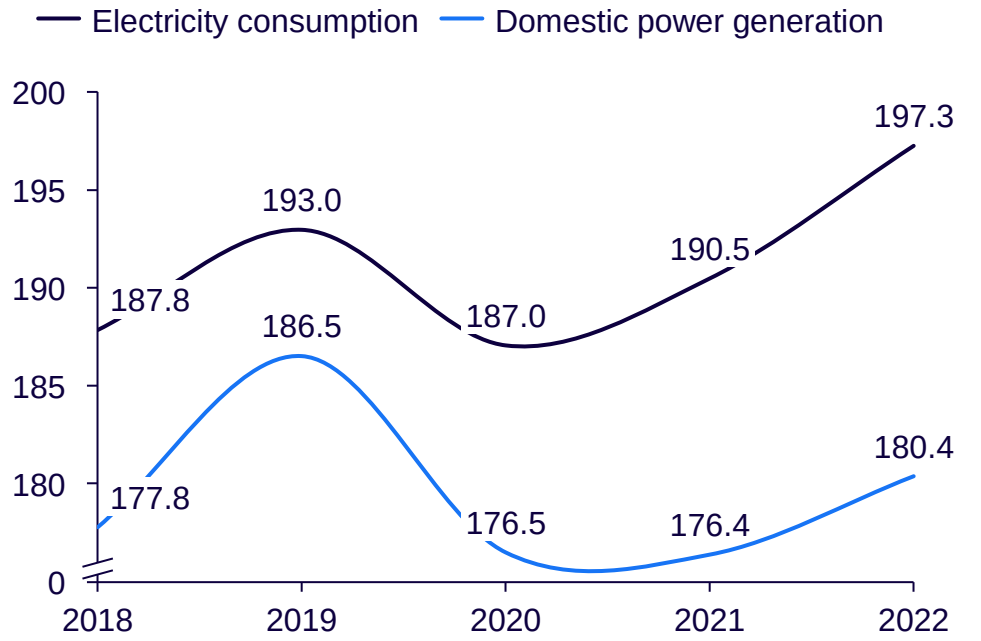
Source: Lorenz & Partners 2021, Arthur D. Little analysis

10 電力需給状況

タイは現在、電力の純輸入国であり、過去5年間で輸入が増加

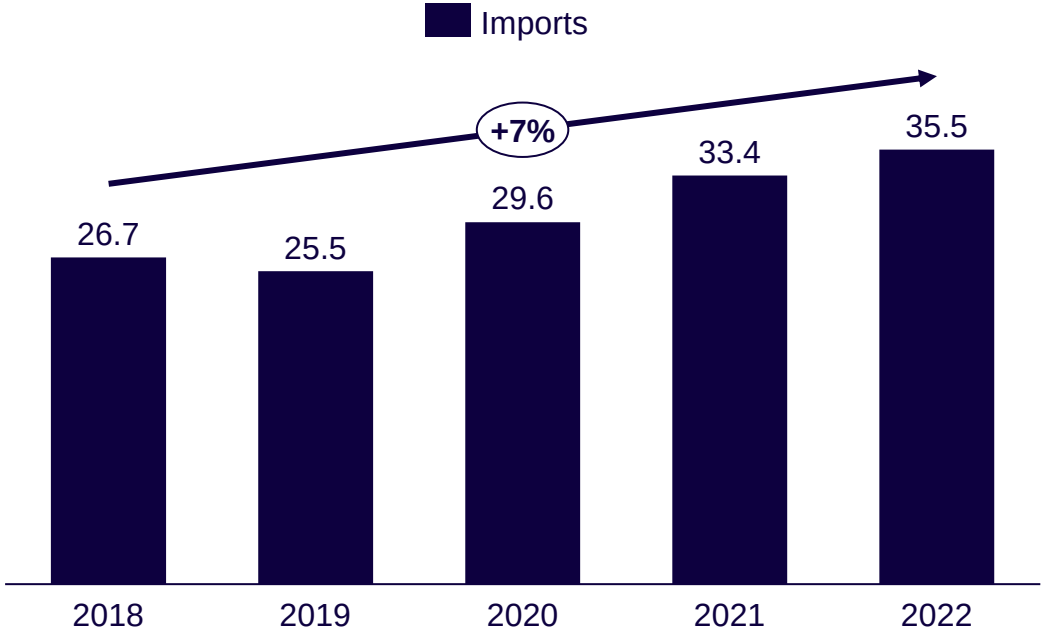
Power consumption and domestic generation

2018 to 2022, TWh[1]



Power imports into Thailand

2018 to 2022, TWh[1]



As a **current net importer** of power, **Thailand's dependence on imports is likely to widen** in the coming years, as consumption rises and known oil and gas reserves are progressively depleted

Note: 1) Terawatt per hour
Source: Energy Policy and Planning Office 2023, International Trade Administration 2022, Arthur D. Little analysis

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