Carbon Neutrality: Sustainable Energy Transformation in Thailand

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Summary

The energy is crucial for achieving carbon neutrality as it contributes to 70% of the country's GHG emissions. Therefore, the energy transformation is a focus for both government and private sector initiatives.

The report outlines several high-potential energy solutions, including renewable energy, energy-efficient technologies, electric vehicles, energy storage systems, and hydrogen. These solutions are at various stage of development, each presenting a range of diverse business opportunities.

Foreign investors can harness the favorable policy landscape to establish operations in Thailand. However, it is important to acknowledge the various challenges, such as the competition situation, consumer concerns, market dynamics, etc. Collaborating with reputable partners may be necessary to access customer bases, navigate existing networks, as well as understanding the market insight and regulatory requirements.

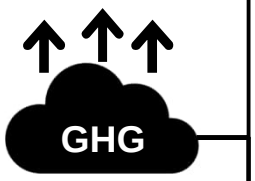
Contents

Thailand's Carbon Neutrality Landscape

Current emission profile

- Energy sector contributed for 70% of total GHG emissions in Thailand, which mainly come from the combustion of fossil fuel in power generation, transport, and manufacturing activities.

GHG emission and key attributed sectors (2019)



Energy 70%

Energy industries 28%

- CO2 is the main GHG emission from energy industries, which **mainly from coal, lignite, and natural gas power generation** for public utilities.
- In Thailand, coal, lignite, and natural gas contribute for 72% of the country's power generation in 2023, meanwhile renewable energy was around 28%.

Transport 21%

- **Road transport** is the country's main transport mode for freight and passenger transport.
- >90% of CO2 emissions from transport activities are from burning fossil fuel for automobiles used in the country, including motorcycles, cars, trucks, and buses.

Manufacturing 14%

- GHG emission, especially CO2, in manufacturing activities are from combustion of fuels, which include coal, natural gas, and oil, for power and heat production for internal used.
- Main industries that release large amount of CO2 from their production process **are cement, ceramics, glass, chemical, food processing, textiles, and metal**.

Oil & gas industries 7%

- There is the fugitive emission of methane (CH4) during the **exploration, transportation, refining, and distribution activities of oil and gas production** business.

Agriculture 15%

- Methane (CH4) is the primary GHG emission from agricultural sector, which mainly from anaerobic decomposition of organic material in flooded rice fields during **rice cultivation and enteric fermentation from cattle and swine farm**.
- Another main gas is N2O, which mainly releases from managed soil activities.

IPPU 10%

- **Mineral and chemical industry are primary source of CO2** releasing from Industrial Processes and Product Use Sector (IPPU).
- GHG emissions from IPPU are not directly the result of energy consumed during the process. but releases from industrial processes that chemically or physically transform materials.

Waste 5%

- CH4 is the main GHG emission from **solid waste disposal and industrial wastewater treatment and discharge.**

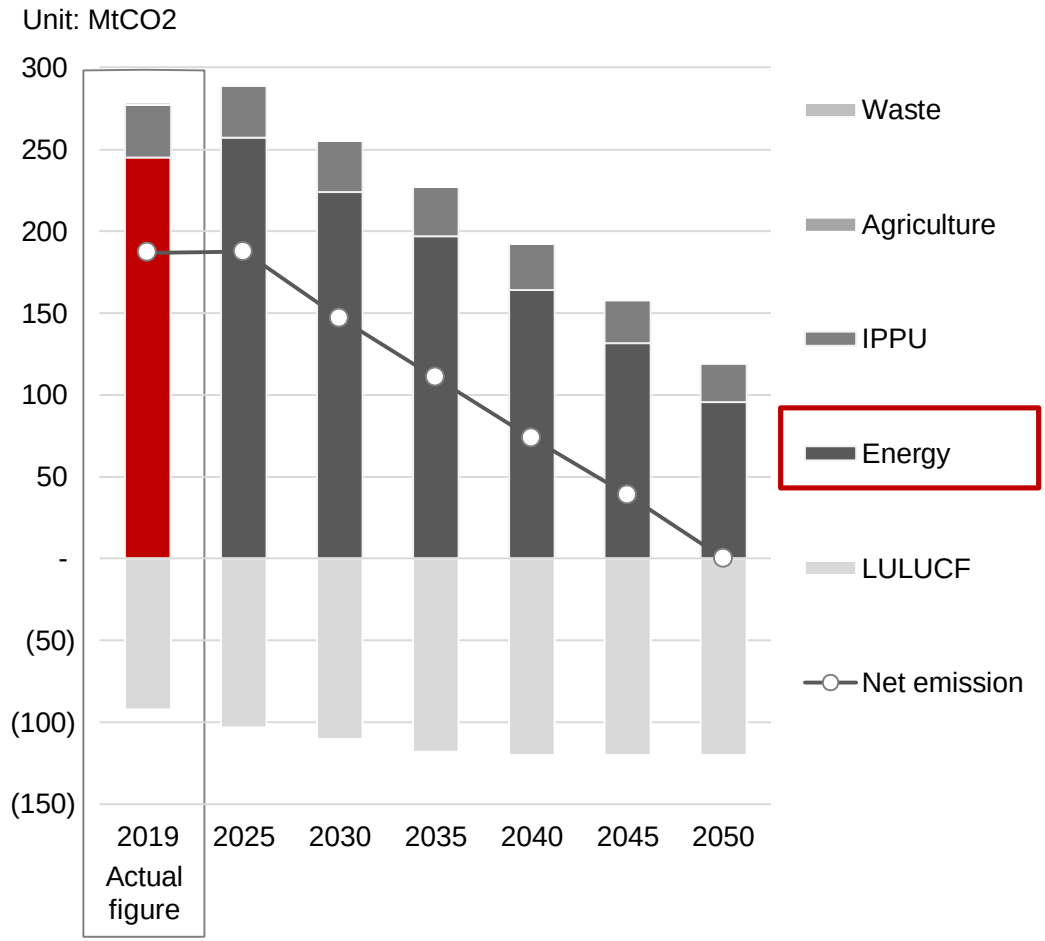
Source: Thailand's Fourth Biennial Update Report, The Office of Natural Resources and Environmental Policy and Planning (ONEP)

Thailand's commitment to carbon neutrality

- To achieve carbon neutrality in 2050, government has focused its attention on reducing CO2 emission in the energy sector.

Thailand's carbon emission reduction and carbon neutrality goal

Thailand CO2 emission reduction/ removal scenario(1)



At COP26, Thailand announced 3 goals to mitigate climate Change.

2030 — **To reduce GHG by 30-40% from the projected business-as-usual (BAU) level**

2050 — **Carbon Neutrality**

	CO2 emission level
Energy	95 $MtCO_2eq$
IPPU	23.8 $MtCO_2eq$
Waste	0.2 $MtCO_2eq$
Agriculture	0.5 $MtCO_2eq$
LLUCF(2)	-120 $MtCO_2eq$

2065 — **Net Zero GHG Emission**

Note: (1) The chart presents only volume of CO2 emission, which is the largest type of gas accounted for 64% of GHG emission in 2019. Other GHG emissions, e.g. CH2, N2O, CO, and so on, are excluded. (2) LULUCF (Land Use, Land Use Change and Forestry) plays an important role as a carbon sink.

Source: Thailand's LT-LEDS (2022 revised version), ONEP

Thailand's Carbon Neutrality Landscape

National targets and measures in key energy solutions

- The government has implemented diverse measures to reduce the emission by increasing renewable energy, improving energy efficiency, promoting electrification and energy storage, and developing hydrogen technologies.

National targets and measures of key energy solutions for acheiving carbon neutrality

	Renewable energy	Energy efficiency	Electrification	Energy storage system	Hydrogen
Target	**2037** • RE >50% of total power generation • RE 38.6% of total energy consumption (heat, power, and fuel) **2050** • RE account 74% of total power generation	**2037** • Energy Intensity (EI) reduce by 36% compared to the base year of 2010 **2045** • Most efficient IC engine vehicles with biofuels **2050** • EI reduction of 40% compared to the 2010 level	**2030** **Production:** • ZEVs(BEV+FCEV) 30% of motor vehicle production • 725,000 ZEVs • 675,000 e-bikes • 34,000 e-trucks & buses **Usage:** • 440,000 ZEVs • 650,000 e-bikes • 33,000 e-trucks & buses	**2030** **Production:** • Battery for EV: 40 GWh **2037** **Power sector adoption**: • BESS: 11.5 GW • PSH: 4.0 GW	**2030** • Hydrogen make up 5% of total power supply **2040** • Hydrogen mix in co-firing power plants and thermal use in industry by 20% • 10,000 FCEV **2050** • Hydrogen mix in co-firing power plants and thermal use in industry by 25-75% • 27,000 FCEV
Target sectors	• Power sector • Industry sector, especially energy intensive industries e.g. cement, ceramics, food, paper	• Industry sector • Building • Transport	• Transport • Industry	• Power sector • Transport	• Power sector • Transport sector • Industry sector
Recent measures	• Public power procurement from renewable energy • Financial subsidies and tax incentives for investment in renewable energy, related equipment, and raw materials • Encourage the use of biofuel in vehicle, sustainable aviation fuel	• Tax incentives for high efficiency machinery replacement • Accelerate the smart grid investment to increase efficiency in power transmission • Set the energy efficiency standard for vehicle, building, machine, electric appliance	• Tax incentives and subsidies to promote EV production and use • Promote investment in charging station and battery swapping station to create EV ecosystem • Set the safety standard of EV and charger	• Tax incentives and subsidy for local produced battery user • Promote battery storage (BESS,PSH) usage with renewable power project • Setting standard for safety, production, utilization, and waste disposal • Promote R&D, battery supply chain matching	• Promote R&D and tax incentives in hydrogen technology

Source: Summarized from various policies and plans by YCST

Thailand's Carbon Neutrality Landscape

Carbon emission reduction initiatives in business sector

- The business sector has been forced and incentivized to implement measures to reduce carbon emissions through regulations, supporting policies, and collaboration with suppliers.
- Large and small companies adopt different approaches, as outlined below.

Comparison of carbon emission reduction approaches between large and small companies

	Large companies	Small companies
Driven factors	• International market pressure and ESG requirements • Stock Exchange of Thailand sustainability reporting requirements • Parent company or global commitments • Brand reputation management	• Focus on cost reduction • Local market competition and differentiation • Supply chain requirements from large customers • Access to government incentives
Measures & practices	• Scope 1 and 2 are adopted with start tracking Scope 3 emission • Set ambitious carbon neutrality and net-zero targets • Dedicated sustainability teams with comprehensive strategies • Company's group-wide, company-wide adoption • Large-scale renewable energy investment • Upgrading technology to be more energy-efficient • Supply chain emission reduction programs • Engaging in carbon offset projects	• Focus primarily on Scope 1 and 2 emission • Focus on short term and cost-effective measures e.g. improving energy efficiency, optimizing logistics • Facility-level project • Basic energy efficiency measures • LED lighting upgrades • Simple waste reduction programs • Plastic reduction initiatives

What are Scope 1, 2 and 3 carbon emissions?

Scope 1: Direct emission

All direct emissions from the activities of the company

- Energy/ heat generation at company facilities
- Company vehicles
- Fugitive emission
  e.g. leakages from valves, pipelines, tanks, and other process equipment.

Scope 2: Indirect emission

Emissions from the generation of purchased electricity consumed by the company

- Purchased Electricity, Steam, Heat & Cooling

Scope 3: Other indirect emission (value chain)

All other indirect emissions that are not produced by the company itself and are not the result of activities from assets owned or controlled by them, but by those that it's indirectly responsible for up and down its value chain

Upstream

- Purchased goods and services
- Capital goods
- Fuel- and energy-related activities
- Transport & distribution
- Waste generated in operations
- Business travel
- Employee commuting
- Leased assets

Downstream

- Transportation and distribution
- Processing of sold products
- Use of sold products
- End of life treatment of products
- Leased assets
- Franchises
- Investment

Source: GHG Protocol

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Renewable Energy: Industry snapshot

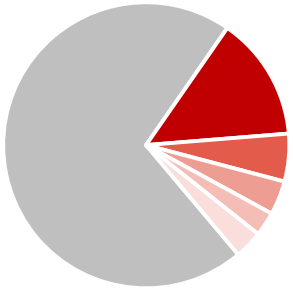
Renewable Energy

Thailand is currently in the accelerated growth phase of renewable energy driven by significant government support and private investment.

Energy Mix Distribution

2023

Total installed capacity: 53,868 MW(1)



Fossil Fuel
38,108 MW
71%

Renewable Energy
15,760 MW
29%

2037 Target: PDP 2024 (draft)(2)(3)

Total installed capacity: 97,231 MW

Fossil Fuel
30,498 MW
31%

Renewable Energy
66,733 MW
69%

Renewable energy capacity

	2023	2037 Target
Hydropower *Incl. domestic and imported hydropower*	**7,580 MW**	**13,555 MW**
	CAGR 2023-2037 : 4%	
Solar *Incl. ground mounted, rooftop, floating solar*	**2,908 MW**	**36,301 MW**
	CAGR 2023-2037 : 20%	
Wind	**1,504 MW**	**9,379 MW**
	CAGR 2023-2037 : 14%	
Biomass	**2,051 MW**	**4,565 MW**
	CAGR 2023-2037 : 6%	
Other RE *Biogas, industrial waste, MSW*	**1,718 MW**	**2,933 MW**
	CAGR 2023-2037 : 4%	

Note: (1) Only COD projects supplied to public utility system are included. The projects have been contracted, but not yet COD are excluded.
(2) The target capacity from PDP 2024 (draft) is currently under revision based on the results of public hearing and is therefore subject to be changed.
(3) Exclude energy storage system (BESS, PSH) and nuclear power

 Source: DEDE

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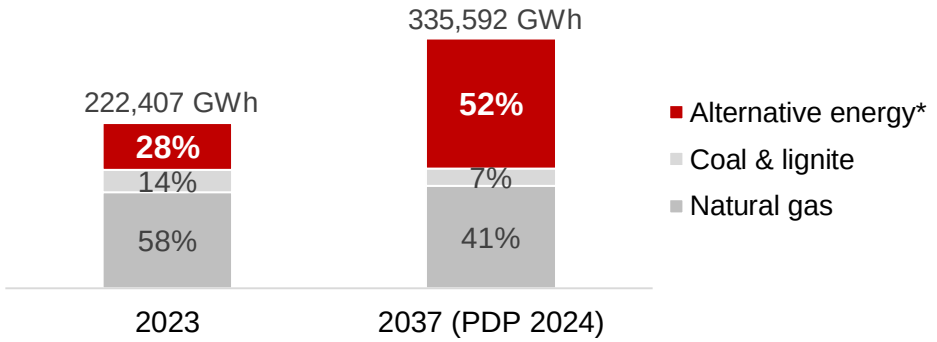
Renewable Energy: Key development & trends

- The renewable energy market will experience rapid growth with the additional capacity of nearly 35 GW by 2037.
- Solar and wind power will dominate the renewable power capacity in the future.

Significant investment in renewable power over the next decade

- To achieve carbon neutrality, the implementation of renewable energy represents the most effective strategy to reduce carbon emission. Particularly within the power generation sector, the renewables will be the preferred source for new addition capacity to replace the coal and natural gas.
- The targets for each renewable source have been periodically revised in response to various factors, such as technology advancement, associated cost, and market trends.
- According to draft PDP 2024, it aims to increase share of renewable sources to more than 50% of the country's power generation in 2037. This requires huge investment in the new renewable power projects and energy storage.
- Solar and wind power are projected to be the predominant sources of new renewable power generation capacity due to the advantages such as declining cost of installation and equipment with no fuel costs.
- The energy storage system, especially BESS, is considered as important to greater use of renewable energy within the power grid. The government started to involve the BESS in solar power project for public procurement in 2022. In addition, the ambitious target of 10 GW is planned for the additional capacity over the coming decades.

Current and target power generation by source of energy



Note: *Alternative energy include renewable energy and nuclear power, which is planned to start power production in 2037.

Additional renewable power capacity during 2024-2037

	Capacity (MW)	Share (%)
Solar power	27,093	77.7%
Wind power	5,345	15.3%
Biomass power	1,046	3.0%
Biogas power	936	2.7%
Waste to energy	312	0.9%
Small hydropower project	99	0.3%
Geothermal power	21	0.1%
New renewable power projects	**34,852**	**100.0%**
Battery Energy Storage System (BESS)	10,485	80.9%
Pumped storage hydropower (PSH)	2,472	19.1%
New energy storage system	**12,957**	**100.0%**

Source: Department of Alternative Energy Development and Efficiency (DEDE), PDP 2024 (draft)

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Renewable Energy: Key development & trends

- The renewable energy industry is experiencing intense competition marked by new entrants and diversification by existing operators.
- Foreign investment is increasing, and the solar power segment is particularly competitive, driven by the growth of the PPA model.

Intensified competition as local and international firms vie for market share

- The competition in the renewable energy industry has becoming intense with increased number of new entrants and business diversification of the existing operators.
- The renewable power industry is **dominated by large operators** e.g. GULF, BGRIM, ACE, EGCO, RATCH. The large operators employ their technological and capital strength to win the government's bidding projects and diversify to various types of renewable energy.
- There has been **growing foreign investment** in renewable energy industry, especially through joint venture projects with local partners.
- **The largest competitive segment is solar power**. The emerging private PPA model in the solar power sector, the more intense competition is occurred from various aspects. For examples:
  - Large operators have expanded customer base from public project to private customers with private PPA model.
  - Engineering, procurement and construction (EPC) providers expand their businesses from construction services to provide solar PPA.

Major renewable power producers in Thailand

Company Group	Type of RE				
	Solar	Wind	Biomass	Biogas	Waste
Gulf Energy Development Pcl. (GULF)	○	○	○	×	○
B.Grimm Power Pcl. (BGRIM)	○	○	×	×	○
Global Power Synergy Pcl. (GPSC)	○	×	×	×	○
National Power Supply Pcl. (NPS)	○	×	○	×	×
Absolute Clean Energy Pcl. (ACE)	○	×	○	○	○
Electricity Generating Pcl. (EGCO)	○	○	○	×	×
Ratch Group Pcl. (RATCH)	○	○	○	×	×
BCPG Pcl.	○	○	×	×	×
Thai Solar Energy Pcl. (TSE)	○	×	○	×	×
Energy Absolute Pcl. (EA)	○	○	×	×	×
Wind Energy Holding Co., Ltd.	×	○	×	×	×
Super Energy Corporation Pcl.	○	○	×	×	○
Gunkul Engineering Pcl.	○	○	×	○	×
Mitr Phol Bio Power Co., Ltd.	×	×	○	×	×
SPCG Pcl.	○	×	×	×	×
Impact Solar Co., Ltd.	○	×	×	×	×
Green Yellow (Thailand) Co., Ltd.	○	×	×	×	×
Constant Energy Services (Thailand) Co. Ltd.	○	×	×	×	×

Source: Office of Energy Regulatory Commission, companies' websites

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Renewable Energy: Key development & trends

- The rise in solar power adoption spans various applications, project types, and investment models.

Trends of solar power adoption in Thailand

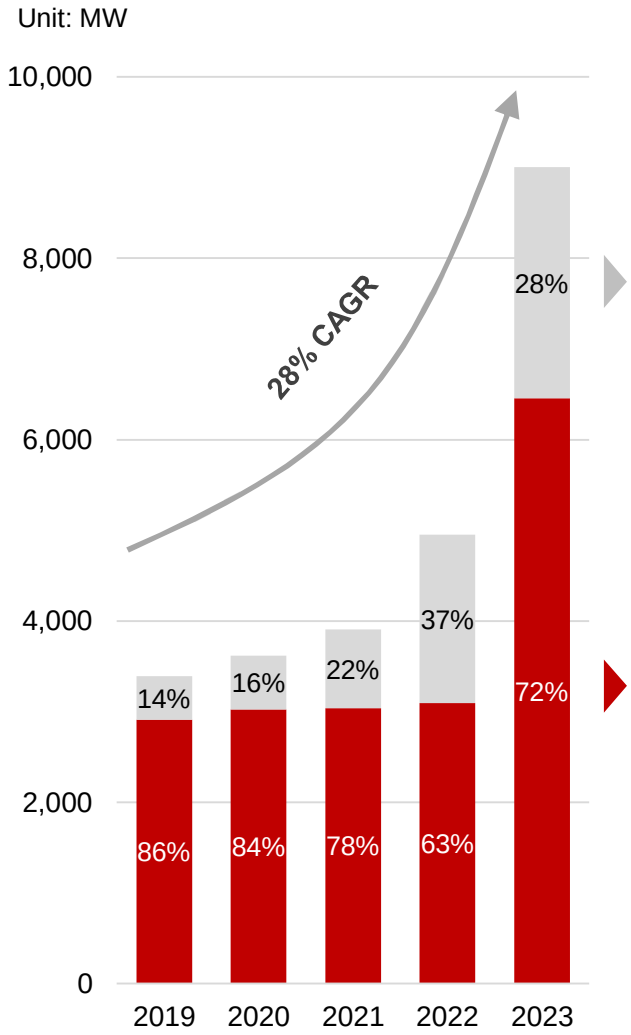
Increasing and widespread implementation across all applications

- **Ground mounted PV** installations are considerably expanding as mainly driven by Feed-in Tariff scheme of public power procurement policy.
- **Rooftop PV** installations are increasing adopted across all sectors - residential, commercial, and industrial - driven by rising electricity cost and the goal of reducing carbon emissions.
- **The floating solar** emerging as a notable trend due to the technology advancement and efficient use of reservoirs and hydro dam.
- In addition, there are rising interest in solar-plus-storage systems, especially within the public PPA projects, seeks to enhance power security and mitigate power supply fluctuation risks.

Increasing trend in self-financing and private PPA

- In recent years, the self-financing and private PPA have gained popularity as investment models among private customers.
- **Self-financing model** is mainly applied for small PV system, such as residential customers, buildings, and some manufactures that have benefited from tax incentives.
- **Private PPA model** is favored for its zero upfront capital investment. This model offers benefits to manufacturers lacking adequate capital and seeking to avoid maintenance burdens.

Installed capacity of PV system in Thailand



IPS: *Independent Power Supply who produce power for their own use or selling directly to the customer without selling to the public utility (which include self-financing and private PPA)*

CAGR 2019-2023: 52%

Capacity share by application (2023)

86%	8%	6%

Public PPA: *The power projects that have signed PPA to sell the power to public utility*

CAGR 2019-2023: 22%

Capacity share by application (2023)

96%	3%	1%

Source: Office of Energy Regulatory Commission (OERC)

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Renewable Energy: Key development & trends

- Although Thailand's wind power sector has not developed as rapidly as solar, significant progress is evident.
- Wind power remains an underutilized resource, yet its potential is substantial.

Trends of wind power in Thailand

Growing onshore wind farm development

- The wind power in Thailand has had significant development over the past decade from 224 MW capacity in 2014 to 4 GW in 2023.
- Now, all wind power projects in Thailand are onshore wind farms. Most of the wind farm projects are located in the Northeastern region, which accounted for more than 80% of the country's installed capacity of wind power.
- Recent years have seen the commissioning of new wind farms with the potential for further expansion being explore thanks to the decreasing cost of wind power technology and favorable government power purchasing policy.

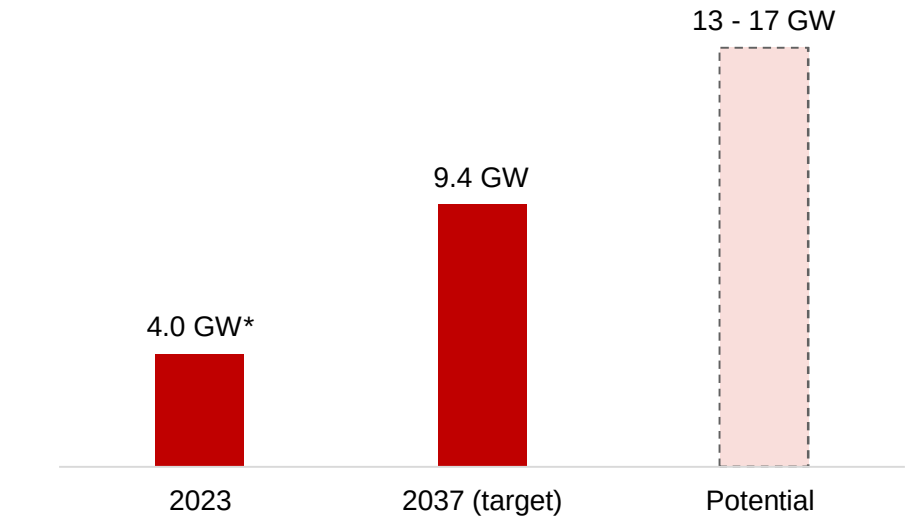
Untapped potential of wind power

- According to the PDP 2024 (draft), the government targeted have total installed capacity of wind power at 9.4 GW, more than 5 GW of installed capacity will be procured during 2025-2037.
- Apart from the country's target, Thailand has a wind power potential of approximately 13-17 GW with deployment of the modern turbines adapted for low wind speeds, as estimated by several studies.
- Despite the decreasing cost of wind power technology, the geographical limitations, high initial cost, and low wind speeds hinder the appeal to investors.

Offshore wind energy potential

- The Gulf of Thailand offers the most promising area, with an estimated magnitude of 7 GW, according to the study conducted by Office of the National Resources and Environmental Policy and Planning (ONEP).
- The extensive coastline in the country's southern region offers significant opportunities for offshore and nearshore projects.

Installed capacity of wind power in Thailand



Note: * Include 1.5 GW of COD and 2.5 GW of PPA signed

Source: Thai Wind Energy Association, Department of Alternative Energy Development and Efficiency (DEDE)

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Renewable Energy: Key development & trends

- Biomass energy has the potential to expand in both the power sector and industrial heating; however, challenges related to feedstocks continue to exist.

Trends of biomass energy in Thailand

Biomass power experiencing moderate growth

- Thailand's biomass power industry has been growing moderately by 4% CAGR during 2015-2023, due mainly to abundant agricultural residues and various government initiatives designed to enhance fuel supply accessibility, facilitate public power procurement, and offer investment incentives.
- As of 2023, biomass power contributed more than 3 GW to the national grid. The government planned to procure additional 1GW capacity from biomass power during 2025-2037.

Competition consolidated among large players

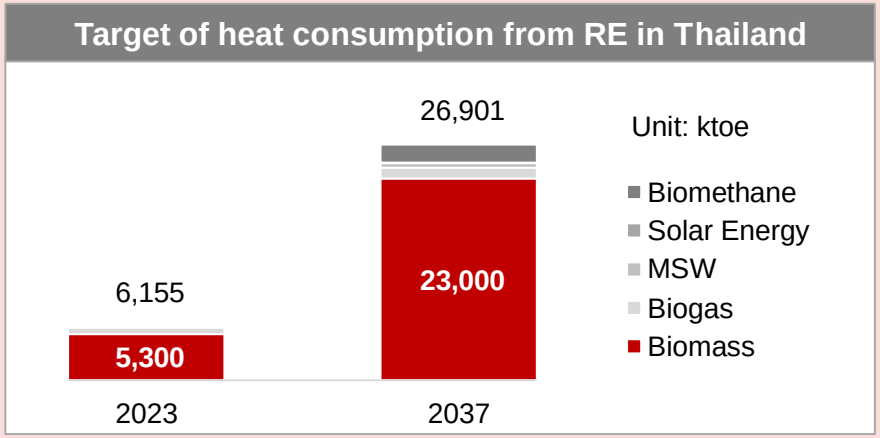
- The biomass power industry has high barrier to entry due to the intense competition in feedstock and high capital investment. Therefore, the industry is relatively consolidated among the large operators.
- The major biomass power producers include the large sugar mills that have abundant residues from production process, such as Mitr Phol Group, Buriram Sugar Group, as well as the independent players who have strong networks with fuel suppliers, namely ACE, TPC Power, and NPS.

Challenges deter the growth of biomass power

- Abundant agricultural residues offer significant potential for energy generation. However, the high logistics cost and storage issues are the crucial factors deter the investment attractiveness.

Substantial growth in heat generation from biomass is anticipated.

- Now, most industrial process heat is currently provided by fossil fuel e.g. coal and natural gas. However, the energy-intensive industries, such as cement, ceramics, glass, food processing, paper, etc., have increasingly replaced fossil fuels with biomass in heat generation.
- According to the AEDP 2024, the country aims to increase the biomass used for heat generation in the industrial sector from 5,300 ktoe as of 2023 end to 23,000 ktoe in 2037.
- There will be increasing adoption of biomass heating in the industrial sectors due to pressure from their trading partners to reduce carbon emission within their supply chain.
- This will potentially drive the demand for machineries and system as well as related services.



 情報管理区分：SC-B

Source: Department of Alternative Energy Development and Efficiency (DEDE), PDP 2024 (draft)

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Renewable Energy: Government initiatives

- Thailand continues to attract local and international investments and adoptions in renewable energy with favorable policies and incentives.

Financial and investment incentives to promote renewable energy development

<table>
<tr><th colspan="2">Incentives</th><th>Eligible entity</th></tr>
<tr><td rowspan="2">Financial incentives</td><td>Feed-in Tariffs scheme</td><td>• Feed-in Tariffs scheme is the crucial instrument for promoting renewable energy development by guaranteeing long-term payments to the power producers at a pre-determined rate.
• Different rates are set for various renewable technologies, reflecting the cost of production.
Thailand’s feed-in-tariff (“FiT”) for the latest public procurement in 2022
<table><tr><th></th><th>Ground-mounted solar</th><th>Ground-mounted solar + BESS</th><th>Wind</th><th>Biogas</th></tr><tr><td>FiT (THB/kWh)</td><td>2.1679</td><td>2.8331</td><td>3.1014</td><td>2.0724</td></tr></table></td><td>▪ Power producers</td></tr>
<tr><td>Net billing scheme</td><td>• Net billing scheme was initial implemented in 2019 to stimulate the rooftop solar PV system installation in household level.
• The scheme allows residential customers to offset their electricity bills by generating their own solar power and selling excess electricity to the local utility at the specific rate, which is 2.2 THB/ kilowatt-hour.</td><td>▪ Residential sector (homeowners)</td></tr>
<tr><td>Investment incentives</td><td colspan="2">• The incentives aims to alleviate project costs by waiving import duties of on machinery and providing corporate income tax exemption for the investment in renewable energy and develop local supply chain.
<table><tr><th>Project types</th><th></th><th>CIT exemption</th></tr><tr><td>Energy production</td><td>• Production of power or power and steam from renewable energy</td><td>8 years</td></tr><tr><td rowspan="3">Fuel & equipment manufacture</td><td>• Manufacture of fuel from agricultural scrap or waste</td><td>8 years</td></tr><tr><td>• Manufacture of parts/ equipment for solar-powered products</td><td>8 years</td></tr><tr><td>• Manufacture of biomass briquette and pellet</td><td>5 years</td></tr><tr><td colspan="2">Factory that invest in upgrading machinery to utilize renewable energy</td><td>3 years</td></tr></table></td><td>▪ Power producers
▪ Manufacture of equipment and fuel
▪ The general business, who invest in renewable energy for their internal used</td></tr>
</table>

Source: BOI, Office of Energy Regulatory Office (OERC)

High-Potential Energy Solutions

Renewable Energy: Business opportunities & challenges

- There will be significant opportunities in solar, wind, and biomass energy projects. Companies involved in the development, installation, and maintenance of renewable energy systems could benefit from this trend.
- However, each energy type presents its unique set of challenges that need to be considered.

Business opportunities & challenges of key renewable energy

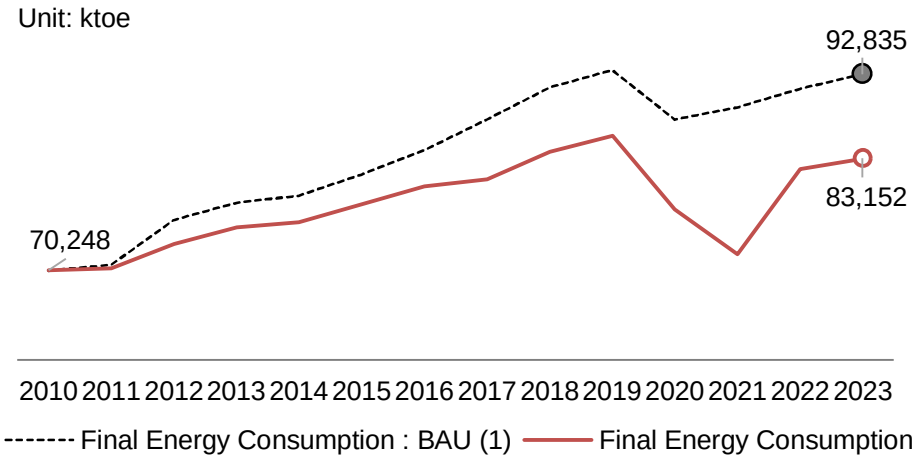
	Solar power	Wind power	Biomass
Business Opportunity	There are abundant opportunities in all types of project and business models. ▪ Rooftop PV for residential sector, commercial and industry sector ▪ Utility-scale solar projects ▪ Solar EPC, private PPA ▪ Equipment manufacturing and supply ▪ Maintenance service ▪ PV recycling facility	▪ Hybrid wind-solar power project development to optimize land use ▪ R&D in technology, particularly in wind turbines designed for low wind speed conditions	▪ EPC services for heat and power generation system with utilizing biomass-fuel ▪ Maintenance services ▪ Energy as a service ▪ Machinery and equipment supply, especially the high-efficient machinery that can use a variety of biomass fuels
Challenges	▪ Land use concerns, especially for large-scale solar projects ▪ Complexities in regulatory and licensing processes ▪ Competition from local players	▪ Less predictable and low wind speed ▪ High upfront cost, specialized equipment requirement, maintenance procedures ▪ Concerns about land use and environmental impact e.g. noise, impact on local wildlife, etc.	▪ Reduction in energy crop yield due to climate change ▪ Feedstock competition from various sectors e.g. biofuel, bioplastics, industrial heat ▪ Complexities of collection logistics and storage of feedstock ▪ Operational issues, e.g. equipment maintenance, feedstock quality variation

Energy-Efficient Solution: Industry snapshot

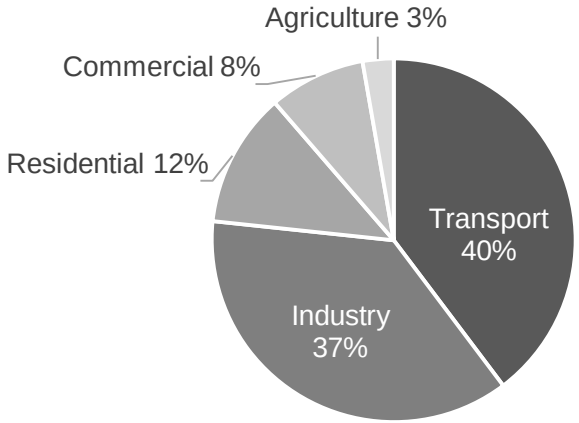
Energy-Efficient Solution

Thailand's energy efficient solutions market is well-established as it was started for more than a decade. However, it still need more investment to reach country's target.

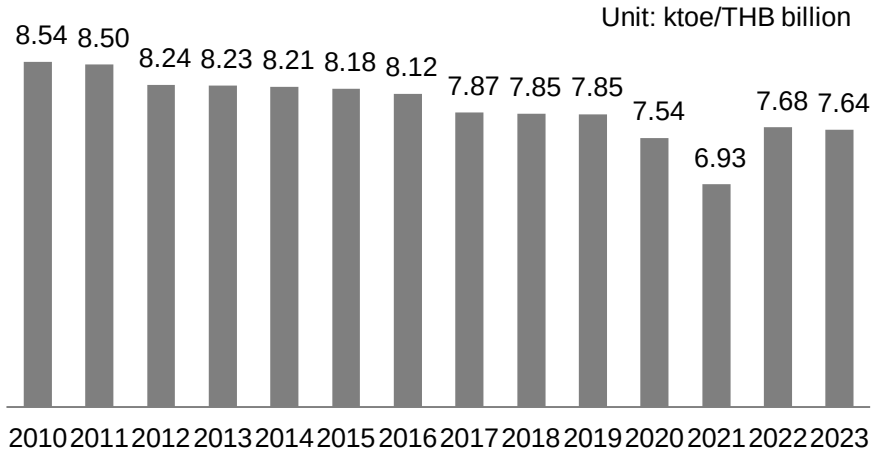
Final energy consumption trend



Final energy consumption by business (2023)



Energy intensity (EI) (2)



Energy Efficiency Target 2037

		Energy saving	Share (%)
By energy type	Heat energy	26,736 ktoe	75%
	Power energy	8,761 ktoe	25%
	Total saving	**35,497 ktoe**	**100%**
By business sector	Transport	17,039 ktoe	48%
	Industry	12,432 ktoe	35%
	Commercial	3,542 ktoe	10%
	Residential	1,774 ktoe	5%
	Agriculture	710 ktoe	2%
	Total saving	**35,497 ktoe**	**100%**

Note:(1) BAU is the business-as-usual.
(2) Energy intensity (EI) is a measure of the energy inefficiency of the country, which is calculated as units of energy per unit of Gross Domestic Product (GDP).

 情報管理区分:SC-B Source: Department of Alternative Energy Development and efficiency (DEDE)

High-Potential Energy Solutions

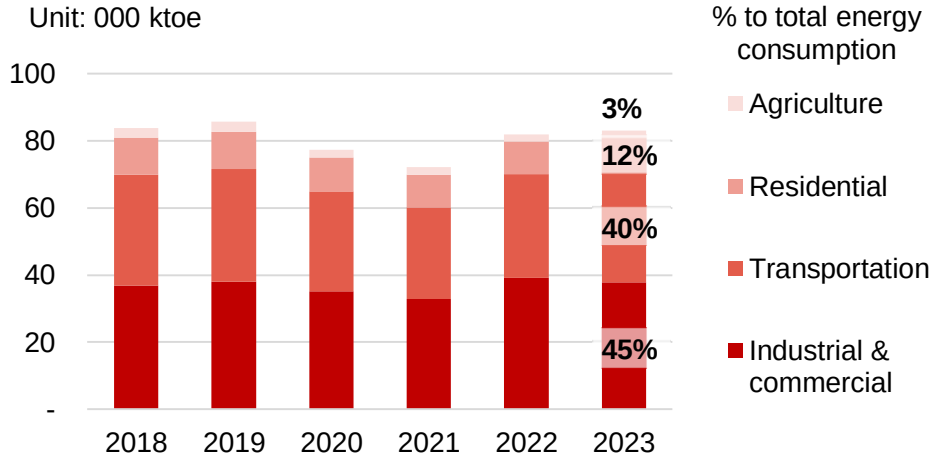
Energy-Efficient Solution: Key development & trends

- The energy efficiency plan aims to reduce the energy consumption in Thailand, mainly by enhancing efficiency in the industrial, commercial, and transport sectors.

Industrial, commercial, and transport sectors contributing to energy efficiency improvement

- The energy consumption has consistently increased over the years, driven by industrial and commercial sector and transport sector, which accounts for approximately 45% and 40% of the country's energy used in 2023, respectively.
- The implementation of the Energy Efficiency Plan (EEP) lays out a clear roadmap for the advancement of energy efficiency across various sectors.
- The draft EEP 2024 aims to reduce energy intensity by 36%, or an expected energy reduction of 35,497 ktoe.
  - **Transport sector**: The plan aims to increase the efficiency of internal combustion energy (ICE) vehicles, drastically utilize EVs, and increase the share of electric trains.
  - **Industrial and commercial sector**: The plan aims to reduce energy consumption in industrial and commercial sector by enforcement of the building energy code and energy management in factories and buildings together with promoting the use of energy efficiency devices, e.g. LED lighting, high-efficient boiler, heat pump, air compressor, ventilation equipment, IoT and smart technology, etc.
  - **Residential sector**: The plan aims to promote the energy-saving labels in the main appliances used in houses, e.g. air conditioners, gas stoves, etc.

Thailand's final energy consumption* by sector



Note: * Include power, heat, and fuel energy consumption

Energy saving target of EEP 2024 (draft)

Sector	Energy saving target in 2037	% to total energy saving
Transport sector	17,039 ktoe	48%
Industrial sector	12,432 ktoe	35%
Commercial sector	3,542 ktoe	10%
Residential sector	1,774 ktoe	5%
Agricultural sector	710 ktoe	2%
Total	**35,497 ktoe**	**100%**

Source: Department of Alternative Energy Development and efficiency (DEDE)

Energy-Efficient Solution: Key development & trends

- The energy efficiency policies are driving the business sector towards sustainable practices.
- This has boosted demand for energy solutions, with trends in the industrial sector including high-efficiency motors and AI-driven automation, while the commercial sector adopts green standards.

Factories and buildings increasingly implement energy efficiency solutions

- The country's energy efficiency policies and measures are regarded as the most crucial factors encouraging the business sector to adopt energy efficiency.
- Compulsory measures, such as building energy code and energy management systems, mandate large and energy-intensive buildings and factories to conserve energy and develop plans for efficient energy use.
- The growing number of large buildings and factories has led to a heightened demand for energy efficiency technologies, equipment, machineries, and related services, e.g. energy consulting, energy audits.

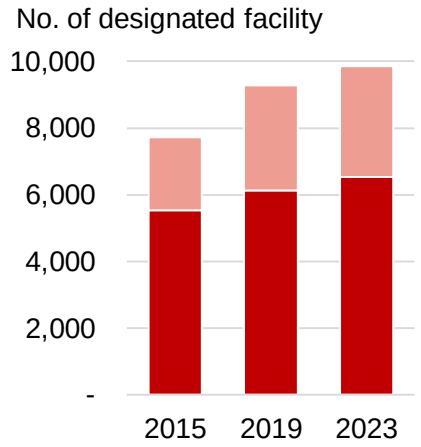
Recent trends in industrial sector

- Increasing use of high-efficiency motors and variable speed drive (VSD)
- Integration of automation and smart monitoring system, e.g. automated guided vehicles, predictive maintenance using AI, real-time monitoring and optimizing operation, etc.

Recent trends in commercial and building sector

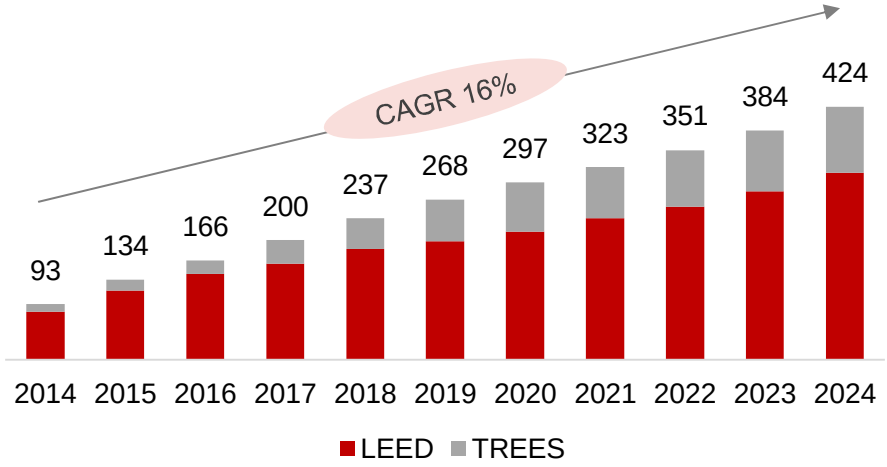
- Gaining popularity of green building standards, e.g. LEED and TREES, among leading property developers
- Focus on LED lighting, efficient HVAC system and chiller as well as smart metering system
- Rising adoption of smart sensors and controls
- Increasing adoption of district cooling system in large-scale properties and mixed-use complex

Designated factories and buildings in Thailand



Criteria of designated facility	
Electric power meter	≥ 1,000 kW
Transformer	≥ 1,175 kVA
Annual energy consumption	≥ 20 mil. MJ

No. green building in Thailand



Source: Department of Alternative Energy and Efficiency (DEDE), U.S. Green Building Council (USGBC), Thai Green Building Institute (TGBI)

High-Potential Energy Solutions

Energy-Efficient Solution: Government initiatives

- The country has implemented various policies and programs to improve energy efficiency across different sectors.

Key government measures on energy efficiency

<table>
<tr><th colspan="2">Measures</th><th>Applicable to</th></tr>
<tr><td rowspan="2">Compulsory measure</td><td>Building Energy Code (BEC)</td><td>• Building Energy Code (BEC) is a set of standards establishing the minimum energy efficiency requirements for buildings

<u>Components required to comply with standard</u>
1) Envelope system: walls, roof, and windows
2) Electric lighting system
3) Air-conditioning system
4) Water heating appliance
5) Renewable energy system
6) Whole building energy</td><td>• Newly constructed and retrofitted buildings with a total area of 2,000 sq.m. or more

<u>Building type coverage</u>
• Education building
• Hospital
• Office building
• Condominium
• Convention hall
• Hotel
• Theatre
• Entertainment venue
• Shopping mall/ Department store</td></tr>
<tr><td>Energy Management</td><td>• Energy Efficiency Promotion Act requires the owner of designated factories and buildings to implement comprehensive energy management approaches and require systematic tracking, reporting, and continuous improvement of energy performance.
<u>Regulatory requirement</u>
• Implementing an energy management system
• Annual energy audit by certified auditor
• Energy management report</td><td>• High energy consumption buildings or factories that are classified as designated facility base on following criteria.

<u>Criteria of designated facility</u>
• Electric power meter ≥ 1,000 kW
• Transformer ≥ 1,175 kVA
• Annual energy consumption ≥ 20 mil. MJ</td></tr>
<tr><td rowspan="2">Voluntary measure</td><td>Investment incentives</td><td>• The investment incentives provided by BOI aim to alleviate project costs by waiving import duties of on machinery and providing corporate income tax exemption for the investment in energy saving technology.

<table><tr><th>Activities</th><th>CIT exemption</th></tr><tr><td>• Energy service company (ESCO)</td><td>8 years</td></tr><tr><td>• Investment in energy-efficient machinery</td><td>3 years</td></tr></table></td><td></td></tr>
<tr><td>Financial incentives</td><td>• Several financial incentives, such as financial subsidies, soft loan, credit guarantee, have been offered to promote the investment in and operations of energy conservation programs and support research and development of energy-efficient technologies.</td><td></td></tr>
</table>

Source: Department of Alternative Energy Development and Efficiency (DEDE), BOI

High-Potential Energy Solutions

Energy-Efficient Solution: Business opportunities & challenges

- The diversity of the industry presents opportunities for differentiation.
- The business opportunities can range from simple measures, such as machine replacement, to advanced technology and professional services.

Business opportunities in the energy efficiency sector in Thailand

Future trend of energy efficiency

- The energy efficiency market is expected to grow steadily, driven by government targets, energy cost fluctuation, and increasing global focus on sustainability.
- The industrial sector is projected to contribute the largest share of energy savings. Meanwhile, the building sector is expected to see significant growth in power efficiency investments.
- The demand for energy-efficient products, ranging from electrical appliances, machinery, to building materials, is expected to surge.
- In the meantime, the rise in digital technology will drive the demand for IoT, data analytics, smart and automation in energy efficiency solutions.

Key challenges:

- High upfront costs of energy-efficient technologies will deter adoption, especially for the small and medium factories.
- Limited awareness and understanding of energy efficiency benefits
- Price pressure from local players
- Regulatory complexities and changes, e.g. business licenses and permits, engineering standard, safety standard
- Foreign restriction in some sectors/ business

Business Opportunities	
Target market	▪ Large manufacturing sector with aging equipment and high energy intensity, e.g. food manufacturing, automotive, electronics, etc. ▪ Rapid urbanization and growing commercial property sector, especially hotels, shopping malls, hospitals, office building, mixed-use building ▪ SMEs market that are underserved due to financing constraints
Products	▪ **Green building materials**: e.g. building insulation, building envelope ▪ **High-efficient machineries**: e.g. LED lighting, HVAC system, electric motor, district cooling system, electric boiler, heat pump, chiller, waste heat recovery system, thermal energy storage technology ▪ **Smart and automation systems (hardware & software)**: e.g. smart meter and monitoring system, energy monitoring, analytic, and reporting, building and factory automation system, building and factory management system, smart home devices and system
Services	▪ Energy audits ▪ Energy management consulting ▪ Green building consultancy services ▪ Green architecture design ▪ Building retrofit services for energy efficiency

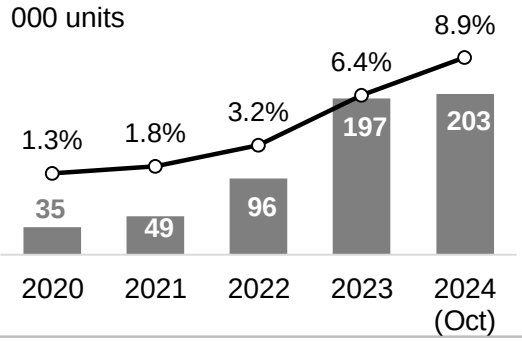
Electric Vehicle & Ecosystem: Industry snapshot

Electric Vehicle & Ecosystem

Thailand's EV market is in an early adoption with significant growth, with multiple players entering making considerable investments in the ecosystem.

Annual sales of EVs

203,120 units of new EV sold in 2024 (as of Oct)
accounted for 8.9% of total motor vehicle sales(1)



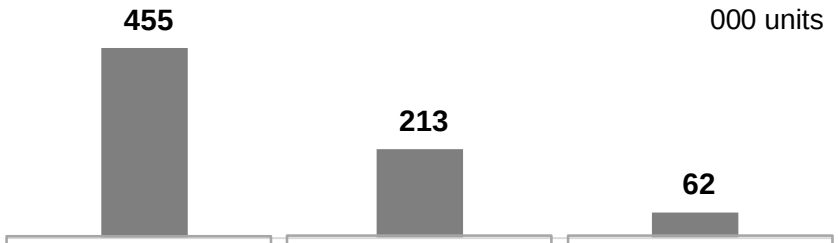
2024 sales share by types	
HEV	56%
BEV	40%
PHEV	4%

Public charging stations (2) (as of June 2024)

Service providers	**15** providers	▪ Major providers are PTT, EA, PEA, Sharge, Evolt, MEA
Charing station (Locations)	**3,175** locations	▪ Concentrated in Bangkok and vicinities
No. of chargers	**10,846** chargers	▪ 5,458 fast chargers (DC) ▪ 5,388 normal chargers (AC)

Accumulative no. of EVs

730,470 units of EV are in use in 2024 (as of Oct)



HEV	BEV	PHEV
Car & pick up trucks **446,041 units** (98%)	Car & pick up trucks **149,373 units** (70%)	Car & pick up trucks **91,913 units** (100%)
Motorcycles **9,321 units** (2%)	Motorcycles **59,396 units** (28%)	Motorcycles -
Buses & trucks **2 units**	Buses & trucks **3,378 units** (2%)	Buses & trucks -
Others -	Others **1,046 units** (0.5%)	Others -

Note: (1) Total motor vehicle sales in 2024 (Jan-Oct) was 2.28 million units, which cover cars, motorcycles, bus, trucks, tractors, and farm vehicles that registered with the Department of Land Transport.
(2) The number does not include charging stations that serve only specific EV owners e.g., Tesla Supercharger, MG Super Charge, etc.

Source: Department of Land Transport (DLT), Energy Policy and Planning Office (EPPO), Electric Vehicle Association of Thailand (EVAT)

High-Potential Energy Solutions

Electric Vehicle & Ecosystem: Key development & trends

- The electric vehicle market in Thailand is still small, but it has experienced significant year-over-year growth.
- The market has seen a number affordable electric car models, popularity of e-motorcycle rental services, and growing adoption of e-bus and truck in logistics sector.

The growing significance of EV in Thailand

- The electric vehicle market in Thailand has seen accelerated growth since 2022, driven by the government incentives, increasing consumer acceptance, decreasing electric vehicle price, and rising fuel cost.

Passenger car:

- HEV has strong market presence in Thailand led by Japanese assemblers.
- The market has gradually shifted to BEV as primarily due to increasing consumer preference for affordable Chinese electric car models. Nevertheless, the high cost of batteries and safety concerns remain significant constraints on demand for BEV.

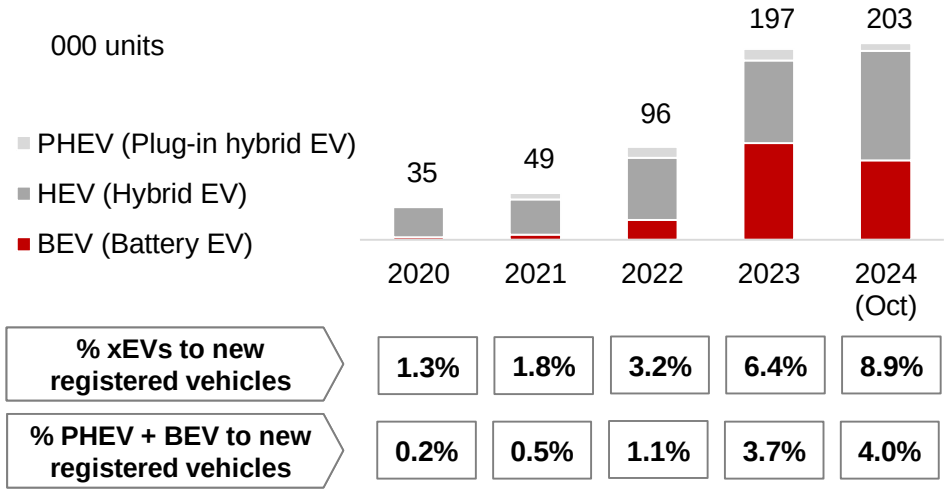
Motorcycle:

- There has been increasing acceptance of e-motorbikes, especially for delivery services.
- Leading ride-hailing and food delivery platforms, alongside emerging rental services are driving increased demand for e-motorbike by offering low rental rates and unlimited battery swaps that eliminating fuel cost concerns for riders.

Bus & truck:

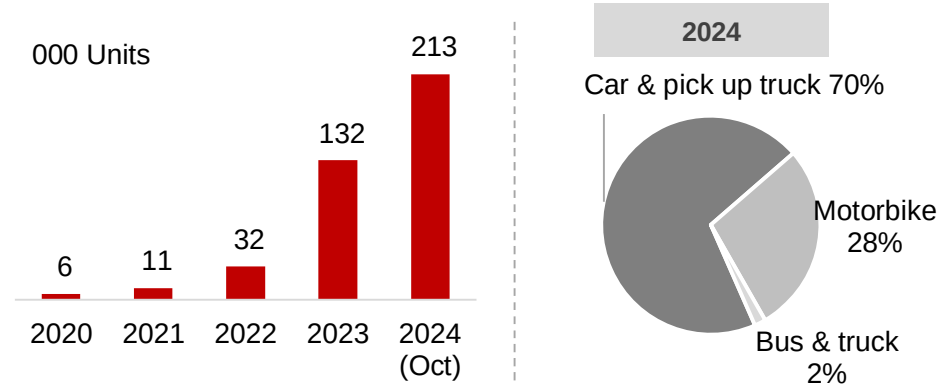
- The market of electric buses and trucks is also growing with increasing adoption by the leading passenger and good transport companies, e.g. DHL, Wise, PTT group, etc.
- The local brands, such as Nex, Mine, ThaiEV, dominate the e-bus and truck market in Thailand.

New registered xEVs in Thailand



	2020	2021	2022	2023	2024 (Oct)
% xEVs to new registered vehicles	1.3%	1.8%	3.2%	6.4%	8.9%
% PHEV + BEV to new registered vehicles	0.2%	0.5%	1.1%	3.7%	4.0%

Accumulated registered BEVs(1) in Thailand



Note: (1) Include all types of vehicle, such as personal car, pickup truck, bus & truck, motorbike, tuk tuk, tractor.
Source: Department of Land Transport (DLT), Energy Policy and Planning Office (EPPO)

High-Potential Energy Solutions

Electric Vehicle & Ecosystem: Key development & trends

- The industry is still evolving, particularly in the area of battery electric vehicle (BEV) assembly, which has been transformed by a wave of Chinese assemblers and new-entry Thai players.

Growing BEV production dominated by Chinese brands

- Currently, Japanese-led HEVs, e.g. Toyota and Honda, dominate electric vehicle production in Thailand.
- Since 2022, the generous investment incentives has attracted huge investment from Chinese manufacturers. Those manufacturers, led by BYD, Changan, GAC Aion, SAIC Motor, GWM, will commence operation during the recent years, increasing annual assemble capacity by more than 600,000 units.
- They intend to utilize Thailand as a manufacturing hub for exporting electric vehicles to the regional market.
- This will potentially reshaping Thailand's automobile industry.

Production capacity of leading Chinese BEV manufacturers in Thailand*

Company / brand	Annual capacity
BYD	150,000 units
Changan Automobile (DEEPAL, LUMIN)	100,000 units
GAC Aion (AION)	100,000 units
SAIC Motor – CP (MG)	100,000 units
Great Wall Motor (GWM)	100,000 units
Chery Automobile (OMODA & JAECOO)	50,000 units
Hozon Auto (NETA)	20,000 units

Source: *Initiate operations for the period 2024-2025

Emerging Thai players enter in EV manufacturing

- There is the emergence of local players joining the vibrant electric vehicle industry.

For example:

- PTT Group, the country's largest energy conglomerate, established the electric vehicle assembly plant through joint venture with Taiwanese Foxxcon Tech Group.
- Energy Absolute Plc, the leading renewable energy company, established 100% owned electric vehicle assembly plant and R&D facility and holds minority share in electric commercial car factory.
- In addition, some local companies produce e-motorcycles, e-Tuk Tuk, and minibuses.

Examples of Thai BEV assemblers

Company	Vehicle type	Annual capacity
Horizon Plus *(JV of PTT Group and Foxconn Tech Group of China)*	Passenger car	50,000 units
Nex Point *(associated company of Energy Absolute Plc. (EA))*	Truck, bus, tractor	9,000 units
Mine Mobility *(Subsidiary of EA)*	Passenger car, pickup truck, bus	3,000 units

Source: Krungsri Research, public news, company's websites

High-Potential Energy Solutions

Electric Vehicle & Ecosystem: Key development & trends

- There has been growing investment in battery assembly, especially from Chinese battery manufacturers.
- The expansion of charging stations is primarily driven by substantial investments from traditional fuel companies and public utility providers.

Growing interest in battery investment

- Chinese and Thai manufacturers have recently dominated investments in battery assembly in Thailand. Thai entities, predominantly led by energy firms such as PTT, EA, and Banpu Next, are collaborating with leading Chinese battery producers to harness their expertise in the industry.
- Now, the investment mainly focuses on assembling battery in form of “Cell to Pack” and “Cell to Module”, with no battery cell production in Thailand. However, there is the heightened interest from Chinese investors in engaging with upstream processes, like battery cell.

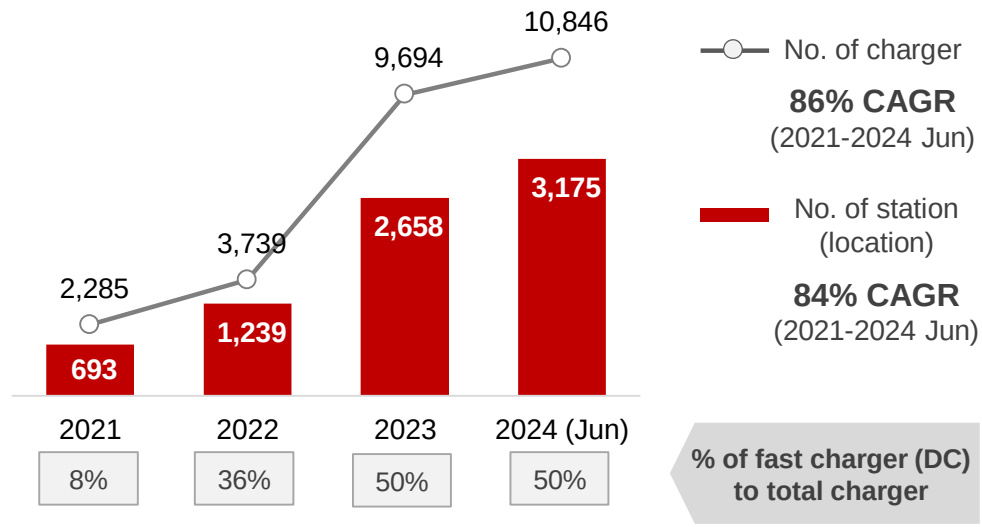
Leading battery assemblers in Thailand

Thai Co.	Foreign partnerships
PTT	• **JV with Gotion**, through Nuovo Plus, a group company, to assemble battery • **JV with CATL**, through Arun Plus, a group company, to assemble battery with annual capacity of 4 GWh
Banpu Next	• **JV with SVOLT** (GWM) to assemble 60,000 battery pack • **Collaborate with Durapower** to set up a battery assembly plant with an annual capacity of 1 GWh
Energy Absolute	• **JV with Amita** to assemble battery with annual production capacity at 4 GWh • **MOU with Sunwoda and EVE Energy** to invest in battery cell manufacturing business with initial capacity of 6 GWh per year

Expansion of public charging networks, but limited availability of supercharger

- The network of public charging stations has expanded considerably with increasing share of DC fast chargers(1). However, the number of superchargers(2) remains limited, which making less convenient for long-distance travelers.
- There is increasing partnership to install charging points at various locations including fuel service stations and shopping malls.
- Currently, there are 15 public charging service providers, dominated by PTT, who has rapidly expanded charging stations by utilizing their existing fuel station infrastructure, and MEA, PEA, and EGAT, who are the state-enterprises providing public utility.

No. of EV charging stations in Thailand



Note: (1) DC fast chargers are typically able to charge an EV to 80% in 30 mins – 2 hrs. (2) Superchargers can charge in 15 mins.

Source: Electric Vehicle Association of Thailand (EVAT), public news

High-Potential Energy Solutions

Electric Vehicle & Ecosystem: Government initiatives

- Thailand has been making significant strides in becoming an EV manufacturing hub in Southeast Asia.
- Several measures, which include investment incentives, financial subsidy, and tax reduction/ exemption, have been implemented to develop an electric vehicle ecosystem to achieve the country's ambitious targets.

Government policies and supporting measures

	EV	Key parts & components	Charging infrastructure
Import duty(1)	• Up to 40% reduction for BEV priced ≤ 2 mil. THB • Up to 20% reduction for BEV priced >2-7 mil. THB	• Import duty exemption for key parts e.g. battery, traction motor, charger, compressor, converter	• -
Excise tax(2)	• Reduce BEV excise tax to 0-2%	• Reduce excise tax to 1%	• -
Subsidy(3)	• Financial subsidy for BEV purchasing is ranging from 5,000 – 100,000 THB. • The eligibility and subsidy amount base on retail price of vehicle, purchasing year, and battery capacity.	• Financial subsidy at 30-50% of investment value for manufacture of battery (start from cell production)	• -
Tax deduction(4)	• 150-200% deduction for CIT for the purchase of E-buses and E-trucks	• -	• -
Investment incentive	• **3-8 years CIT exemption** for manufacture of BEV(5), PHEV, HEV, FCEV, battery electric motorcycle, battery electric tricycle, e-bus & truck, e-bike	• **5-8 years CIT exemption** for manufacture of key parts and battery(6)	• **3-5 years CIT Exemption** for charging station and battery swapping station

2030 Target

ZEV 30% of motor vehicle PRODUCTION

ZEV or Zero Emission Vehicle include battery EV, fuel-cell and hydrogen vehicle

Cars & pickup trucks	Motorcycles	Buses & trucks
725,000 units	675,000 units	34,000 units

ZEV USAGE *(accumulative registration)*

Cars & pickup trucks	Motorcycles	Buses & trucks
440,000 units	650,000 units	33,000 units

Charging Infrastructure

Fast charge station	Battery swapping station for E-motorcycle
12,000 stations	1,450 stations

Note: (1) The import duty will be reduced and exempted under certain conditions.
(2) The excise tax will be effective until the end of 2025. The excise tax for PHEV, HEV, and ICE are higher base on the level of carbon emission.
(3) EV measure Phase 2 (2024 – 2027)
(4) The granting of the tax deduction will be effective until the end of 2025.
(5) Maximum at 13-year CIT exemption in case of R&D
(6) Maximum at 15-year CIT exemption for battery cell.

Source: Electric Vehicle Association of Thailand (EVAT), BOI, public news

High-Potential Energy Solutions

Electric Vehicle Ecosystem: Business opportunities & challenges

- The future outlook of Thailand's electric vehicle industry will be characterized by an evolving market landscape, infrastructure enhancements, and technological innovations.
- There are significant opportunities in the manufacturing, the development of charging infrastructure, and supporting services.

Potential business opportunities in Thailand's EV market and ecosystem

Thailand's EV market & industry trend

- Domestic EV market is expected to continued growth as primarily driven by the reduction in EV price and more charging network coverage.
- Due to the technological advancement, the market is expected to see more model launches with longer range capabilities.
- The remarkable expansion of EV market is expected to attract new entrants, thereby increasing pressure for more intense competition.

Global demand trend

- As Thailand is positioned itself as the global hub for EV production, the global demand will drive the country's EVs export performance.
- Despite the market's current fluctuation, the long-term growth outlook for EVs remains positive. The global passenger EV sales will grow at around 21% annually during 2024-2027, according to BloombergNEF.

Key challenges & issues:

- Several consumer concerns, such as lack of widespread charging station, high maintenance cost, safety issues, may limit the market growth.
- The heightened competition, especially from Chinese brands, is expected to reduce prices, potentially causing consumers to hesitate in purchasing as they await more stable market pricing.

	Business Opportunity
EV parts and components	▪ The expansion of EV production, in conjunction with the requirement for local contents, will drive the demand for key parts and components, e.g. motor, motor core, invertor, semiconductor and electronics components, etc.
Battery related	▪ As demand for EV escalates, the demand for battery will be risen. According to BOI, the domestic demand of battery will exceed 40 GWh per year by 2030 to serve the EV production. ▪ There are plenty opportunities in battery related businesses, for examples; battery cell, battery component manufacturing, battery management system, battery-as-a-service models, battery recycling and waste management facilities.
Charging infrastructure	▪ The increasing use of EV will drive the demand for charging infrastructure. ▪ Therefore, the major equipment for EV charging will have substantial room for future expansion, for examples: charger devices, home charging solution, public charging solution, especial fast/ super fast charging.
Related services	▪ There will be increasing demand in the related services, for examples: EV maintenance and repair services, EV fleet services, e.g. for taxi, delivery services, logistics services, and corporate fleets

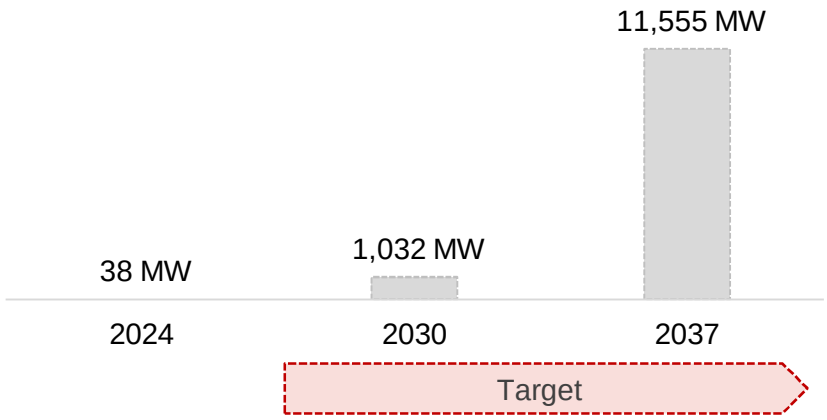
Energy Storage System: Industry snapshot

Energy Storage System

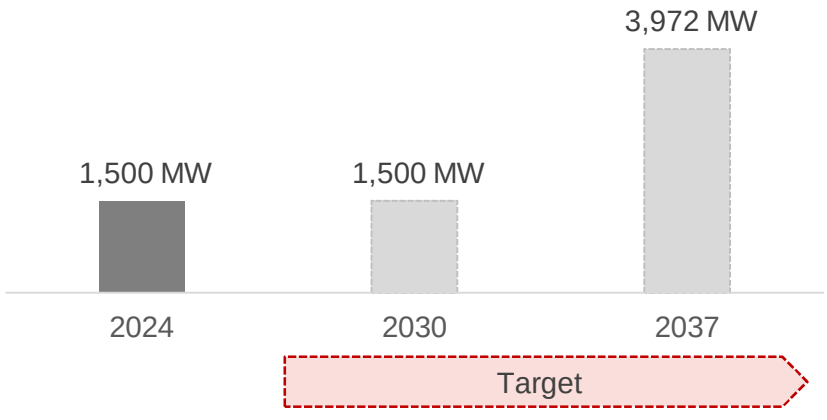
Thailand is currently in the transitioning from initial exploration to more active implementation of energy storage system driven significantly by government support.

Installed capacity of Energy Storage System(1)

Battery Energy Storage (BESS)



Pumped Storage Hydro (PSH)



Recent development

- **Utility-scale power project**: Remarkable growth of BESS application due to government support and aim for power security amid growing of renewable energy
- **Business and home application:** Limited application due to high cost

- All PSH system in Thailand is invested by EGAT at its reservoirs of hydropower plant projects.

Note: (1) The installed capacity of energy storage system for power projects under PDP, which the EV battery and home-used are excluded.

Source: PDP 2024 (draft)

High-Potential Energy Solutions

Energy Storage System: Key development & trends

- In Thailand, energy storage systems focus on utility-scale projects, primarily using BESS, with future expansions planned.
- Pumped storage hydropower is also utilized but has limited growth due to commercial viability challenges.
- Fuel cell energy storage is minimally adopted, with only small capacity in operation.

Current situation of energy storage system in Thailand

Strategic focus on renewable energy integration

- Currently, the energy storage systems are primarily utilized for utility-scale projects, as the government has proactively endorsed initiatives under the feed-in-tariff scheme.
- Battery Energy Storage System (BESS) dominates the deployment in Thailand.
- Pumped storage hydropower (PSH)(1) and fuel cell energy storage are mainly adopted by EGAT because of commercial unviability. In addition, EGAT plans to expand pumped hydro facilities using existing reservoirs and dams, thereby minimizing both development costs and environmental impact.
- The public utility authorities, *including EGAT and PEA*, have actively invested in the research and pilot project to deploy substation-sited storage. The grid has also been continuously changed to smart grid technologies to enhance the efficiency and management of energy storage system.
- The energy storage system deployment in the industrial, commercial and residential use, *or so called "behind-the-meter storage system*, remains limited, as they are deemed not yet financially viable.

Recent energy storage system adoption in power sector	
Battery energy storage system (BESS)	• EGAT has installed grid-scale BESS to manage fluctuations of renewable energy in 3 projects with combined capacity of **38 MW**. • In addition, in 2022, the government approved 24 projects of ground-mounted solar with BESS for the power procurement during 2022-2030. Their total combined storage capacity was **994 MW**. • Furthermore, PDP 2024 (draft) aims to add **10.5 GW** of BESS capacity during 2025-2037.
Pumped storage hydropower (PSH)	• Currently, there are 3 pumped storage hydropower projects, operated by EGAT, with the combined generation capacity of **1.5 GW.** • EGAT plans to add **2.5 GW** of PSH at three existing dams during 2025-2037.
Fuel cell energy storage	• Only one project of fuel cell energy storage adoption in power sector in Thailand. • The project was developed by EGAT at the wind-hydro hybrid power project, which fuel cell storage was installed with the generation capacity of **0.3 MW**.

Note: (1) Pumped storage hydropower (PSH) is a type of hydroelectric energy storage. It is a configuration of two water reservoirs at different elevations that can generate power as water moves down from one to the other (discharge), passing through a turbine.

Source: PDP 2024 (draft), Office of Energy Regulatory Commission, IEA, EGAT

High-Potential Energy Solutions

Energy Storage System: Key development & trends

- Among various energy storage technologies, BESS maintains market dominance and is likely to continue in the future due to its adaptability across various sectors and decreasing costs.

Battery will Dominate Energy Storage Market

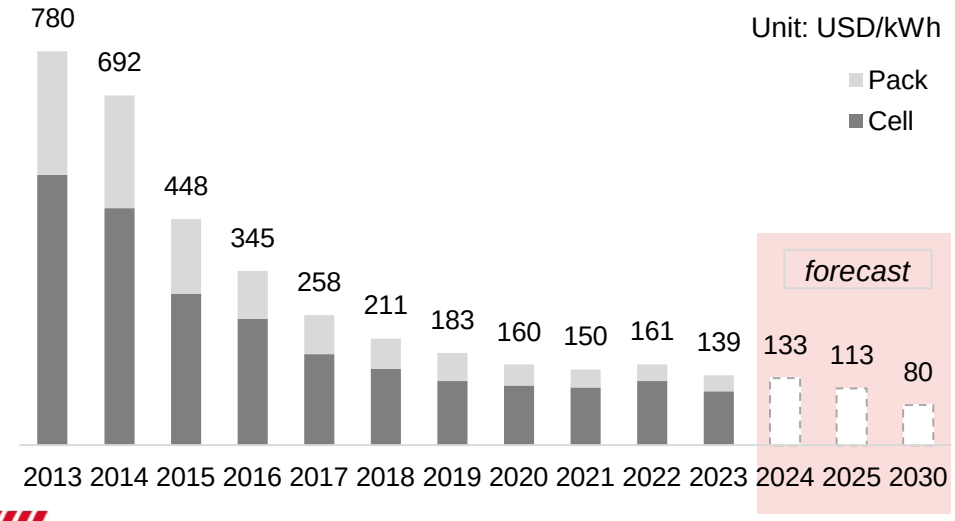
Decreasing trend of battery cost

- The market has witnessed rapid technology advancement, especially Lithium-ion batteries, which are becoming increasingly cost-effective, improved battery performance, and longer lifecycle.
- Bloomberg NEF forecasted that the average battery pack prices to drop to USD 133/kWh due to the decreasing prices of key battery metals like lithium, nickel and cobalt.
- In addition, technological innovation and manufacturing improvement should drive further declines in battery pack prices to USD 80/kWh in 2030.

BESS Applications

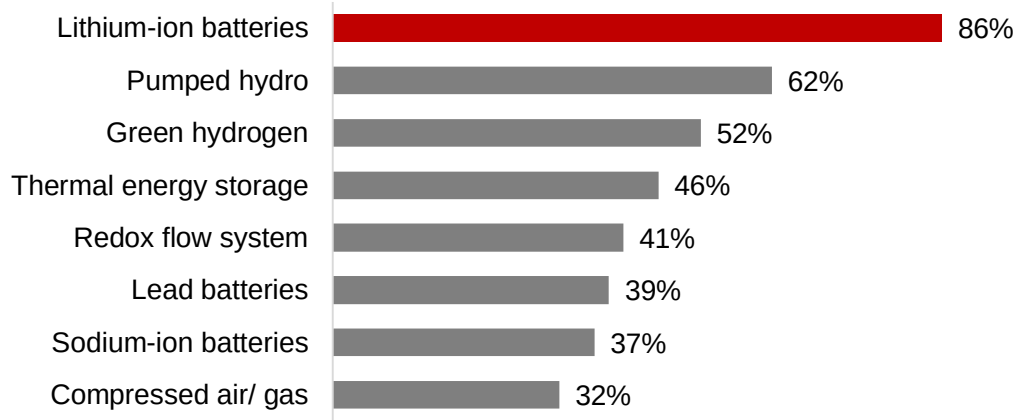
Front of the meter	Behind the meter	
Power generation & distribution	Commercial & industrial	Residential
• Power stations • Transmission & distribution • Substation • Utility-scale generation	• Renewable integration • UPS • Power cost optimization • EV charging infrastructure	• Solar roof integration • EV charging infrastructure

Average Lithium-ion battery pack prices forecast



Key storage technologies expected to develop over the next 3 years

(% represent the percent of all respondents who selected the specified technology)



Note: Survey of over 436 senior executives with involvement in energy storage systems in various regions worldwide in 2023.

Source: Bloomberg NEF, McKinsey, DNV

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Energy Storage System: Government initiatives

- Thailand has implemented 10-year plan to promote battery energy storage system.
- Four key areas were targeted: production, usage, laws & standards, and research, development & personnel building.
- The favorable investment incentives are offered to accelerate the local production of battery from upstream process.

Key supporting measures on battery energy storage system

Battery energy storage system industry promotion plan 2023-2032

Production	• Promote battery value chain matching • Establish one-stop-service for BESS industry to promote ease of doing business • Support to net zero emission factory
Demand driven	• **Integration of renewable power & BESS** for both existing and new renewable power projects • **Tax measure and financial subsidy** for locally produced battery user • **Replace the government vehicles to EVs** with using locally produced battery
Regulation & standard	• Revision of regulation • Setting standard for production, safety, utilization and waste disposal
R&D capability building	• Create ecosystem of BESS R&D • Technology readiness for next generation of ESS • Human resource development

Investment incentives for battery energy storage

	CIT exemption
Battery cell for EV and energy storage(1)	15 years
Manufacture of high-density batteries with the cell production process	8 years
Manufacture of high-density batteries in the case of using cells in the production of modules or battery packs	8 years
Manufacture of high-density batteries in the case of using modules in the production of battery packs	5 years
Manufacture of supercapacitors(2)	8 years

Note:
(1) In addition to tax exemption, the government also offer financial subsidies for the investment expenditure, R&D, and human development, which will be considered case by case.
(2) Specific energy density not less than 10,000 Watt-hour/ gram and charging cycle not less than 10,000 cycles

Source: EPPO, BOI

Energy Storage System: Business opportunities & challenges

- It is anticipated that there will be growth for energy storage system adoption, which presenting numerous opportunities in the utility-scale, business-scale, and residential application.
- Key challenges include high upfront cost and regulatory uncertainties that could hinder widespread adoption of the energy storage.

Business opportunities in the energy storage system in Thailand

- As the country strive to enhance its renewable energy capacity, especially solar and wind, energy storage solutions will increasingly be used to stabilize supply fluctuation and ensure reliable power system.
- Among various types of energy storage, BESS will be the major commercially utilization due to the technological advancement, cost competitiveness, flexibility and easy for capacity expansion, and scalable from residential to utility-scale application.
- The power sector liberalization and the enforcement of TPA code, which will allow the excess power to be sold, is anticipated to further boost the demand for behind-the-meter battery, especially in the industrial and building sector.

Key Challenges

- The upfront investment cost remains a major barrier to widespread energy storage system adoption.
- Regulatory uncertainty and delay, especially TPA codes that are still in draft and there is no clear timeline of the implementation.

Business opportunities	
Target market	**Short term (1-5 years):** ▪ Power producers (especially, solar-plus-storage) **Medium to long-term (next 5 years and further):** ▪ **Commercial and industry sector:** The multinational corporations, particularly those in RE100 committed to carbon neutrality *(as BESS will be a key solution for achieving 100% renewable energy utilization)* ▪ **Residential sector:** 1) Homeowners may need to pair energy storage with rooftop solar to improve energy independence. 2) The residential property developers *(as BESS may be offered as integration system with solar rooftop to their customers)*
Business	▪ The potential businesses can be ranging from manufacturing of battery and components, EPC and consulting services, energy storage management system, etc.

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Hydrogen: Industry snapshot

Hydrogen

Thailand is currently in the Early Exploratory Phase of developing hydrogen as a solution for clean energy.

Hydrogen production in Thailand

Commercial production

Natural gas → Gasification/ SMR → **Grey Hydrogen**

Hydrogen manufacturers and distributors in Thailand

- Bangkok Industrial Gas Co., Ltd.
- Air Liquide (Thailand) Co., Ltd.
- Praxair (Thailand) Co., Ltd.
- Linde (Thailand) Co., Ltd.
- Nippon Sanso (Thailand) Co., Ltd.

Exploring/ R&D/ demonstration

Natural gas → Gasification/SMR + CCUS → **Blue Hydrogen**

RE (solar, wind) → Electrolysis → **Green Hydrogen**

Biogas → Reforming → **Bio-H2**

Hydrogen application in Thailand

Hydrogen is used in industrial process, not as an energy.

The hydrogen applications in Thailand are predominantly focused on its role as a precursor and component in certain industrial production processes. For examples:

- **Metallurgy industry:** To reduce metal oxides
- **Petrochemical industry:** To use as a precursor in the synthesis of ammonia and methanol
- **Food industry:** To use in the hydrogenation process to convert unsaturated fatty acids into saturated fatty acids

Hydrogen is exploring to be used as alternative energy.

Key sectors

- **Transportation**
- **Power and heat (substituting natural gas and coal)**

Source: Energy Policy and Planning Office (EPPO), BIG

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Hydrogen: Key development & trends

- Key players have been exploring the feasibility of low carbon hydrogen production in Thailand.

Examples of recent studies and demonstration projects regarding low carbon hydrogen production in Thailand

Green hydrogen electrolysis	▪ In 2017, **EGAT** introduced the pilot project of wind hydrogen hybrid system utilizing fuel cell technology for electricity generation. The modular water electrolyzer system was installed to convert excess electricity from wind to hydrogen during off-peak hours. The hydrogen will then be used by fuel cell plant to generate 300 kW to use internally in EGAT Energy Learning Center.
Green hydrogen and ammonia	▪ In 2023, **EGAT and three Japanese companies, Mitsui O.S.K. Lines, and Mitsubishi Company (Thailand), Chiyoda Corporation**, signed MOU to jointly conduct feasibility study on clean hydrogen and ammonia production from renewable energy sources in EGAT's potential sites. ▪ The study cover the whole supply chains, including production, storage, transport, utilization, and supply to domestic and international markets. The project is funded by METI.
Bio-hydrogen	▪ Since 2023, **CP Group and Toyota** have conducted pilot project of hydrogen production from farm-waste for vehicles. The hydrogen production equipment will be manufactured by **Mitsubishi Kakoki** and installed to produce hydrogen from biogas derived from local chicken manure and food waste. ▪ Toyota and Toyota Tsusho will cooperate on hydrogen production to consider the construction and introduction of an overall system for the compression, storage, and transportation of biogas and hydrogen, as well as the establishment of an operating system. C.P. Group plans to use such bio-hydrogen for their truck fleet for long-haul logistics for its supply chains. This trial will test the viability and performance of bio-hydrogen as an alternative energy source for the transportation sector
Blue hydrogen	▪ **PTTEP and POSCO Holdings** have collaborated to explore opportunities across the entire blue and green hydrogen value chain and CCS projects. Both companies will also collaborate on the research and development of technologies necessary for the realization of business opportunities.

Source: Public news, Companies' new releases

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Hydrogen: Key development & trends

- Large corporates are recognizing the potential of hydrogen and have been investing in R&D and demonstration projects of hydrogen uses.

Examples of recent studies and demonstration projects regarding hydrogen application in Thailand

Industrial sector	**Hydrogen use in steel production**	▪ In 2023, **GPSC signed a MOU with Meranti Steel Pte. Ltd**., a leading steel producer in Singapore, to study the feasibility of clean energy development projects and the energy management systems for use in the green steel production process, which focuses on the use of clean energy like solar and wind energy.
Power sector	**Hydrogen application for power**	▪ In 2023, **EGCO Group and BIG** signed a MOU for the project "Development and Application of Hydrogen for Power Generation" with the purpose to jointly study the feasibility of developing and utilizing hydrogen for environmentally friendly power generation. The findings from the study will be applied to power plants within the EGCO Group.
	hydrogen blending	▪ In June 2024, **EGAT and BIG** signed a MOU to study the potential for storing and transporting hydrogen for the Hydrogen Blending Demonstration project at EGAT's power plant.
Transport sector	**Hydrogen fuel station**	▪ **PTT, BIG, and Toyota Motor** developed "The Research and Development on Hydrogen Utilization Demonstration Systems for FCEV," in 2022 and launched the first pilot-scale hydrogen station for FCEV in Chonburi province. Toyota Mirai cars were imported for test run. In 2023, a hydrogen fuel systems testing for trucks, tractors, and buses was started by leading Japanese automotive network e.g. Toyota, Isuzu, Suzuki, Daihatsu, Hino.
	FCEV truck manufacturing	▪ **Toyota Tsusho, Denso, and Nex Point** signed MOU to develop the first hydrogen-powered commercial electric vehicle in Thailand. The project is set to deliver Thailand's first FCEV truck prototype by the end of 2024, with trials scheduled to commence in May 2025.
	Hydrogen energy application in logistics	▪ **PTT, BIG, and Toyota Motor** developed "The Research and Development on Hydrogen Utilization Demonstration Systems for FCEV," in 2022 and launched the first pilot-scale hydrogen station for FCEV in Chonburi province. Toyota Mirai cars were imported for test run. In 2023, a hydrogen fuel systems testing for trucks, tractors, and buses was started by leading Japanese automotive network e.g. Toyota, Isuzu, Suzuki, Daihatsu, Hino. ▪ In early 2024, **Thailand Post, BIG, and EGCO Group** collaborate to explore the utilization of hydrogen energy in the enhancement of logistics services. Thailand Post will provide routes for testing hydrogen energy applications in land transportation, BIG oversee the procurement of transportation vehicles and hydrogen filling operations. Meanwhile, EGCO will support and expertise in the development and exploration of hydrogen innovation.

Source: Public news, Companies' new releases

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Hydrogen: Government initiatives

- The government has established a hydrogen development roadmap encompassing strategies for market growth, industry support, infrastructure development, and regulations for hydrogen use in industrial, transportation, and power sectors.

Summary of Thailand's hydrogen development roadmap

Period	Focused technology	Strategic goals	Strategies / Approaches			
			Market Development	Industry support	Infrastructure	Regulation/ standard
2021-2030 ***Preparation***	**Grey Hydrogen**	• R&D • Pilot project	• Support investment in pilot project	• Set up "hydrogen valley" • Study new business models • Develop plan to support imports and exports	• Test and improve pipeline, storage and transportation systems	• Develop safety standards in production and use
2031-2040 ***Commercial development***	**Blue Hydrogen** & **Green Hydrogen**	• **Electricity and heat**: 10-20% in pipeline system • **FCEV**: 10,000 heavy duty FCEV	• Support for device modification and mitigation • Tax incentives weighted by GHG emission	• Privileges and R&D investment promotion, increase efficiency, reduce production & transport cost	• Improve the pipeline system • Develop other forms of transportation • Station development plan (>70 locations)	• Develop regulation & standard for natural gas mixed with hydrogen and hydrogen transport sector • Develop regulation & standard for storage tanks and location
2041-2050 ***Important alternative in country's fuel mix***	**Blue Hydrogen** & **Green Hydrogen**	• **Electricity and heat**: 25-75% in pipeline system • **FCEV**: 27,000 heavy duty and low duty vehicles	• Carbon valuation in price structure and mechanism	• Develop market platform and carbon trading mechanism	• Increase mixing ratio • Renewable power network support green hydrogen • Comprehensive station network (>180 locations)	• Develop regulation & standard of road and pipeline transportation of hydrogen • Standard of fuel cell, FCEV, refueling station

Source: Energy Policy and Planning Office (EPPO)

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Hydrogen: Business opportunities & challenges

- Thailand does not currently have a substantial hydrogen industry, but it has great potential to develop low carbon hydrogen for domestic use, particularly in mid- to long-term.

Business opportunities in the hydrogen sector in Thailand

Supply trend
- With the available infrastructure, including gas pipeline network and renewable energy target, there will be potential to enable large-scale hydrogen production.
- Leveraging existing natural gas infrastructure, blue hydrogen emerges as the most competitive option in the Thai market in the near term.
- In the long term, the green hydrogen is anticipated to expand in line with the growth of renewable energy, declining cost of water electrolysis technology, supported by government incentives.

Market demand trend
- The country is expected to use hydrogen commercially in power and industrial sector by 2030.
- The use of low carbon hydrogen in fossil fuel power plants has the potential to play a significant role in decarbonizing the power sector.
- Hydrogen uses in various industrial applications is expected to increase. The adoption of hydrogen to replace fossil fuels will facilitate the decarbonization of hard-to-abate sectors, which electrification is more difficult, such as chemical refining, glass, steel manufacturing, long-haul transportation.
- The advantage of hydrogen-powered vehicles in long-range performance and higher load capacity make it competitive for heavy-duty vehicles compared to battery EV. Accordingly, the growing interest in fuel cell electric vehicles (FCEVs) will fuel the demand for hydrogen.

Key challenges
- High initial investment cost for R&D and pilot projects
- Steel production in Thailand is decreasing, which might decrease demand for hydrogen
- As the hydrogen market in Thailand is still in its infancy, investors may encounter various uncertainties, including regulatory and technological challenges.

Business Opportunity

Short term (within 1-5 years):
- During the initial phase of hydrogen development and adoption, investments **R&D, feasibility studies, and pilot projects** to evaluate technological and market viability will qualify for subsidies from governmental and international organizations, simultaneously enhancing brand recognition.

Medium to long term (next 5 years and further):

Products	• Electrolyzer • Fuel cell • Hydrogen gas turbine, Hydrogen firing technology • Heavy duty FCEV • Carbon capture and storage technologies
Services	▪ Long-haul fleet management service ▪ Maintenance service

Source: IEA, GIZ, NSTDA, EPPO, BIG

Conclusion

- The market of each energy solution is in different development phase, which presents unique set of opportunities and challenges.

	Current stage of development and market situation		Recommendations
Market Growing	**Energy Efficiency Solutions**	• Strong growth potential with increasing adoption across various sectors, as driven by rising energy cost, government policy, rapid urbanization • Diverse opportunities in products and services ranging from cost-competitive products to high-tech solution	▪ Focus on high-growth area such as smart automation and IoT solutions ▪ Consider entering through underserved SME market or specialized services
	Renewable Energy	• Rapid growth with solar power leading the expansion, followed by wind and biomass • Highly competitive market, dominated by large operators with increasing foreign investment through JV	▪ Diversifying across multiple renewable resources and investing in energy storage solutions ▪ Consider joint ventures with local partners
Early adoption – early growth	**Electric Vehicle**	• Early stage of growth with increasing adoption and developing ecosystem • Intense competition and aggressive entering of Chinese manufacturers • Promising opportunities line in the supporting ecosystem, e.g. EV parts & components, battery-related businesses	▪ To form strategic partnership with strong players, especially Chinese manufacturer, to remain competitive ▪ Focus on battery-related businesses
	Energy Storage System	• Early adoption of energy storage system, dominated by BESS • The market is still limited, mainly adoption in the utility-scale power project. • The market growth is anticipated to be influenced by the cost of battery and power liberalization policy.	▪ Focus should be on utility and grid-scale storage solutions ▪ Consider entering through manufacturing, EPC services, or consulting
Development	**H2**	• Early exploration phase of development with several projects are R&D, demonstration, and feasibility study for low-carbon hydrogen production and application, especially in power and transport sector • Expected to commercialize during 2041-2050	▪ Capitalize on short-term opportunities through R&D and pilot project that qualify for subsidies from government or international organization

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