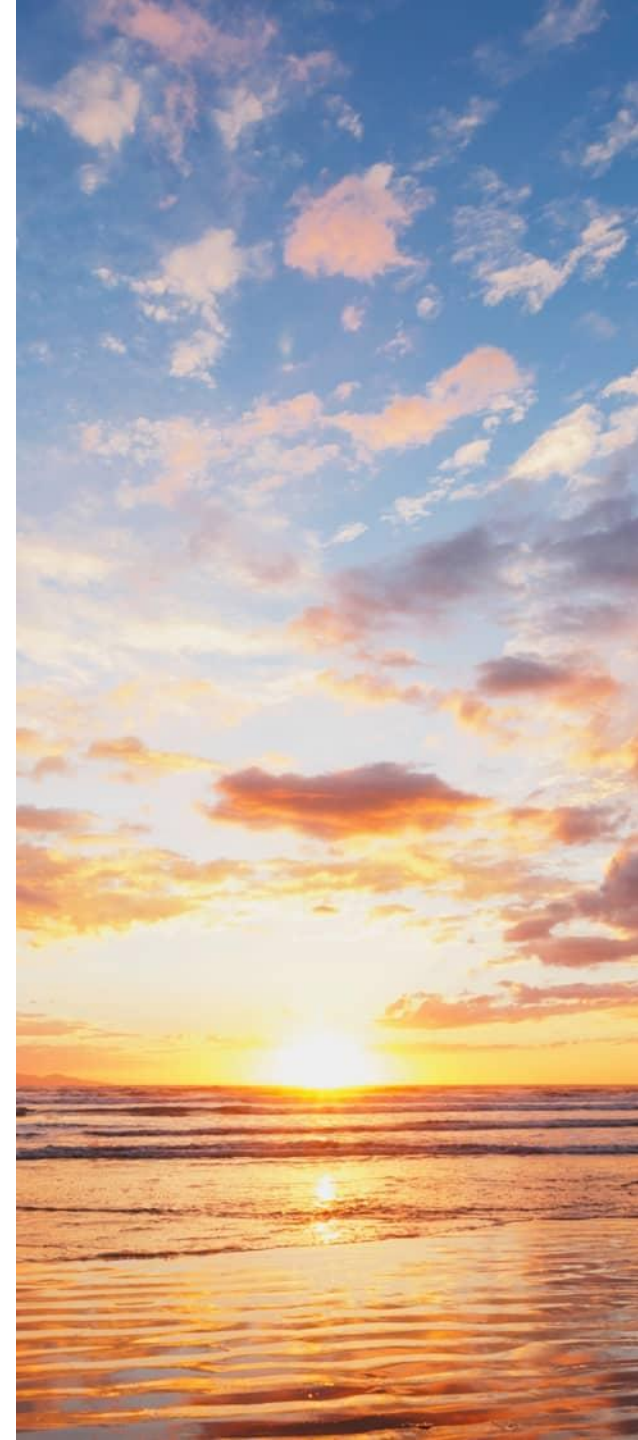


Final Report

Study on the Feasibility of Introducing Japanese CCU Technology into Thailand's Hard-to-Abate Sector

NRI Consulting & Solutions (Thailand) Co., Ltd.

2026年3月6日



Executive Summary

Chapter 1: Identification of Japanese Technologies

Chapter 2: Identification of Issues by Thai Companies

Chapter 3: Basic Information for Japanese Companies

Appendix

Key Findings

Interest Towards Decarbonization / CCU

- In Thailand, the government has set a net zero target for 2050. When comparing the decarbonization efforts by local companies, it is **highly polarized between large conglomerates and other companies**
 - For example, market leaders which are primarily conglomerates such as PTT and SCG have not only set carbon neutral targets but also set the targets for scope 3 as well. For initiatives, the companies are not only conducting initiatives for reducing energy consumption and using green energy, but **also developing targets and actively searching for technology partners for advanced energy transition technologies to reduce the CO₂ emission per unit of energy and CO₂ removal such as CCU and CCS**
 - Meanwhile, for non-market leaders even if decarbonization targets have been set, many companies focus primarily on energy saving and basic technology for CO₂ reduction per unit of energy consumption such as renewable energy usage, and the **current priority for CCU implementation is low and interest is limited**
 - Unless the external pressure increases (e.g. implementation of mandatory carbon pricing schemes which companies are obliged to comply, demand from customers becomes high enough to impact company's business negatively to the extent that it can not be ignored), companies adopting the technology voluntarily will be limited

High Opportunity Areas

- For the industry which CO₂ will be captured, **hard-to-abate industries will be industries with high potential for carbon capture adoption**
- For the use-case of CO₂ captured, the primary interest will be **usage for CO₂ within the same industry with the CO₂ emission**. However, **usage for chemical products is a use case which is commonly considered across industries**, given that it is an ingredient required to be used within the production process across industries

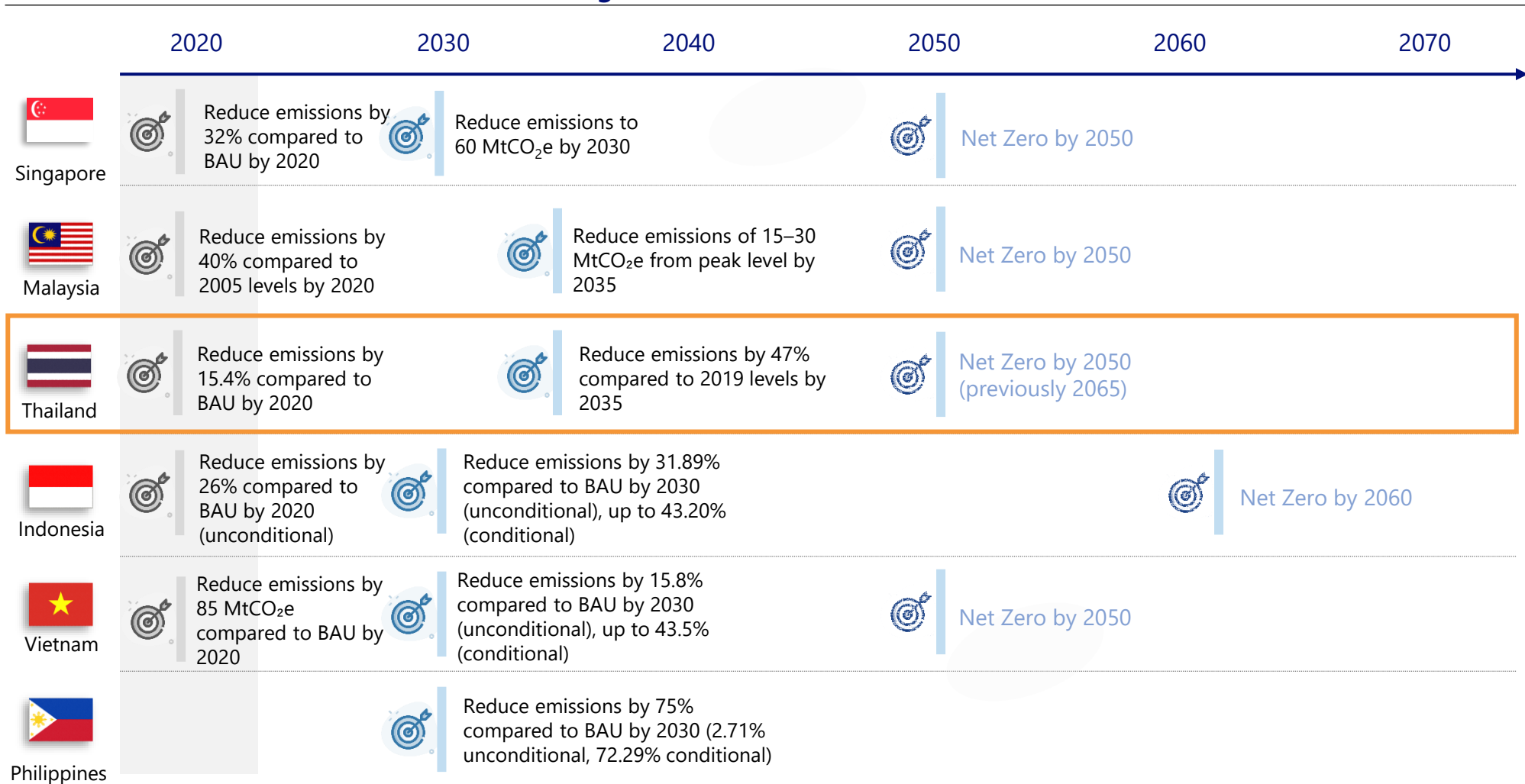
Issues/ Challenges by Local Companies

- Likewise with Japan, **CCU adoption is constrained primarily by economics and technology maturity**, and local companies with interest towards CCU adoption is in need for technologies which can resolve this
- Japanese companies have **sufficient portfolio of technology across industries (e.g. chemical, fuel, minerals) to cover the local companies' needs comprehensively**, in which many of the technology have track record of demonstration projects conducted. Technological advancement of such Japanese technology are supported by subsidies of Japanese government (e.g. NEDO's demonstration projects, NEDO's Green Innovation Fund), which can be used as a way to promote the technology and movement for this area

Decarbonization Targets in Thailand

As decarbonization efforts accelerate worldwide, Thai government set new target of net-zero emissions by 2050, 15 years earlier than the previous goal

ASEAN countries' GHG emission reduction targets



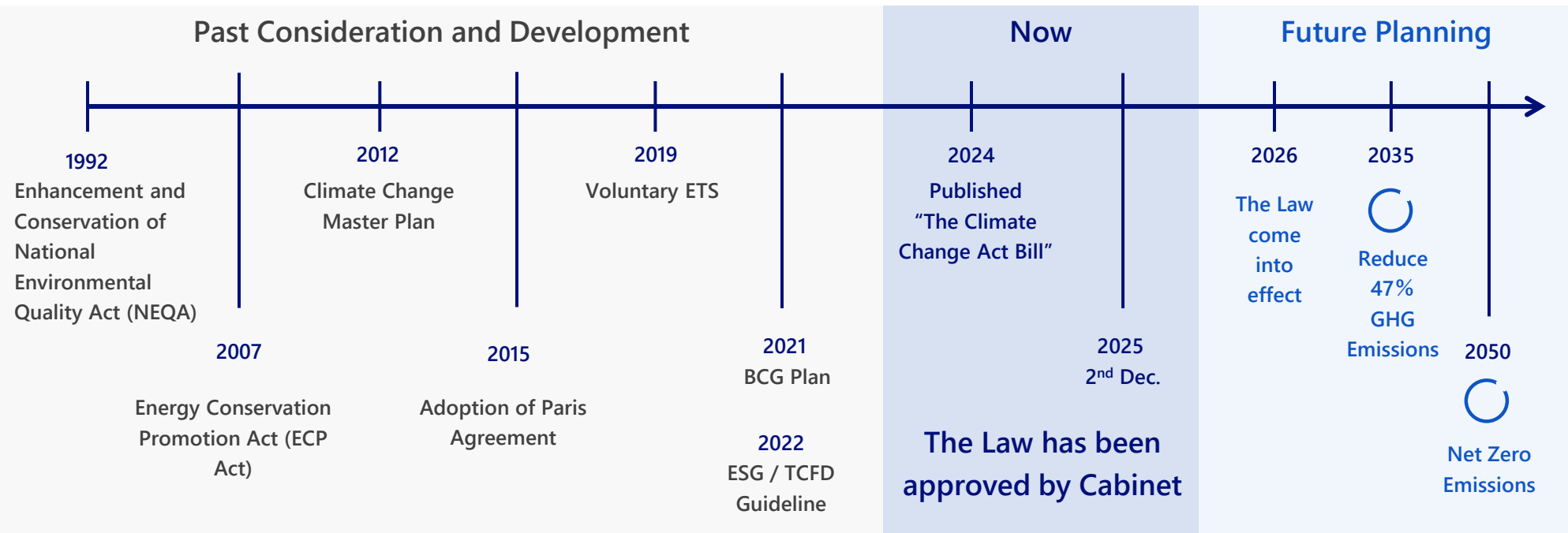
Note: BAU (Business as usual) refers to a natural state case without special measures)

Source: United Nations Climate Change, Government press release, News article

To achieve target, Climate Change Act, the first national climate framework law, is introduced with Carbon Mechanism in Thailand

Climate Change Act transitions and goals in Thailand

- The Thailand Climate Change Act becomes Thailand's first "climate framework law" for climate policy and carbon pricing.
- As for the latest update on 2nd December 2025, this act has been approved by the Cabinet and will proceed to the next step in parliament before implementation.



Climate Change Act will require all companies in Thailand to comply, with penalties like ETS and carbon tax for those not complying with the law

Requirement of Climate Change Act for all the companies in Thailand

	Greenhouse gas (GHG) data reporting	Carbon Border Adjustment Mechanism (CBAM) for imports	Emissions Trading Scheme (ETS)	Carbon tax on high-emission products	Carbon credits for business/used
Company's Obligations	Must report emissions yearly.	<ul style="list-style-type: none"> Must submit emissions data Pay carbon price via "Adjustment Certificates" 	Must hold allowances equal to their emissions	Must pay carbon tax	Must register before operating businesses/service providers for carbon credit
Definition	Report GHG emission yearly data	A fee on carbon-intensive products	Sets a limit on GHG emissions, then trades emission permits	Tax collected by Excise and Customs	Carbon credits are property and can be traded
Target	The company under control list *1	Importer of the listed product *2	The company under control list *1	Manufacturers and importers of products that emit GHG during use	The companies that would like to enter the carbon credit market
Penalties	<ul style="list-style-type: none"> Maximum 5 million THB of fine Three times the value of the benefit from such action 		Fine not exceeding three times the price of emission during those years	<ul style="list-style-type: none"> Imprisonment not more than three years Maximum 400,000 THB of fine 	<ul style="list-style-type: none"> Maximum 100,000 THB of fine An additional fine of 1,000 THB per day

*1 The control list companies will be published later.

*2 The list of imported products will be published later.

Source: DCCE

Climate Change Act is planned to be applied in 3 phases according to the target industries, with providing the benefits

Impact, implementation details, and benefits from Climate Change Act

Impact on all companies in Thailand – Production costs are expected to increase due to carbon taxes and ETS introduced by the new act. Especially, the high-GHG-emission industry.

Period	2026 (Effective Period)	Future *1	
	<u>Phase I</u>	<u>Phase II</u>	<u>Phase III</u>
Affected Industry	<ul style="list-style-type: none"> • Transport • Public utility • Metal • Non-metal 	<ul style="list-style-type: none"> • Petroleum products • Rubber and plastics • Chemicals coal mining • Paper 	<ul style="list-style-type: none"> • Agriculture • Food and Beverages • Computers • Electrical equipment
Total Value of Industry	<ul style="list-style-type: none"> • 1.71 Trillion THB • Equivalent 10% of GDP *2 	<ul style="list-style-type: none"> • 1.77 Trillion THB • Equivalent 10% of GDP 	<ul style="list-style-type: none"> • 3.02 Trillion THB • Equivalent 17% of GDP
Benefits for Company	<p>Financial Support:</p> <ul style="list-style-type: none"> • Access to Green Loans from a financial institution. • Tax exemption from BOI. <p>Supply Chain Benefit:</p> <ul style="list-style-type: none"> • Better positioning in export markets and multinational supply chains that require emissions data. 		

*1 There has been no official announcement yet. Phase II and III are forecasting that the act will expand the target industries as shown.

*2 Calculation based on 2022 GDP data

Source: DCCE, K-bank Research Institute

Government has identified CCUS as one of the core actions for carbon neutrality, in which various ministries collaborate to drive the long-term implementation

Thailand's Plans Regarding CCS Development

Rank: Plan Sub-Plan

Type	Plan	Responsible ministry	Overview	CCU point discussion
Plan	<p>Long-Term Low Greenhouse Gas Emission Development Strategy (launched in Nov 2022 and <u>currently being updated starting from Jan 2026 to align with new NDC target</u>)</p>	<ul style="list-style-type: none"> Ministry of Natural Resources and Environment - The Office of Natural Resources and Environmental Policy and Planning (ONEP) 	<ul style="list-style-type: none"> Providing long-term mitigation actions in key sectors (energy, industrial processes and product use, waste, agriculture and forestry) 	<ul style="list-style-type: none"> CCUS are identified as potential negative emission technologies to support decarbonization efforts in the energy Aim to deploy CCUS technologies in power generation by 2040 to achieve the Carbon Neutrality in 2050. Mitigation technology biomass-based power plants equipped with CCS/CCUS will be applied from 2050 for achieving net zero GHG emissions in 2065. Aim to apply CCUS in cement industry by 2040.
Plan	<p>Thailand CCUS Technology Roadmap (launched in Jan 2024)</p>	<ul style="list-style-type: none"> Ministry of Higher Education, Science, Research and Innovation - National Science and Technology Development Agency – National Nanotechnology Center (NANOTEC) 	<ul style="list-style-type: none"> To analyze the development status of CCUS technology, technology trends, market information and the needs of the energy and industrial sectors in Thailand. To prioritize CCUS Key technology and to propose important policy issues, goals, directions, guidelines for research and development of CCUS technology Collaboration with Ministry of Energy, Ministry of Industry, Ministry of Natural Resources and Environment and Thailand greenhouse gas management organization (TGO). Target for CCU application in each phase are as follows <ul style="list-style-type: none"> ✓ Short term (2023-2030): Carbonate, concrete ✓ Mid term (2030-2040): Urea, methanol, formic acid, light olefin ✓ Long term (2040-2050): SAF, high-value materials and chemical 	

Government has identified CCUS as one of the core actions for carbon neutrality, in which various ministries collaborate to drive the long-term implementation

Thailand's Plans Regarding CCS Development

Rank: **Plan**  **Sub-Plan** 

Type	Plan	Responsible ministry	Overview	CCU point discussion
Plan	The National Energy Plan 2024 (in drafting process, expected to launch by 2026)	<ul style="list-style-type: none"> Ministry of Energy - Energy Policy and Planning Office (EPPO) 	<ul style="list-style-type: none"> Providing the guidelines for 5 energy development plans: PDP, Renewable and Alternative Energy Development Plan, Energy Efficiency Plan, Gas Plan and Oil Plan. 	<ul style="list-style-type: none"> Define to study and prepare the development plan for CCUS in power generation.
Sub-Plan	Power Development Plan 2024 (in drafting process, expected to launch by 2026)	<ul style="list-style-type: none"> Ministry of Energy - Energy Policy and Planning Office (EPPO) 	<ul style="list-style-type: none"> Providing Thailand's plan regarding power generation to foster energy efficiency and to bring energy security, also with the aim to reach Carbon Neutrality and Net Zero Carbon. 	<ul style="list-style-type: none"> Applying CCUS technology is defined as one of the five mitigation actions to lead to Carbon Neutrality.

Overview of High Potential Sectors for CCU Areas

The hard-to-abate industries within energy sector and industrial sector are the areas which there is high interest in Thailand for CO₂ capture

Hard-to-abate industry

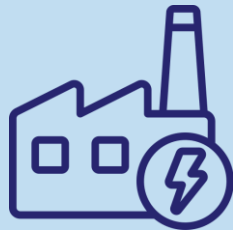
- Hard-to-abate industry is industries where emissions are difficult to eliminate with conventional decarbonization methods (e.g., cement, iron & steel, chemicals, oil & gas, power generation)
- These sectors generate unavoidable process emissions, making CCU an important pathway to reduce and utilize CO₂

Energy sector



Oil and gas

Oil and gas operations generate significant CO₂ emissions from refining and processing activities



Power generation

Power generation remains hard to abate where conventional fuels dominate the energy mix

Industrial sector



Cement

Cement production inherently releases CO₂ from limestone calcination



Chemical

Many chemical production processes generate unavoidable process emissions in addition to energy-related emissions.



Iron and steel

CO₂-intensive blast furnace and utilization of iron ore using coke can create large amount of CO₂ in iron and steel production

Majority of companies implement cost-effective energy efficiency, while market leaders move further into advanced initiatives such as fuel transition and CCUS

Initiative for decarbonization for companies in Thailand in general

	Reduce energy usage	Reduce CO ₂ per energy usage	Remove the CO ₂
Market leaders	<p>Energy efficiency: implemented</p> <ul style="list-style-type: none"> • Most companies are already doing this initiative as the company can save cost with minimal budget and technology required • Standard measures are heat recovery, boiler/steam optimization, equipment upgrades etc. 	<p>Energy transition: activities ongoing for leveraging advanced energy transition in addition to mature technology</p> <ul style="list-style-type: none"> • Companies start increasing usage of renewable electricity and cleaner fuels e.g. LNG and biomass, as well as develop low-carbon products and recycle feedstocks • Some companies are exploring or piloting hydrogen as fuel or feedstock 	<p>CCUS: in study CO₂ offsetting: partially implemented</p> <ul style="list-style-type: none"> • Companies are developing targets and reaching out to potential partners for CCUS as pathway to address hard-to-abate emissions with current progress of initial and feasibility studies • Companies also plan to use verified carbon credits and nature-based solutions e.g. reforestation to compensate emissions
Non-market leaders	<p>Energy efficiency: implemented</p> <ul style="list-style-type: none"> • Smaller companies also implement energy efficiency measures due to low investment requirements and cost-saving benefits • Common actions include upgrading to more energy-efficient equipment 	<p>Energy transition: partially implemented mature technology</p> <ul style="list-style-type: none"> • Some companies adopt mature and relatively low-cost technologies for energy transition e.g., solar panels • Plans for other more advanced renewable energy remain unclear 	<p>CCUS: no clear plan CO₂ offsetting: partially implemented</p> <ul style="list-style-type: none"> • Most companies lack clear CCUS plans and have limited knowledge • CO₂ offsetting is largely limited to reforestation, not carbon credits

CCU Initiatives of Non-Market Leaders

Many companies remain cautious on CCU from high costs. Foreign subsidiaries, export-driven firms, and association members may have interest in CCU more

Current situation of CCU adoption

Limited engagement beyond market leaders

- Only a small number of non-leading companies have shown concrete interest in CCU
- Most companies lack clear roadmaps or commitments for decarbonization

High investment and limited support

- Significant budget requirements and unclear returns remain major barriers for CCU adoption
- Subsidies and support from the government is still very limited as well

Cautious wait-and-see approach

- Companies are monitoring regulatory developments and movement/outcomes from large companies before deciding on further CCU investment

Example of companies with potential of interest in CCU



Foreign subsidiaries with parent company's decarbonization commitments

- Local subsidiaries aligning with parent companies' global net-zero and CCU roadmaps may adopt CCU to meet group targets



Companies facing external pressure from stakeholders and mandatory carbon pricing

- Companies selling to overseas buyers which demand suppliers to reduce CO₂ emission (e.g. buyers with scope 3 target or impacted by CBAM)
- Companies in industries subject to mandatory carbon pricing schemes (e.g. carbon tax, ETS) under the Climate Change Act




Consortium or association members

- Companies joining associations with sector-level decarbonization direction may follow collective CCUS direction e.g., Thai Cement Manufacturers Association Net Zero Roadmap

Across sectors, chemical products attract the strongest interest, driven by their high value and diverse applications

Interest in CCU product of each sector


 Common utilization need across sectors

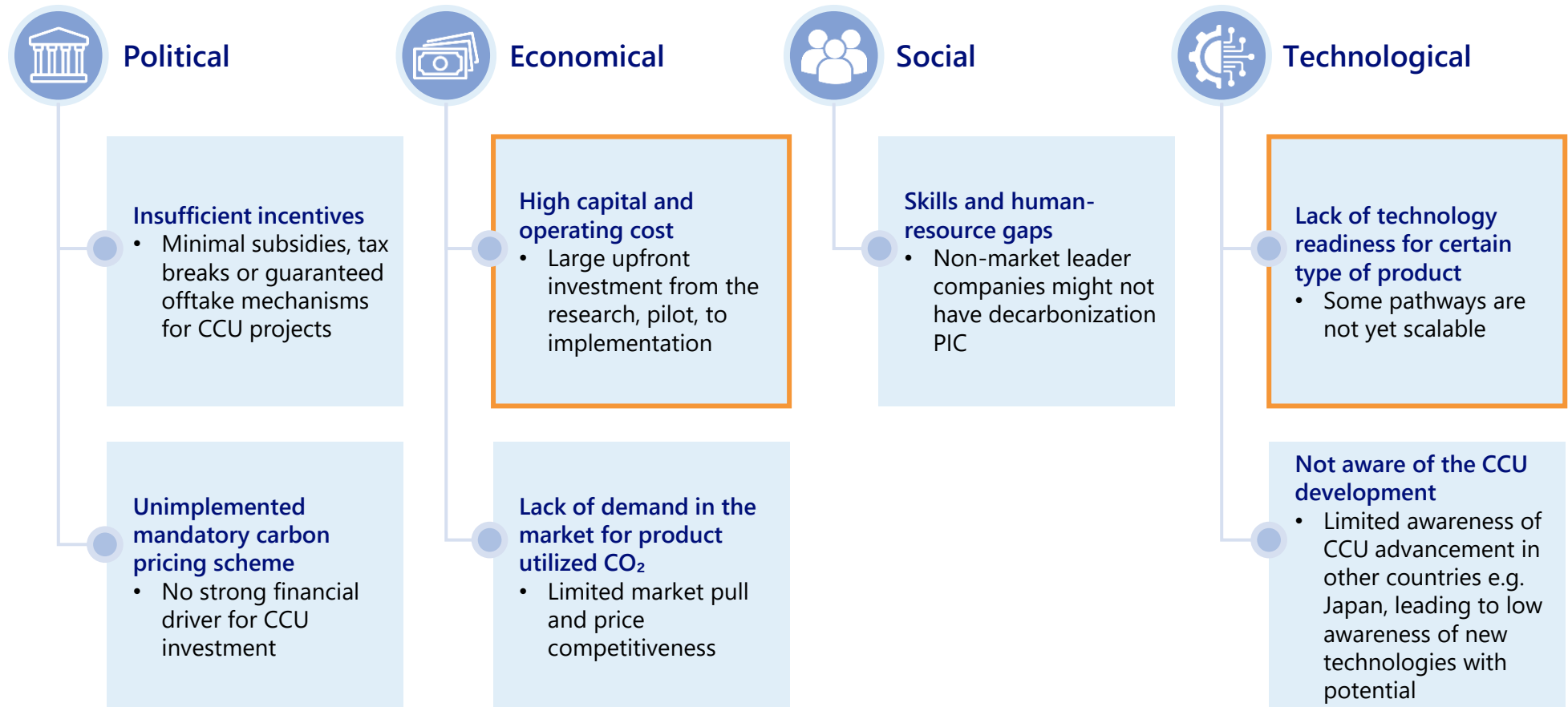
			Utilization				
			Fuel	Chemical	Mineral		
Sector for CO ₂ capture	High emission	Energy	Power generation	✓ (e-fuel, syn gas)	✓ (methanol, calcium carbonate)		
			Oil and Gas	✓ (e-fuel)	✓ (olefins, polycarbonate, calcium carbonate)		
		Industry	Cement		✓ (methanol)		✓ (cement)
			Chemical	✓ (e-fuel)	✓ (olefins, calcium carbonate)		
			Iron and steel		✓ (urea, polycarbonate, calcium carbonate)		
	Low emission	Pulp & paper	<i>Out of project scope</i>				
		Food & beverage					
		Textiles					

Source: Companies' official website, interview

Japanese companies have strong potential to support Thai companies in CCU adoption by addressing economic and technological challenges

Summarization of issues in CCU adoption

 Area which Japanese companies are able to support through technological solutions



Japanese companies have strong potential to support Thai companies in CCU adoption by addressing economic and technological challenges

Challenge in CCU adoption in Thailand

NRI's view

Economical challenge

- **High capital and operating costs** remain the main barriers to CCU adoption, particularly for companies that are not market leaders
- Implementing CCU **requires significant upfront investment across multiple stages**, including research and development, pilot projects, and full-scale deployment.
- For many companies, these costs create substantial financial risk, making it **difficult to justify investment without clear economic returns** or supportive policy incentives



- Japanese companies could support CCU adoption by partnering with local firms and sharing technology, expertise, and financial resources
- Through such collaborations, they can help **address key barriers such as high implementation costs.**
- In particular, **Japanese companies that possess technologies capable of reducing costs**, such as more efficient CO₂ capture systems, are **likely to attract strong interest from local companies seeking practical and economically viable solutions**

Technological challenge

- **Limited technology readiness** for certain products remains another key challenge for CCU adoption.
- While several CCU pathways have been demonstrated at pilot or demonstration scale, **many are not yet technologically mature or commercially scalable.**
- As a result, companies face uncertainty regarding performance, cost, and long-term viability, making it **difficult to commit to large-scale investment until these technologies have proven scalability**



- Compared to the Thai companies, Japanese companies have wider experience in research and pilot projects for technologies related to CCU
- Japanese companies have potential to support CCU development in Thailand by **leveraging advanced technologies covering both capture and utilization (e.g. fuel, chemicals, and minerals) which can comprehensively cover the Thai companies' industry of interest**
- **By sharing technical expertise, proven solutions, and operational know-how, Japanese companies could help accelerate technology readiness and facilitate the adoption of CCU solutions among Thai industries**

Agenda

Executive Summary

Chapter 1: Identification of Japanese Technologies

Pitchbook of Japanese Technologies

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Appendix

Executive Summary

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Pitchbook of Japanese Technologies

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Introduction of Japanese Technologies

Chapter 2: Identification of Issues by Thai Companies

Chapter 3: Basic Information for Japanese Companies

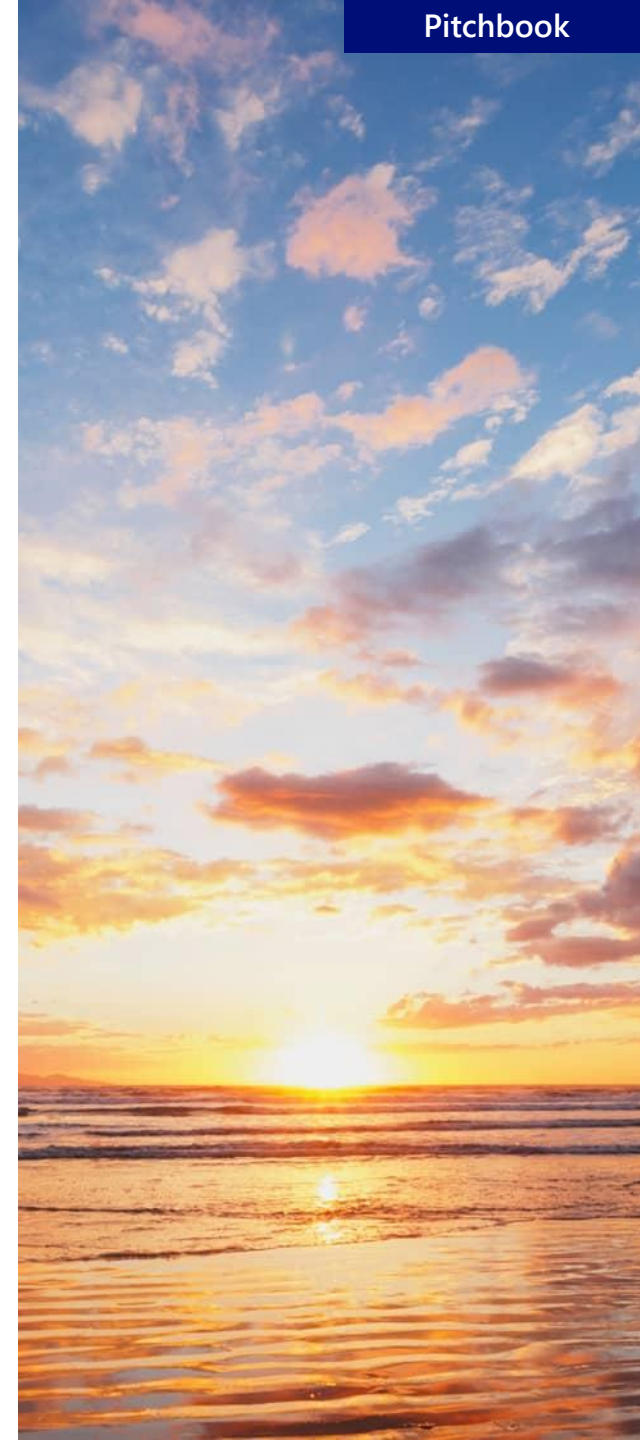
Appendix

Introduction Materials

Introduction of Japanese Technology for CCU (carbon capture and utilization)

NRI Consulting & Solutions (Thailand) Co., Ltd.

February 2026



Agenda

Executive Summary

Chapter 1: Identification of Japanese Technologies

Pitchbook of Japanese Technologies

Overview of Technology for CCU

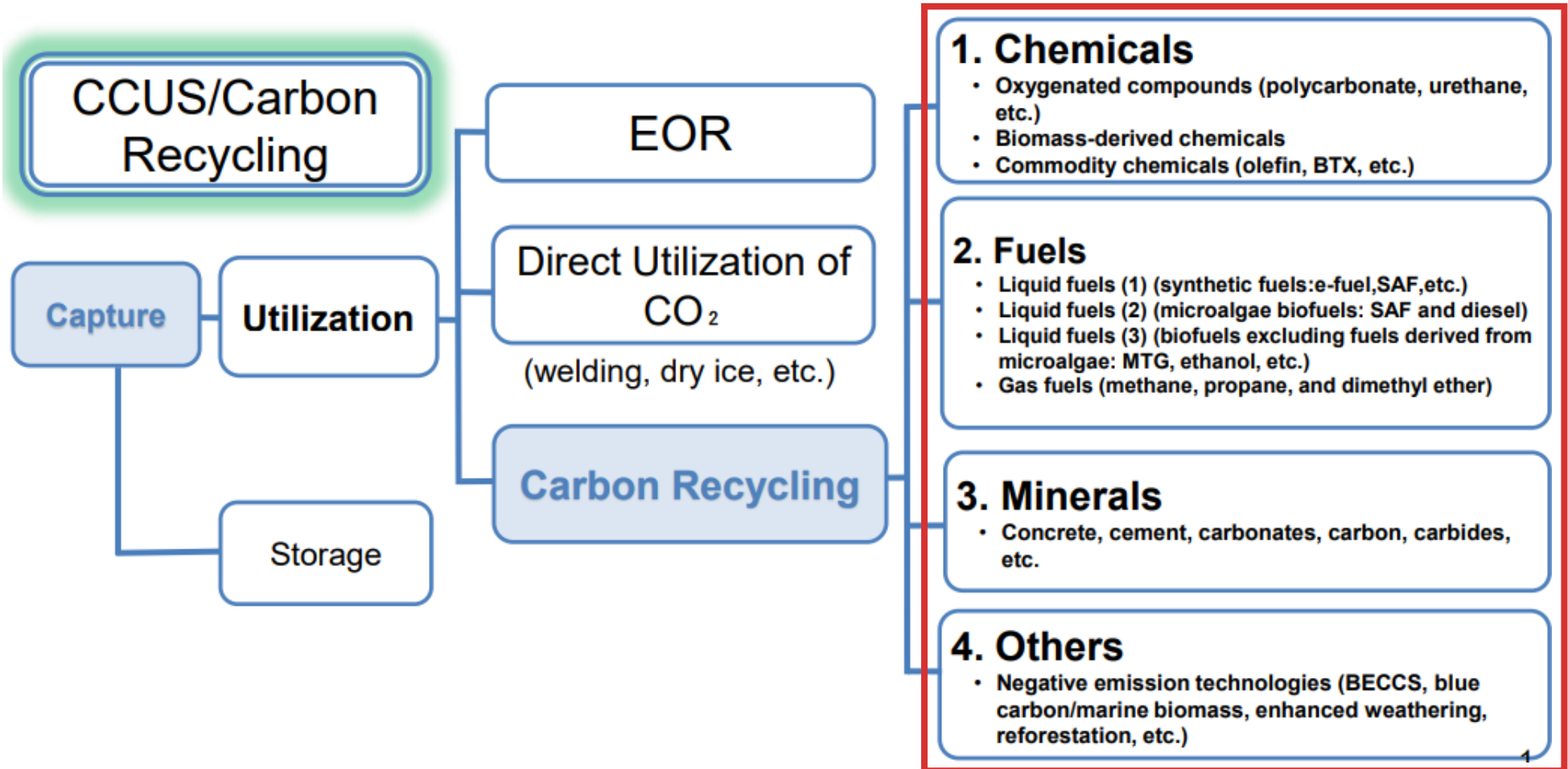
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Appendix

Key Technology for CCU

Key technology for CO₂ utilization are usage of CO₂ for chemicals, fuels, and mineralsOverview of Key Technology for CO₂ Utilization

Source: From "Roadmap for Carbon Recycling Technologies" by METI (https://www.enecho.meti.go.jp/category/others/carbon_recycling/pdf/20190607002-2.pdf)

Agenda

Executive Summary

Chapter 1: Identification of Japanese Technologies

Pitchbook of Japanese Technologies

Overview of Technology for CCU

Introduction of Japanese Technologies

Utilization (45 examples)

Chemicals (17 examples)

Fuel (17 examples)

Minerals (11 examples)

Capture and separation (17 examples)

Chapter 2: Identification of Issues by Thai Companies

Chapter 3: Basic Information for Japanese Companies

Appendix

Agenda

Executive Summary

Chapter 1: Identification of Japanese Technologies

Pitchbook of Japanese Technologies

Overview of Technology for CCU

Introduction of Japanese Technologies

Utilization (45 examples)

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To create list of companies with technology for CO₂ capture and utilization, NRI listed companies from sources using keywords identifying relevant technology

Step 1

Primary screening of companies with technology via METI and NEDO website

- Reviewed METI and NEDO website in the following links. CO₂ capture and separation technology is listed based on source “METI Carbon Recycling Technology Case Studies” and “NEDO Green Innovation Fund Projects Development of CO₂ separation and capture” only.
 - ✓ METI Carbon Recycling Technology Case Studies
(https://www.enecho.meti.go.jp/category/others/carbon_recycling/tech_casebook/)
(https://www.enecho.meti.go.jp/category/others/carbon_recycling/pdf/tech_casebook.pdf)
 - ✓ METI Examples of Cross-Industry Collaboration
(https://www.meti.go.jp/shingikai/energy_environment/carbon_recycle_rm/pdf/20230623_04.pdf)
 - ✓ METI Selected Projects for FY2023 Supplementary Budget (https://gs-hojo-web.jp/saitaku.html?_fsi=ZtA43h4y)
 - ✓ METI Selected Projects for FY2024 Supplementary Budget (<https://gs-hojo-web-fspoc.jp/saitaku.html>)
 - ✓ METI Selected Projects for FY2024 Supplementary Budget “Global South Future-Oriented Co-Creation Project Subsidy”
(<https://www.meti.go.jp/information/publicoffer/saitaku/2026/s260205001.html>)
 - ✓ METI Asia Zero Emission Community (AZEC)
(https://www.meti.go.jp/policy/energy_environment/global_warming/azec.html)
 - ✓ NEDO Green Innovation Fund Projects Development of Technology for Producing Concrete and Cement Using CO₂
(<https://green-innovation.nedo.go.jp/project/development-manufacturing-concrete-using-co2/scheme/#anchorContents>)
 - ✓ NEDO Green Innovation Fund Projects Development of Technology for Producing Raw Materials for Plastics Using CO₂ and Other Sources
(<https://green-innovation.nedo.go.jp/project/development-plastic-raw-material-manufacturing/scheme/#anchorContents>)
 - ✓ NEDO Green Innovation Fund Projects Development of Technology for Producing Fuel Using CO₂
(<https://green-innovation.nedo.go.jp/project/development-fuel-manufacturing-technology-co2/scheme/#anchorContents>)
 - ✓ NEDO Green Innovation Fund Projects Development of CO₂ separation and capture
(<https://green-innovation.nedo.go.jp/project/development-co2-separation-recovery/>)
 - ✓ NEDO Green Innovation Fund Projects Promotion of Carbon Recycling Using CO₂ from Biomanufacturing Technology as a Direct Raw Material (<https://green-innovation.nedo.go.jp/project/bio-manufacturing-technology/scheme/#anchorContents>)
 - ✓ NEDO Biomanufacturing Projects (https://www.nedo.go.jp/activities/introduction5_001.html)
 - ✓ NEDO Carbon recycle (<https://www.nedo.go.jp/activities/field26.html>)
 - ✓ NEDO Next-generation thermal power generation (https://www.nedo.go.jp/activities/introduction8_05_04.html)
 - ✓ NEDO Research, Development and Demonstration of CCUS Technology
(https://www.nedo.go.jp/activities/ZZJP_100141.html)

To create list of companies with technology for CO₂ capture and utilization, NRI listed companies from sources using keywords identifying relevant technology



Step 2

Selection with technology-focused keywords

- Identified relevant technologies using targeted keywords as follows
 - ✓ **Keywords for CO₂ utilization:**
 - Chemicals: chemical plant, polycarbonate, urethane, olefin
 - Fuel: gas plant, oil refinery, methane, propane, bio-fuel (bio-diesel, bio-ethanol), e-fuel, SAF
 - Minerals: cement plant, concrete plant, steel plant, concrete, cement, iron, steel
 - ✓ **Keywords for CO₂ capture and separation:** CO₂ capture, CO₂ separation

Supplementary research based on publicly available source

- Conducted additional desktop research beyond above websites using the same keywords across news articles and company websites with keywords "CCU" and "Carbon recycling"
- Added relevant companies based on discussion and alignment with NEDO
- The supplementary research is not meant to be an exhaustive list of companies

Step 3

Agenda

Executive Summary

Chapter 1: Identification of Japanese Technologies

Pitchbook of Japanese Technologies

Overview of Technology for CCU

Introduction of Japanese Technologies

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Chapter 2: Identification of Issues by Thai Companies

Chapter 3: Basic Information for Japanese Companies

Appendix

Introduction of Japanese Technology for CO₂ Utilization | Chemical

Japanese companies like MGC and Tosoh provide CCU technologies for chemical utilization including production of methanol and carbon monoxide

#	Company Name	Year Established	Technology related to CCU	HP
1	<i>Mitsubishi Gas Chemical Company</i>	1971	Co-develop CO ₂ -derived functional plastic material manufacturing technology, converting captured CO ₂ into plastic feedstock intermediates and materials with lower greenhouse gas emissions. Development partners include Tosoh Corporation, Tohoku University, and Osaka Metropolitan University	https://www.mitsubishi.com/ja/profile/csr/mpac/monthly/topics/2024/06/1.html
			Developed the Circular Carbon Methanol (Carbopath™) technology, which converts captured CO ₂ , waste plastics, biomass, etc. into methanol and recycles it for use in chemicals, fuel, and power generation	https://www.carbopath.mgc.co.jp/en/
2	<i>Tosoh Corporation</i>	1935	Develop CO ₂ capture and feedstock conversion facility, using CO ₂ from its own chemical plant and converting it to carbon monoxide (CO), replacing part of petrochemical feedstock (e.g., naphtha) for producing isocyanates used to make polyurethanes	https://www.tosoh.com/news-press/news-releases/2024/tosoh-launches-carbon-dioxide-capture-and-feedstock-conversion-facility-to-achieve-low-carbon-isocyanate-products
3	<i>Sumitomo Chemical</i>	1913	Develop technology to produce methanol, a raw material for a wide range of products, from captured CO ₂ with Internal Condensation Reactor (ICR) technology through joint development with Shimane University for a higher yield result	https://www.sumitomo-chem.co.jp/english/news/detail/20231212e.html

Source: METI, NEDO, Carbon Recycling Fund Institute, company websites

Introduction of Japanese Technology for CO₂ Utilization | Chemical

Asahi Kasei, TBM, and IHI provide technologies for production of polycarbonate, calcium carbonate, and olefins

#	Company Name	Year Established	Technology related to CCU	HP
4	<i>Asahi Kasei (Chemicals)</i>	1931	Produce polycarbonate, a synthetic resin, using CO ₂ and ethylene oxide (EO) as raw materials without using toxic phosgene. CO ₂ and EO are converted into carbonate intermediates (EC, DMC, DPC), which are then used to produce polycarbonate	https://www.asahi-kasei.co.jp/tlb/en/
5	<i>TBM Co., Ltd.</i>	2008	Develop Next-Generation LIMEX with partnership of Tohoku University, using CO ₂ captured from industrial exhaust gases and calcium-containing waste to chemically synthesize CCU calcium carbonate, which is blended with resin (including recycled plastic) to produce CCU-based low-carbon material for various of product including industrial films, food packaging, and label base materials	https://tb-m.com/eng/business/limex2.0/
6	<i>IHI Corporation</i>	1853	Develop CO ₂ conversion technology uses advanced catalysts to transform captured CO ₂ and hydrogen into lower olefins, which can be used as feedstock for plastics and packaging materials such as bottles and resins.	https://www.ihl.co.jp/en/technology/techinfo/contents_no/1200704_13586.html

Introduction of Japanese Technology for CO₂ Utilization | Chemical

Sustenatech develops CCU technology for water-free textile dyeing while Atomis and Kawasaki Heavy Industries use CCU for methanol production

#	Company Name	Year Established	Technology related to CCU	HP
7	<i>Sustenatech</i>	2020	Develop textile dyeing and finishing product replacing conventional water-intensive methods, using CO ₂ as the processing medium to reduce water use, energy consumption, waste discharge, and CO ₂ emissions. Development partner is Fukui University	https://sustainatech.co.jp/business/
8	<i>Atomis</i>	2015	Develops PCP (porous coordination polymers) based systems that capture CO ₂ and convert it into valuable chemicals such as methanol and formic acid, enabling distributed CCU solutions that create economic value from emissions.	https://www.atomis.co.jp/business/
9	<i>Kawasaki Heavy Industries, Mitsui Chemicals</i>	<ul style="list-style-type: none"> • 1896 • 1997 	Kawasaki Heavy Industries and Mitsui Chemicals, in collaboration with Osaka University, demonstrated a CCU demonstration tests that synthesizes methanol and para-xylene from captured CO ₂ using hydrogen as a feedstock. Methanol can be used as an ingredient in chemical production, lower-impact fuel and para-xylene serves as a chemical raw material for polyester resins	https://jp.mitsuichemicals.com/en/release/2025/2025_0220/index.htm

Introduction of Japanese Technology for CO₂ Utilization | Chemical

Japanese companies are developing CCU technology for fertilizer, urethane, polycarbonate, and CO

#	Company Name	Year Established	Technology related to CCU	HP
10	<i>National Institute of Advanced Industrial Science and Technology (AIST)</i>	2001	Research a technology using captured CO ₂ as a carbon feedstock instead of toxic fossil-derived chemicals to synthesize useful materials such as urethane	https://www.aist.go.jp/aist_j/magazine/202118.html
			Develop a CCU process that directly uses low-pressure, low-concentration CO ₂ from sources like power plant flue gas to synthesize diethyl carbonate, a precursor for polycarbonate and polyurethane materials	https://www.aist.go.jp/aist_j/press_release/pr2024/pr20240610_2/pr20240610_2.html
11	<i>Electric Power Development</i>	1952	Conduct demonstration project to capture and liquefy CO ₂ from a gasified coal fuel cell combined power plant and transport it for effective reuse, such as supplying liquefied CO ₂ to a tomato greenhouse as fertilizer	https://www.jpower.co.jp/news_release/2022/07/news220727.html
12	<i>Research Institute of Innovative Technology for the Earth (RITE), Sekisui Chemical Co., Ltd.</i>	<ul style="list-style-type: none"> • 1990 • 1947 	Develop microorganisms to convert CO ₂ to CO in high efficiency. The CO will be converted into polymer raw materials for epoxy resin using CO-utilizing bacteria and later be photodimerized and epoxidized to produce heat-resistant adhesives	https://www.rite.or.jp/en/results/today/pdf/rt2025_molecularmicrobiologyandbiotechnology.pdf
13	<i>Kaneka Corporation, Bacchus Bio Innovation Co., Ltd.</i>	<ul style="list-style-type: none"> • 1949 • 2020 	Develop a gas fermentation biofoundry and microorganisms to produce biodegradable polymers produce using CO ₂ as a raw material to establish recycled-oriented biomanufacturing technology	https://www.kaneka.co.jp/en/topics/news/2023/enr2303221.html

Source: METI, NEDO, Carbon Recycling Fund Institute, company websites

Introduction of Japanese Technology for CO₂ Utilization | Chemical

Mitsui Kinzoku and Toyo Engineering develop technology to produce methanol while Nippon Steel, UBE, and CHEMIPAZ develop for polyurethanes, biopolymers

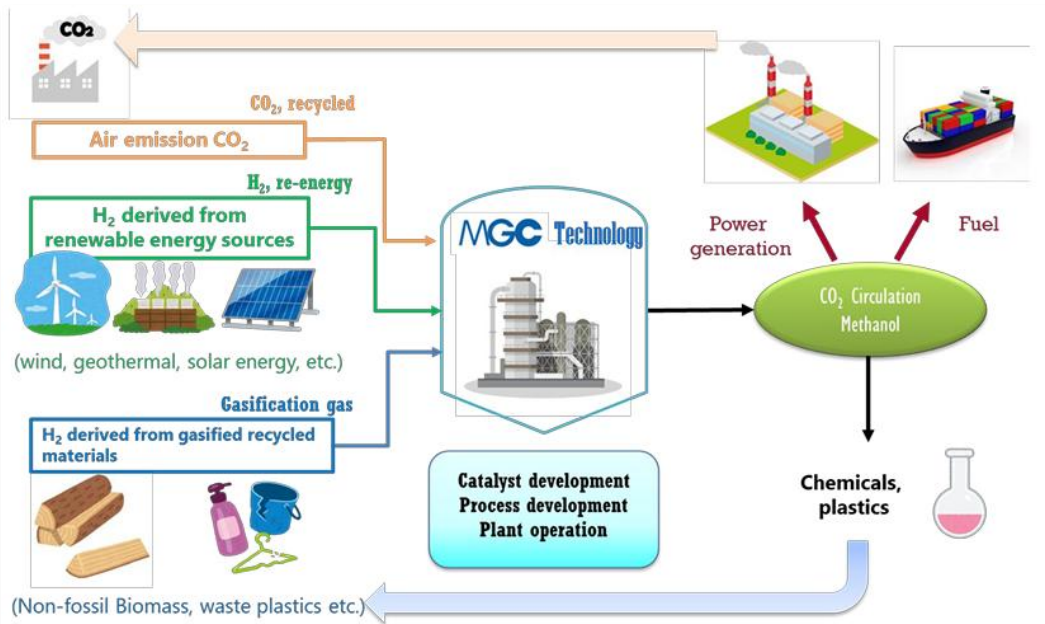
#	Company Name	Year Established	Technology related to CCU	HP
14	<i>Mitsui Kinzoku</i>	1950	Develop CCU technology and conduct demonstration project in India to use captured CO ₂ reacting with hydrogen to produce methanol	https://www.mitsui-kinzoku.com/LinkClick.aspx?fileticket=dTV%2BHatAW%2FM%3D&tabid=278&mid=824&TabModule1277=0
15	<i>Toyo Engineering Corporation</i>	1961	Develop g-Methanol™ technology that synthesizes e-methanol by combining captured CO ₂ with renewable-energy-derived hydrogen using a proprietary high-efficiency reactor and energy-saving process design	https://www.toyo-eng.com/jp/ja/solution/g-methanol/
16	<i>Nippon Steel Corporation, UBE Corporation</i>	<ul style="list-style-type: none"> • 1970 • 1897 	Develop a one-step synthesis technology converting captured CO ₂ into polycarbonate diol, a key raw material for high-performance polyurethanes e.g. paint and coating by using CO ₂ as a chemical feedstock for lower-impact production of high-value polymer materials	https://www.ube.com/ube/en/news/2023/development-of-one-step-synthesis-process-for-polycarbonate-diol-from-co2-selected-for-nedo-commissi.html
17	<i>CHEMIPAZ</i>	1968	Develop CCU technology that converts wood biomass and captured CO ₂ into multi-use platform chemicals and biopolymers through a biopolymer synthesis jointly researched with Kyushu University and Tohoku University	https://www.chemipaz.com/news/5860/

Case Study: Mitsubishi Gas Chemical Company | Chemical

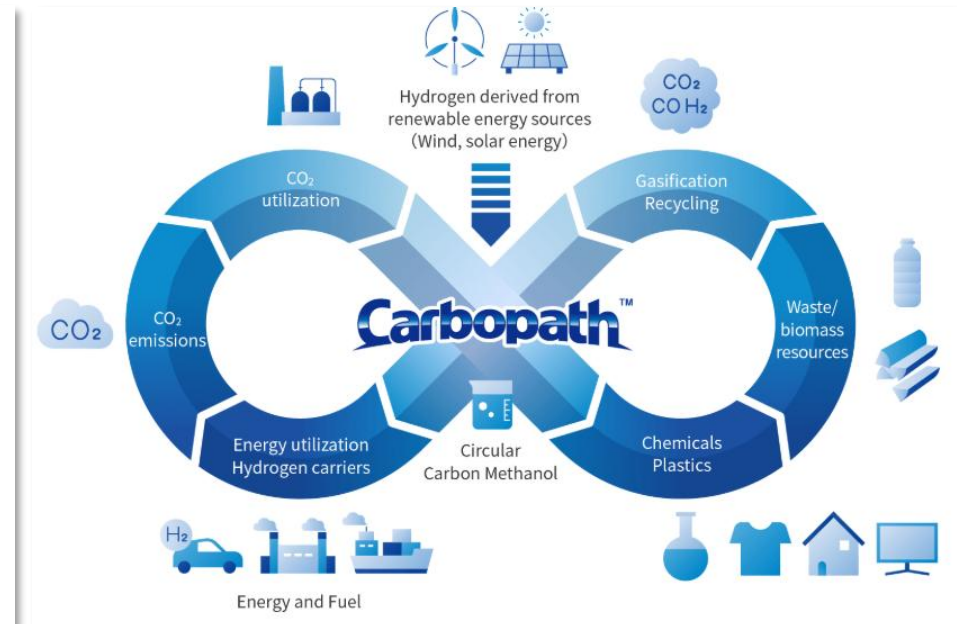
Mitsubishi Gas Chemical develops Carbopath™, a carbon-recycling pathway converting CO₂ into methanol as a raw material for fuels, chemicals, and energy

Overview of Technology

- Carbopath™ is a CCU platform that integrates CO₂ capture from industrial sources with hydrogen-based methanol synthesis, converting recovered CO₂ into low-carbon methanol. The methanol can be used as a chemical feedstock, fuel, or hydrogen carrier, enabling circular carbon utilization across chemical and energy value chains. The system is designed for scalability and integration with renewable hydrogen and existing industrial infrastructure.



Environmentally Circulating Methanol Concept



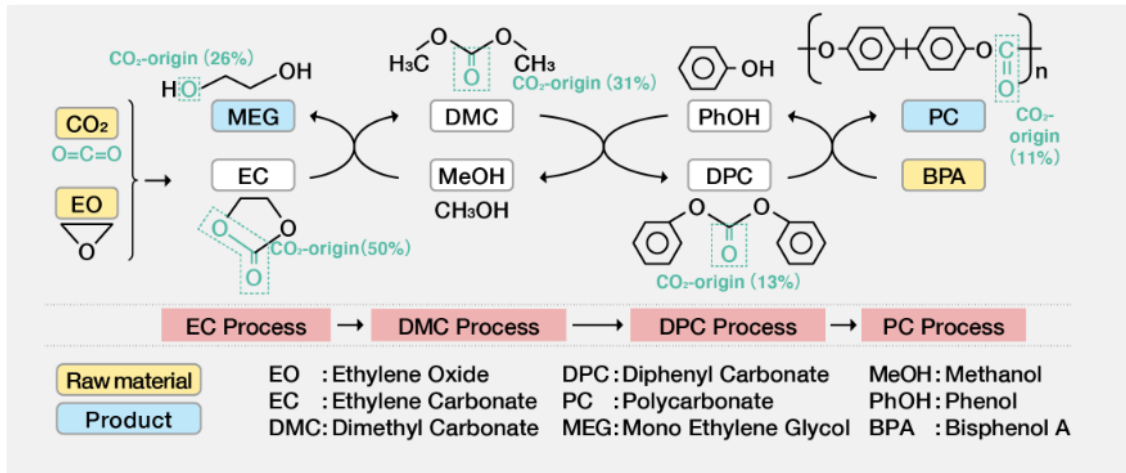
Carbopath™ products and services

Case Study: Asahi Kasei | Chemical

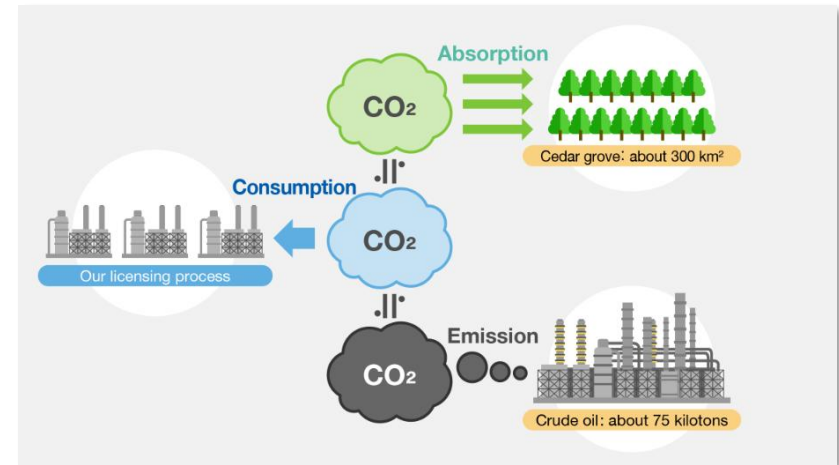
Asahi Kasei develops and licenses a non-phosgene polycarbonate process that reuses CO₂ and ethylene oxide as raw materials

Overview of Technology

- Asahi Kasei pioneered an environmentally friendly polycarbonate production process that uses CO₂ and ethylene oxide as raw materials to produce polycarbonate and high-purity carbonate chemicals (e.g., ethylene carbonate and dimethyl carbonate used in lithium-ion battery electrolytes), licensed globally to reduce CO₂ emissions and eliminate toxic phosgene from the chemical process



Asahi Kasei's polycarbonate production process



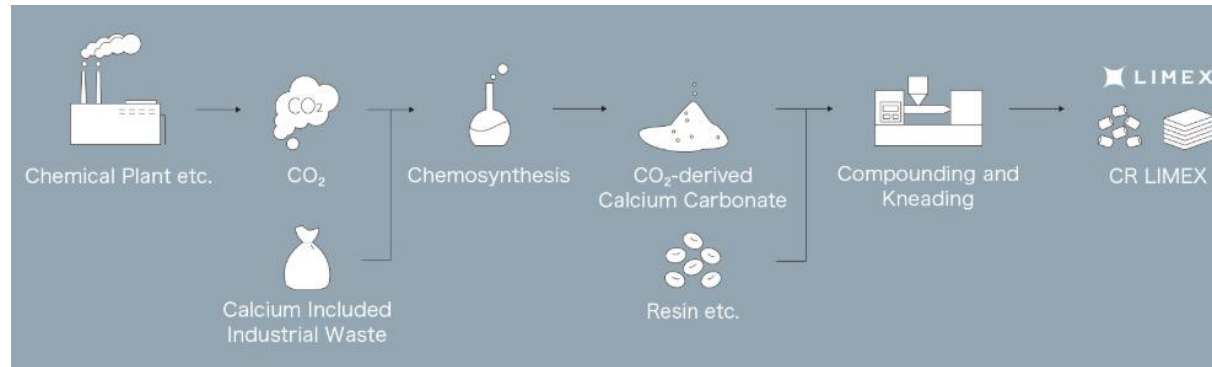
Consumption amount of CO₂ as a raw material

Case Study: TBM | Chemical

LIMEX by TBM uses CO₂ from industrial exhaust and calcium waste to synthesize calcium carbonate that becomes material for industrial use and construction

Overview of Technology

- Next-Generation LIMEX is a low-carbon material that uses CO₂-derived calcium carbonate instead of petroleum-based plastic, allowing plastic products to be replaced with a durable, recyclable alternative for applications such as construction materials, industrial parts, and daily-use products while significantly reducing fossil-based plastic consumption.



LIMEX production process



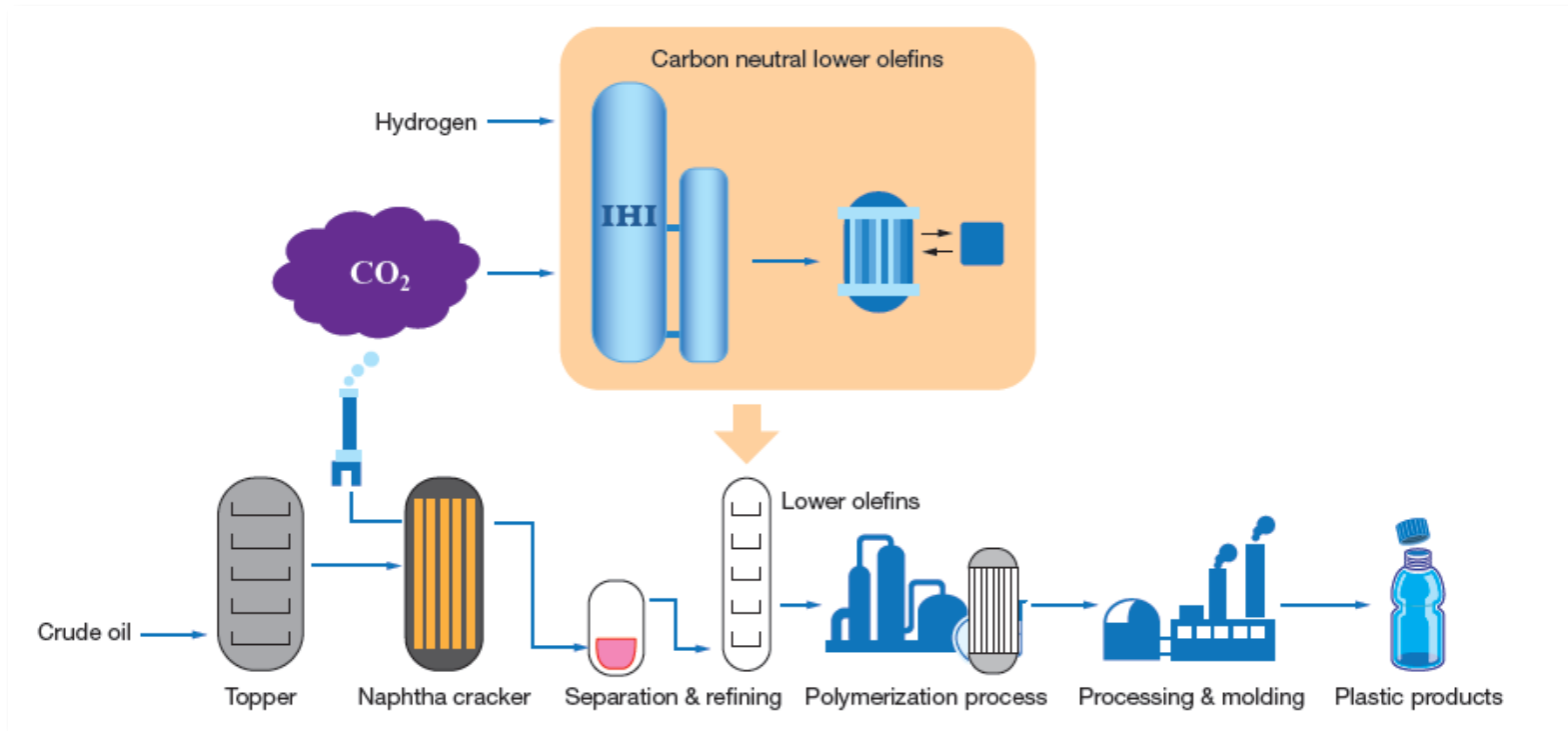
A wide range of uses for next-generation LIMEX

Case Study: IHI | Chemical

IHI develops CCU technology that converts captured CO₂ into lower olefins used as feedstock for plastics and resins

Overview of Technology

- IHI's CO₂ conversion technology uses advanced catalytic processes to hydrogenate captured CO₂ with hydrogen into lower olefins such as ethylene and propylene, key feedstocks for plastics and resins, reducing reliance on naphtha feedstock and lowering the carbon footprint of end-product materials



Manufacturing of plastic products from carbon neutral lower olefins as feedstock

Agenda

Executive Summary

Chapter 1: Identification of Japanese Technologies

Pitchbook of Japanese Technologies

Overview of Technology for CCU

Introduction of Japanese Technologies

Utilization (45 examples)

Chemicals (17 examples)

Fuel (17 examples)

Minerals (11 examples)

Capture and separation (17 examples)

Chapter 2: Identification of Issues by Thai Companies

Chapter 3: Basic Information for Japanese Companies

Appendix

Introduction of Japanese Technology for CO₂ Utilization | Fuel

Companies like Kanadevia, Tokyo Gas provide CCU technologies for production of methane, while Chiyoda Corporation provide technology for syngas

#	Company Name	Year Established	Technology related to CCU	HP
1	<i>Kanadevia</i>	1881	Manufacture "HiMethz" which is a methanation equipment for producing methane from hydrogen and recovered CO ₂ of various sources ,including gas plant	https://www.kanadevia.com/english/busine/ss/field/electrolytic-hydrogen/methanation.html
2	<i>Tokyo Gas</i>	1885	Develop CCU solution to use CO ₂ from exhaust gases of gas appliances and other sources for methane production and for direct utilization of CO ₂ as an industrial gas	https://eee.tokyo-gas.co.jp/solution/ccu/index.html
			Develop e-methane innovative methanation technology from CO ₂ exhaust gases or captured sources with Hybrid Sabatier & PEMCO ₂ systems aiming to reduce production CO ₂ and equipment costs. Development partners include IHI, Toyama University, Kyusyu University, and Osaka University	https://www.tokyo-gas.co.jp/e-methane/technology/index.html?wovn=en
3	<i>Chiyoda Corporation</i>	1948	Develop CT-CO ₂ AR [®] (Chiyoda CO ₂ Reforming Technology), using CO ₂ from emissions (e.g., oil/gas plant exhaust or low-grade natural gas fields) as a reforming agent together with steam/methane to produce syngas with customizable H ₂ /CO ratios.	https://www.chiyodacorp.com/jp/service/transionenergy/gtl/co2-reforming/

Introduction of Japanese Technology for CO₂ Utilization | Fuel

Idemitsu, Sumitomo, and IHI develop CCU technology to produce liquid fuel including SAF via Fischer–Tropsch process

#	Company Name	Year Established	Technology related to CCU	HP
4	<i>Idemitsu Kosan, ENEOS</i>	<ul style="list-style-type: none"> • 1911 • 1888 	Co-develop integrated production process that uses captured CO ₂ from industrial sources and renewable hydrogen/electricity to synthesize hydrocarbons via FT producing liquid synthetic fuels (gasoline, diesel, and jet fuel). Development partners include Seikei University, Nagoya University, Yokohama National University, Petroleum Energy Center	https://www.idemitsu.com/jp/news/2021/2/10824_2.html
5	<i>Sumitomo Heavy Industries</i>	1934	Develop CO ₂ -to-Liquid Fuel via FT Synthesis Technology using CO ₂ from industrial emissions mixed with hydrogen to produce syngas and then convert it through FT into liquid hydrocarbon fuels (e.g., kerosene, SAF diesel)	https://www.shi.co.jp/info/2023/6kgpsq000000mrde.html
6	<i>IHI Corporation</i>	1853	Develop CO ₂ conversion technology uses advanced multi-stage catalytic processes to hydrogenate captured CO ₂ into liquid hydrocarbon intermediates, which can be further upgraded into SAF	https://www.ihico.jp/en/technology/techinfo/contents_no/1200704_13586.html
			Develop compact methanation system using proprietary catalysts to convert captured CO ₂ and hydrogen into synthetic methane that can be used as a low-carbon fuel in existing city gas infrastructure or at industrial sites	https://www.ihico.jp/en/all_news/2022/resources_energy_environment/1198178_3488.html

Source: METI, NEDO, Carbon Recycling Fund Institute, company websites

Introduction of Japanese Technology for CO₂ Utilization | FuelCompanies like CHITOSE Group, IT Tech, ENEOS use captured CO₂ to produce microalgae for bio-based materials, SAF, and synthetic fuels

#	Company Name	Year Established	Technology related to CCU	HP
7	<i>CHITOSE Group</i>	2005	Operates a CCU system that uses CO ₂ from industrial emissions to cultivate microalgae at scale, turning the captured carbon into biomass that can be converted into SAF, plastics, food ingredients, and other bio-based products.	https://chitose-bio.com/news/5155/
8	<i>IT Tech. Corporation</i>	2018	Develop carbon fixation and synthesis technology that uses CO ₂ and water to chemically synthesize hydrocarbon fuels (n-alkane-based petroleum products such as diesel and heavy oil) named "Dream Light Oil"	https://ittech.co.jp/service/p1/
9	<i>Idemitsu Kosan</i>	1911	In collaboration with Hiroshima University, develop a novel two-stage fermentation process that converts captured CO ₂ from power plant flue gas into acetate and then into lipids through microbial action, resulting in lipids as feedstock for fuels, cosmetics, and health-food ingredients	https://www.enecho.meti.go.jp/category/others/carbon_recycling/pdf/tech_casebook.pdf
10	<i>ENEOS Corporation</i>	1888	Develop technology to produce synthetic fuels using captured CO ₂ and hydrogen from renewable energy to establish a high-efficiency production process for liquid fuels from CO ₂ based on a synthetic reaction through bench scale plant and scaled-up pilot plant operations	https://www.eneos.co.jp/english/newsrelease/2022/pdf/20220419_01.pdf

Introduction of Japanese Technology for CO₂ Utilization | FuelCompanies like ENEOS, Osaka Gas, Green Earth Institute, Nippon Steel explore the use of CO₂ to produce synthetic fuels, e-methane, bioethanol, and LPG

#	Company Name	Year Established	Technology related to CCU	HP
12	<i>Green Earth Institute, Nippon Paper Industries</i>	<ul style="list-style-type: none"> • 2011 • 1949 	Explore the use of bio-generated CO ₂ , CO ₂ emitted from biological raw materials, to produce bioethanol from biomass	https://contents.xj-storage.jp/xcontents/AS04799/ef17a168/fd57/43df/9540/077e3c1e4da6/140120250217577366.pdf
13	<i>Nippon Steel Engineering, Toyota Motor Corporation</i>	<ul style="list-style-type: none"> • 2006 • 1937 	Develop technology to utilize high levels of concentrated CO ₂ from biomass and process residues e.g. lignin generated in the fermentation process to produce second-generation bioethanol	https://www.eng.nipponsteel.com/en/news/detail/20230621/
14	<i>N.E. CHEMCAT Corporation</i>	1964	Develop carbon-recycling LPG synthesis technology that converts captured CO ₂ and renewable hydrogen into carbon-neutral propane and butane, co-developed with the Institute of Japan Green LP Gas Promotion	https://www.j-lpgas.gr.jp/en/dl/20220510.pdf
15	<i>Toshiba Energy Systems & Solutions Corporation</i>	2017	Develop CO ₂ electrolysis technology that converts captured CO ₂ into highly reactive carbon monoxide (CO) at high conversion efficiency under near-ambient conditions, enabling integration with hydrogen-based synthesis processes to produce synthetic fuels	https://www.global.toshiba/ww/news/energy/2023/10/news-20231025-01.html

Introduction of Japanese Technology for CO₂ Utilization | Fuel

Furukawa Electric and Taisei Corporation explore the use of CO₂ to produce Green LP Gas and microalgae for biodiesel and SAF

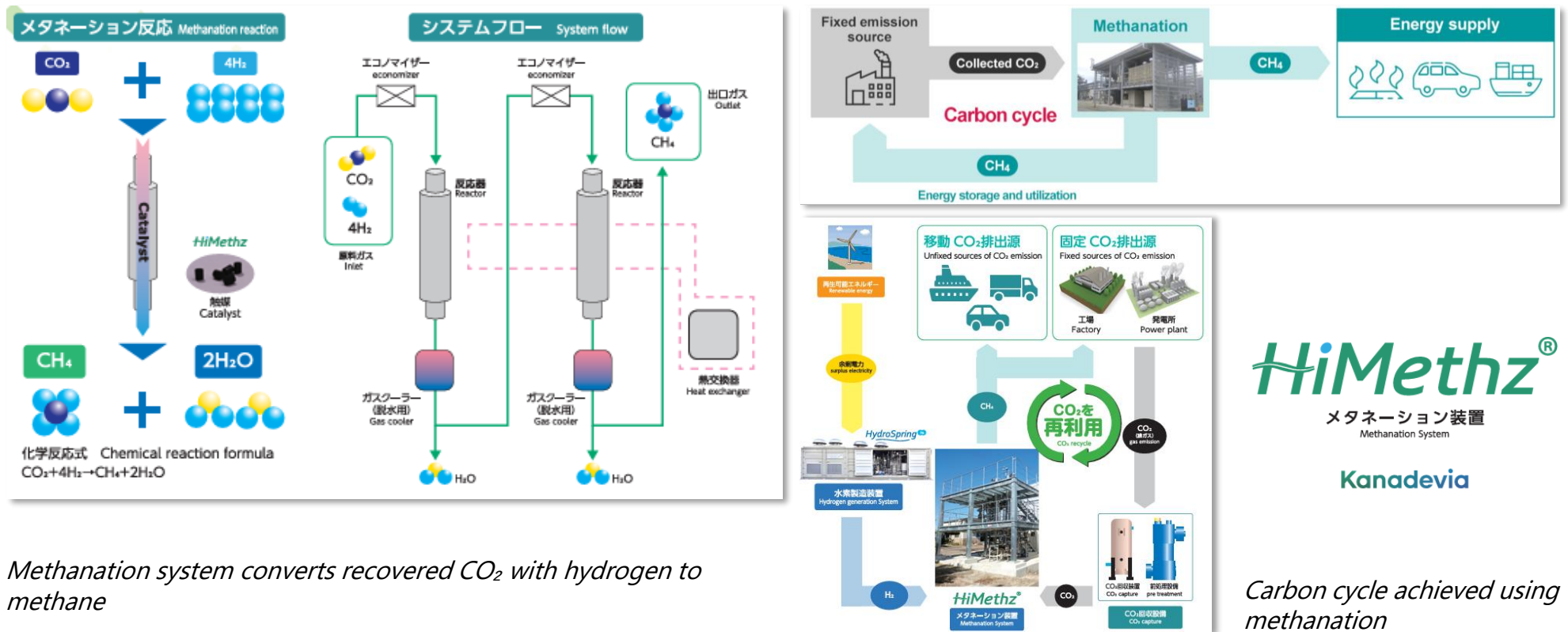
#	Company Name	Year Established	Technology related to CCU	HP
16	<i>Furukawa Electric Co., Ltd.</i>	1884	Develop technology to produce Green LP gas by synthesizing carbon monoxide and hydrogen from biogas from the methane fermentation process of organic waste	https://www.furukawaelectric.com/en/rd/review/fr056/fr56_08.pdf
17	<i>Taisei Corporation</i>	1837	Develop technology to utilize CO ₂ generated from methane production in wastewater treatment for microalgae cultivation, producing free fatty acids that can be refined into biodiesel or sustainable aviation fuel	https://www.taisei.co.jp/tact/tr/2024/06/

Case Study: Kanadevia | Natural Gas Processing

Kanadevia provides methanation equipment that can generate methane gas from CO₂ recovered from the exhaust gas of industrial facilities and hydrogen

Overview of Technology

- CO₂ recovered from various emission sources e.g. gas plants is converted into methane fuel through a reaction with H₂ produced from renewable energy. Since synthesized methane gas is the main component of natural gas, it can be transported, stored, and used via a conventional natural gas infrastructure. Furthermore, CO₂ generated by combustion of methane is recovered and converted to methane again. This achieves utilization of a carbon cycle.



Methanation system converts recovered CO₂ with hydrogen to methane

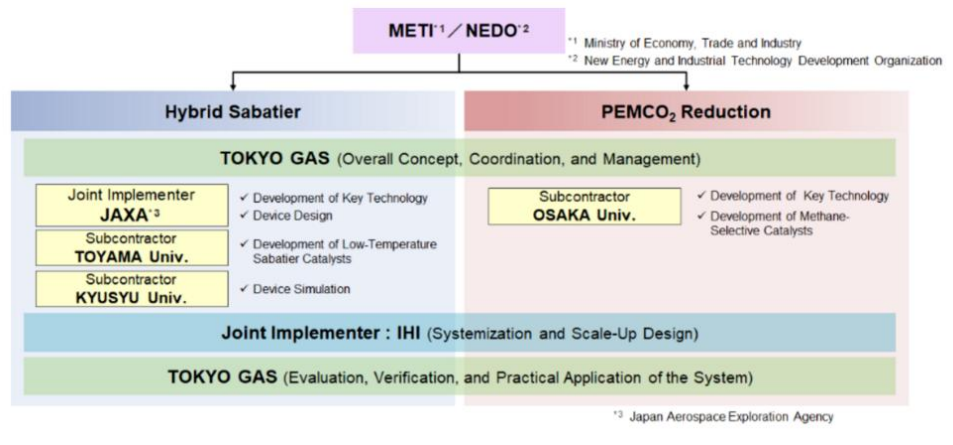
Carbon cycle achieved using methanation

Case Study: Tokyo Gas | Natural Gas Processing

Tokyo Gas develops advanced methanation technologies (Hybrid Sabatier and PEMCO₂ reduction) to convert captured CO₂ into e-methane

Overview of Technology

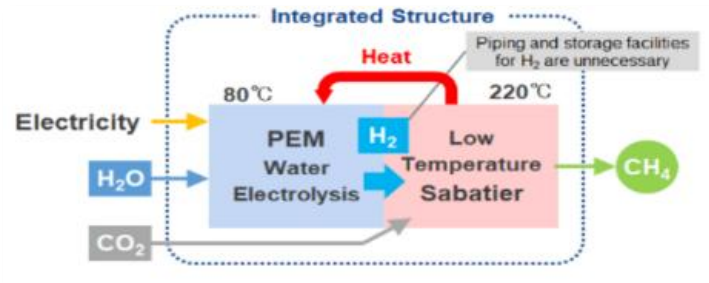
- Tokyo Gas is developing advanced methanation technology, including Hybrid Sabatier and electrochemical PEMCO₂ reduction, that efficiently synthesizes e-methane from captured CO₂ and produce methane identical to natural gas for use in existing city gas infrastructure with lower production costs and improved energy efficiency.



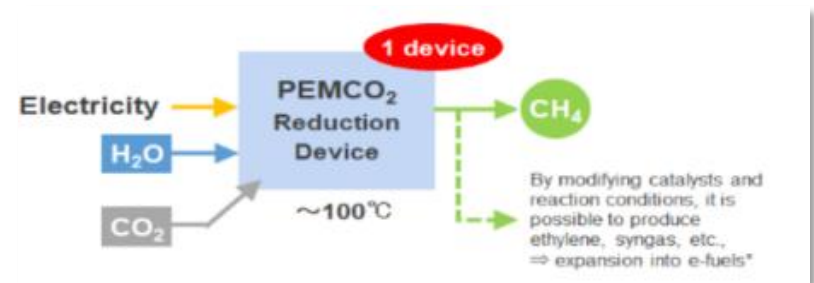
Project development structure

	Figure	Efficiency	Equipment cost	Heat management
Conventional Technology		50 % Electrolysis + Methanation	High cost Multiple processes	Difficult High operating temperature (about 500°C)
Innovative Methanation ① Hybrid Sabatier		80% target	Simplified system due to Integrated equipment	Low temperature reaction • Easy start-stop • Easy heat management
Innovative Methanation ② PEMCO ₂ Reduction		70% target	Drastic cost reduction Direct synthesis with single reaction	

Comparison with conventional technology



Methane Production by Hybrid Sabatier



Methane Production by PEMCO₂ Reduction

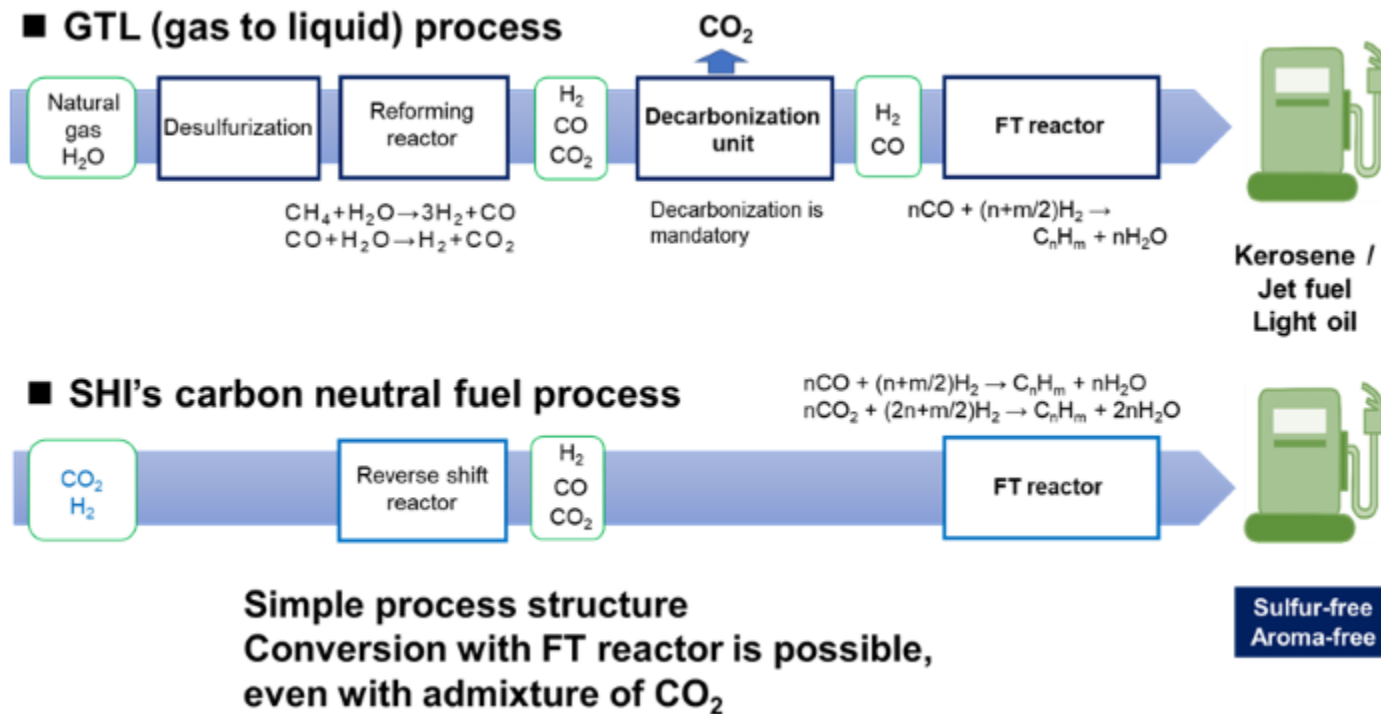
Source: Tokyo Gas (<https://www.tokyo-gas.co.jp/e-methane/technology/index.html?wovn=en>)

Case Study: Sumitomo Heavy Industries | Natural Gas Processing

Sumitomo Heavy Industries develops technology using captured CO₂ to make sustainable liquid fuels such through the Fischer–Tropsch process

Overview of Technology

- Sumitomo Heavy Industries' FT synthesis technology integrates CO₂ (including from industrial flue gas) with renewable hydrogen to produce syngas (CO + H₂), which is catalytically converted via Fischer–Tropsch reactions into liquid hydrocarbons such as kerosene, jet fuel (SAF), and diesel



Comparison of conventional GTL process and Sumitomo Heavy Industries process

Agenda

Executive Summary

Chapter 1: Identification of Japanese Technologies

Pitchbook of Japanese Technologies

Overview of Technology for CCU

Introduction of Japanese Technologies

Utilization (45 examples)

Chemicals (17 examples)

Fuel (17 examples)

Minerals (11 examples)

Capture and separation (17 examples)

Chapter 2: Identification of Issues by Thai Companies

Chapter 3: Basic Information for Japanese Companies

Appendix

Introduction of Japanese Technology for CO₂ Utilization | Minerals

Japanese companies provide a wide range of technologies for CO₂ utilization for minerals including Sumitomo Osaka Cement, Taiheiyo Cement and Denka

#	Company Name	Year Established	Technology related to CCU	HP
1	<i>Sumitomo Osaka Cement Co., Ltd.</i>	1994	Develop a dual recycling technology for calcium and CO ₂ that combines calcium contained in waste with carbon dioxide to produce the artificial limestone and develop a pilot-scale facility for to produce the artificial limestone by using recycling technology for calcium and CO ₂	https://www.nedo.go.jp/english/whatsnew_00340.html
2	<i>Taiheiyo Cement Corporation</i>	1881	Develop CARBOFIX® cement which was developed to absorb CO ₂ during hardening in manufacturing process through a chemical reaction	https://www.taiheiyo-cement.co.jp/english/summary/pdf/220920.pdf
			Conduct a trial stage of utilizing CO ₂ captured from cement plant exhaust gas in horticulture by using in greenhouse at National Federation of Agricultural Cooperative Associations	https://www.taiheiyo-cement.co.jp/english/
3	<i>Denka Company Limited, Kajima Corporation, Takenaka Corporation</i>	<ul style="list-style-type: none"> • 1915 • 1930 • 1937 	Develop CO ₂ -SUICOM, a carbon-capturing concrete and develop technologies to utilize CO ₂ in concrete making	https://www.kajima.co.jp/english/tech/katri/special/carbon_neutral/index.html
4	<i>Kajima Corporation, Mitsubishi Corporation,, Chugoku Electric Power Co., Inc</i>	<ul style="list-style-type: none"> • 1930 • 1954 • 1951 	Develop technology to use CO ₂ for the application in the reinforced and cast-in-place concretes used in building construction in large outdoor tests	https://www.mitsubishicorp.com/jp/en/news/release/2020/files/0000045783_file1.pdf

Source: METI, NEDO, company websites

Introduction of Japanese Technology for CO₂ Utilization | Minerals

Japanese companies provide a wide range of technologies for CO₂ utilization for minerals including carbon-negative artificial sand, carbon-recycled concrete

#	Company Name	Year Established	Technology related to CCU	HP
5	<i>Mitsubishi UBE Cement Corporation</i>	2021	Develop GX-e Beads™, a carbon-negative artificial sand, made from wastes and by-products containing calcium and CO ₂ (dry basis) contained in exhaust gas which is absorbed by its own carbonation technology	https://www.mu-cc.com/information/20240128_01.html
6	<i>Taisei Corporation</i>	1837	Manufacture a carbon-recycled T-eConcrete® which is made from carbon-recycled materials such as calcium carbonate, and ground granulated blast furnace slag	https://www.taisei.co.jp/english/profile/business/t-econcrete/
7	<i>TBM Co., Ltd.</i>	2008	Develop technology to capture CO ₂ emitted from chemical plants and combine with calcium ions of the steel slag and develop Next generation LIMEX which utilizes CCU carbonate calcium as its primary products	https://tbm.com/eng/business/material/products-sheet/
8	<i>JFE Steel Corporation</i>	2003	Develop technology to manufacture materials using CO ₂ emitted from coal-using industries e.g. iron manufacturing by synthesizing methanol from CO ₂ in exhaust gas emitted from ironworks	https://www.jfe-steel.co.jp/en/release/2021/211015.html
9	<i>Sekisui Chemical Co., Ltd.</i>	1947	Develop Carbon Capture and Recycling Technology for use in steelmaking processes which captures CO ₂ emitted in steelmaking and converts into synthesis gas to use in the blast furnace in collaboration with ArcelorMittal	https://corporate.arcelormittal.com/media/news-articles/arcelormittal-and-sekisui-chemical-s-carbon-recycling-project-achieves-target-ahead-of-schedule

Source: METI, NEDO, company websites

Introduction of Japanese Technology for CO₂ Utilization | Minerals

Sumitomo Osaka Cement, Taisei Corporation, Nihon Kaisui, and Idemitsu Kosan develop technology CCU to produce calcium carbonate

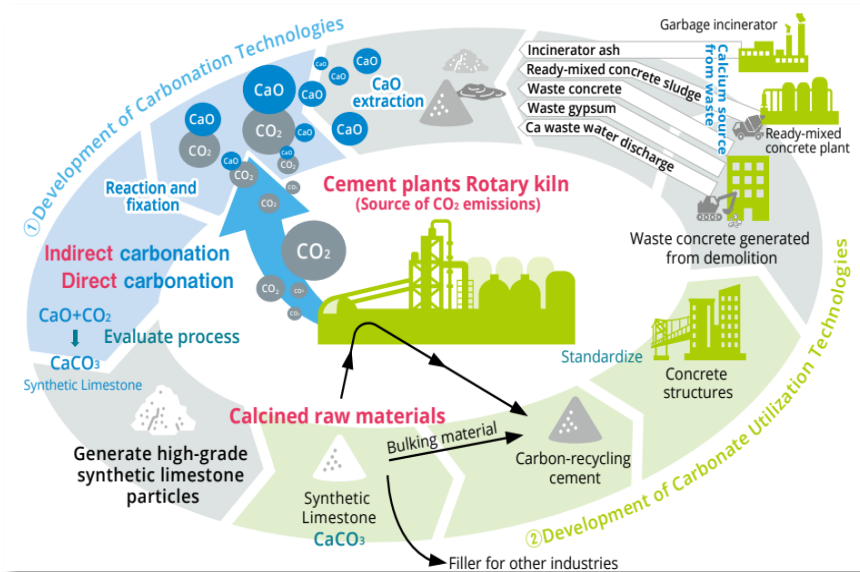
#	Company Name	Year Established	Technology related to CCU	HP
10	<i>Sumitomo Osaka Cement Co., Ltd., Taisei Corporation</i>	<ul style="list-style-type: none"> • 1994 • 1837 	Conduct demonstration project to produce artificial calcium carbonate from flue gas desulfurization gypsum and flue gas CO ₂ which are the by-products generated at thermal power plant in Thailand to use in local carbon recycled concrete	https://www.meti.go.jp/information/publicoffer/saitaku/2026/s260205001.html
11	<i>Nihon Kaisui, Idemitsu Kosan</i>	<ul style="list-style-type: none"> • 1995 • 1911 	Develop a CO ₂ mineralization technology using seawater and bio-amines that reacts captured CO ₂ with calcium in seawater to fix it as valuable calcium carbonate	https://www.a.u-tokyo.ac.jp/news/news_20220301-1.html

Case Study: Cement | Sumitomo Osaka Cement Co., Ltd.

Sumitomo Osaka Cement provides technology which produce artificial limestone from recycling CO₂ with calcium contained in waste

Overview of Technology

- Sumitomo Osaka Cement Co., Ltd. develops a dual recycling technology for combining calcium and CO₂ and establish a pilot-scale facility



Process of CO₂ recycling using CO₂ emitted from cement plants

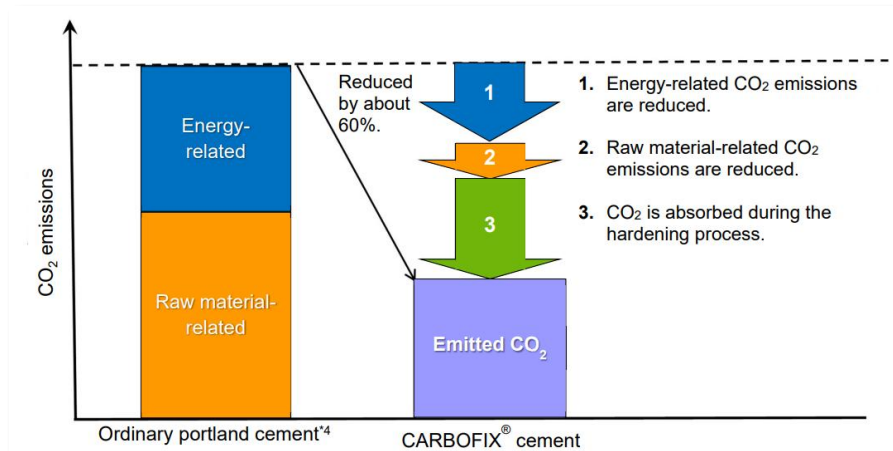
Pilot-scale facility of artificial limestone production

Case Study: Cement | Taiheiyo Cement Corporation

Taiheiyo Cement Corporation developed a carbon recycling technology to produce CARBOFIX cement

Overview of Technology

- Taiheiyo Cement Corporation developed CARBOFIX cement, a low-carbon cement and used the cement in manufacturing of interlocking paver blocks. During the manufacturing of CARBOFIX cement, the cement will absorb CO₂ during carbon curing in the supplied CO₂-containing gas and strengthen through the chemical reaction



Process of recycling CO₂ in CARBOFIX[®] cement

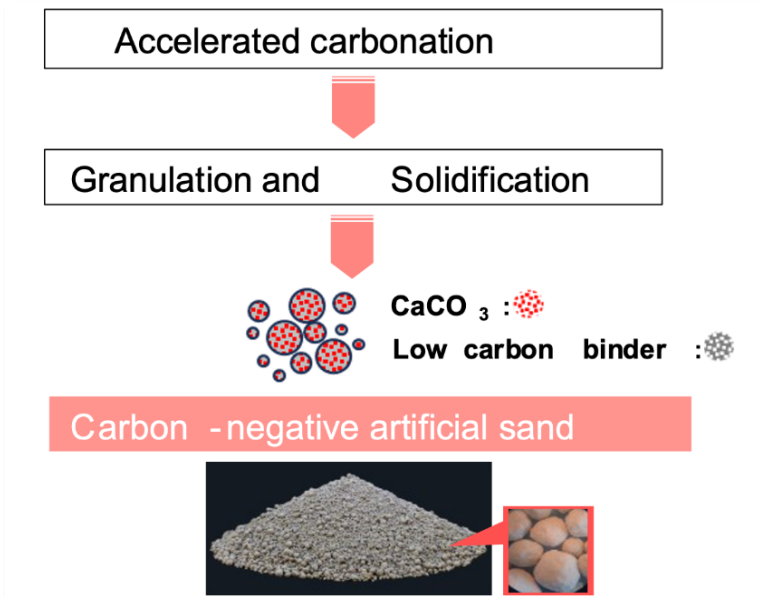
Picture of CARBOFIX cement and interlocking paver block made from CARBOFIX cement

Case Study: Cement | Mitsubishi UBE Cement Corporation

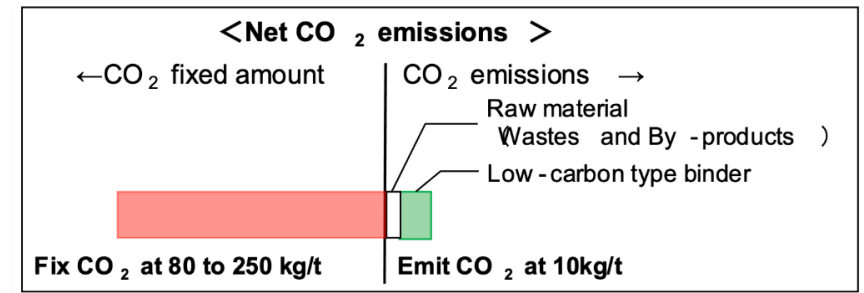
Mitsubishi UBE Cement develops carbonation technology and manufactures GX-e Beads™, a carbon-negative artificial sand

Overview of Technology

- Mitsubishi UBE Cement Corporation develops GX-e Beads™ that are produced from waste and by-products containing calcium (Ca) and CO₂ which is absorbed from exhaust gases through its own development of accelerated carbonation technology



Process of utilizing fixed CO₂ in the manufacture of carbon-negative artificial sand



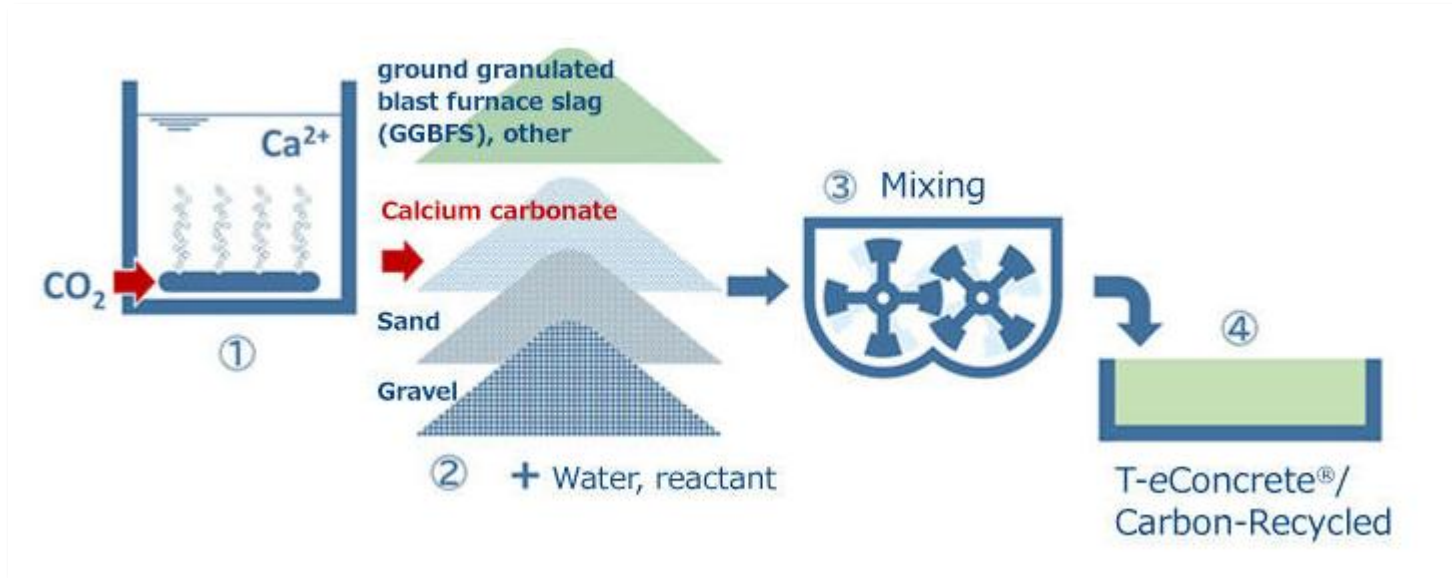
Amount of CO₂ fixed in GX-e Beads

Case Study: Cement | Taisei Corporation

Taisei Corporation manufactures a carbon-recycled concrete using captured CO₂ which is absorbed in calcium carbonate

Overview of Technology

- Taisei Corporation develops technology to manufacture Carbon-recycled concrete by using carbon-recycled materials such as calcium carbonate made from CO₂ captured from exhaust gases, along with ground granulated blast furnace slag (GGBFS), a steelmaking by-product. CO₂ is absorbed inside by converting into calcium carbonate and mixing into the concrete



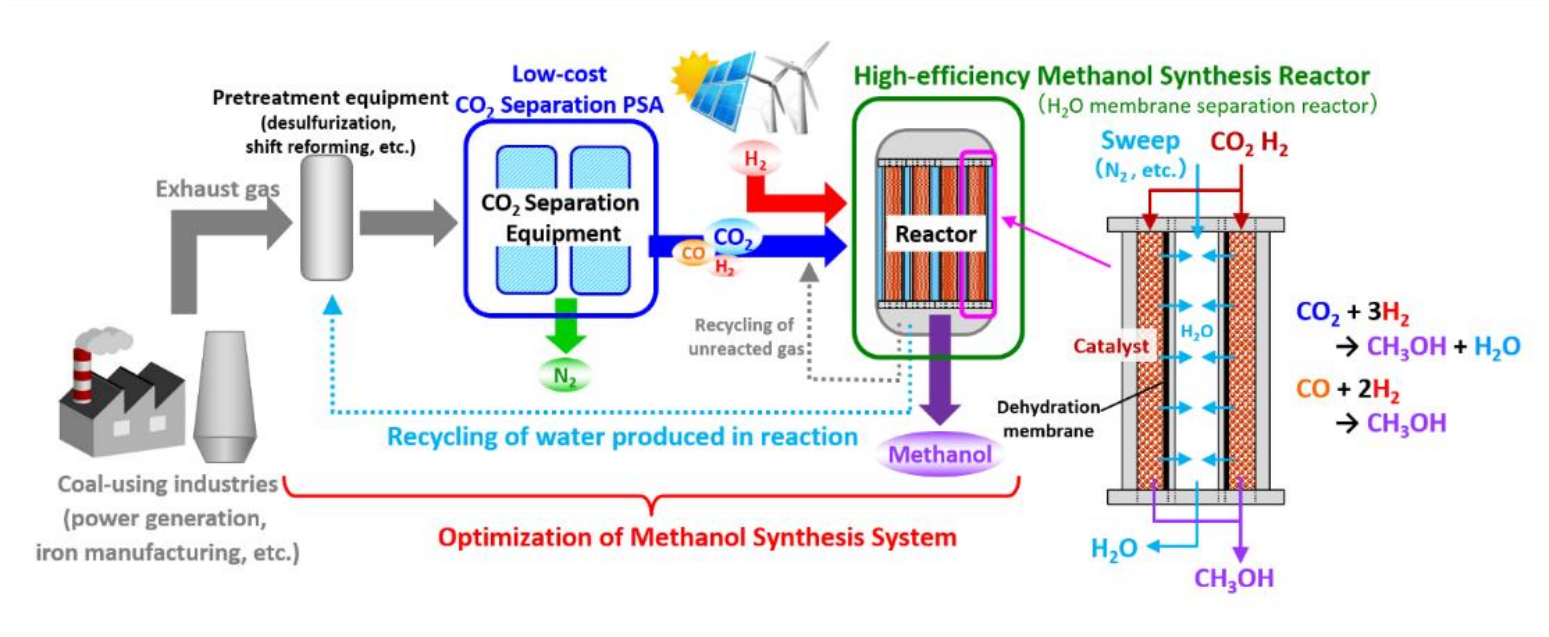
Process of manufacturing Carbon-Recycled T-eConcrete®

Case Study: Steel & Iron | JFE Steel Corporation

JFE Steel provides technology which utilizes CO₂ in exhaust gases from iron works to produce methanol

Overview of Technology

- JFE Steel Corporation develops technology to efficiently synthesize methanol from CO₂ in exhaust gases from ironworks. By utilizing the high CO₂ concentration and secondary components such as CO and H₂ in blast furnace gas, the project aims to achieve low-cost, high-efficiency methanol production through advanced PSA-based CO₂ separation, an H₂O membrane separation reactor, and an optimized system including pretreatment and water recycling.



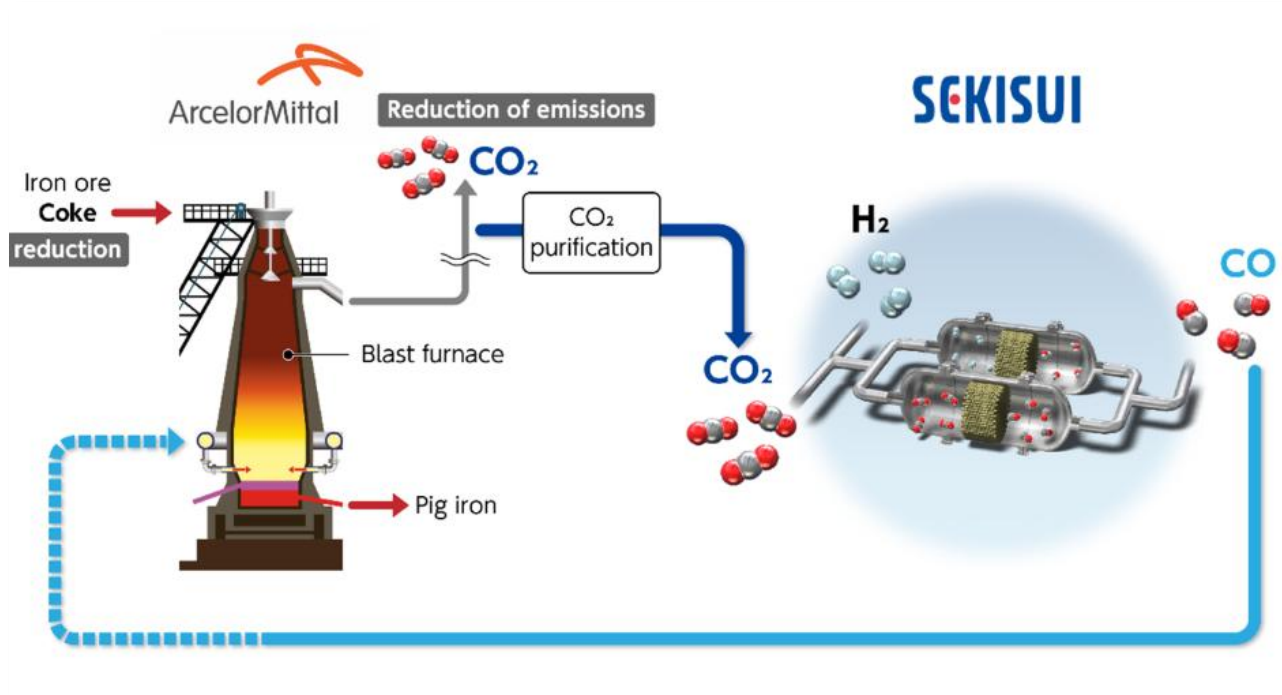
Process of utilizing CO₂ emitted in exhaust gas for methanol production

Case Study: Steel & Iron | Sekisui Chemical Co., Ltd.

Sekisui Chemical provides technology which utilizes CO₂ in exhaust gases from steelmaking to produce synthesis gas and reuse within the plant

Overview of Technology

- Sekisui Chemical Co., Ltd. develops technology to use actual blast furnace gas at ArcelorMittal's plant in Asturias, Spain and converts it into synthesis gas composed of carbon monoxide and hydrogen via a chemical process, then introduces this synthesis gas into the blast furnace as a reducing agent to replace coke. During the test, a conversion rate of CO₂ at 90% and a conversion rate of hydrogen has been achieved



Process of converting CO₂ emitted in steelmaking plant to synthesis gas

Agenda

Executive Summary

Chapter 1: Identification of Japanese Technologies

Pitchbook of Japanese Technologies

Overview of Technology for CCU

Introduction of Japanese Technologies

Utilization (45 examples)

Chemicals (17 examples)

Fuel (17 examples)

Minerals (11 examples)

Capture and separation (17 examples)

Chapter 2: Identification of Issues by Thai Companies

Chapter 3: Basic Information for Japanese Companies

Appendix

Introduction of Japanese Technology for CO₂ Utilization | CO₂ capture and separationCompanies like JGC Corporation, NGK Insulators, and Atomis provide membrane and material for CO₂ capture and separation

#	Company Name	Year Established	Technology related to CCU	HP
1	<i>JGC Corporation, NGK Insulators</i>	<ul style="list-style-type: none"> • 1928 • 1919 	Develop CO ₂ separation and recovery technology using DDR-type Zeolite Membrane, a ceramic CO ₂ separation membrane that can be operated under high pressure and high CO ₂ concentrations for CO ₂ removal during natural gas treating and production of crude oil	https://www.jgc.com/en/business/tech-innovation/environment/ddr-membrane.html
2	<i>National Institute of Advanced Industrial Science and Technology</i>	2001	Develop CO ₂ capture membranes (30,000 - 40,000 membranes in membrane area 1,500 m ²) enabling the separation of CO ₂ emitted from thermal power plant which is expected to reduce emissions by 6 - 7.5 million tons of CO ₂ per year for one plant (1 million kWh)	https://www.enecho.meti.go.jp/category/ot_hers/carbon_recycling/pdf/tech_casebook.pdf
3	<i>Atomis</i>	2015	Develop advanced PCP (porous coordination polymers) materials for highly selective CO ₂ adsorption and separation, enabling efficient capture from low-concentration, moisture-containing gas streams, supporting compact and distributed CCU systems	https://www.atomis.co.jp/business/
4	<i>JFE Steel Corporation</i>	2003	Develop PSA (Pressure Swing Adsorption) technology to separate carbon dioxide from blast furnace gas under CO ₂ Ultimate Reduction System for Cool Earth 50 (COURSE50) project	https://www.jfe-steel.co.jp/en/research/report/019/25.html

Introduction of Japanese Technology for CO₂ Utilization | CO₂ capture and separationJapanese companies provide innovative CO₂ capture technologies that reduce energy consumption by using effective absorbent

#	Company Name	Year Established	Technology related to CCU	HP
5	<i>Kawasaki Heavy Industries</i>	1896	Develop Kawasaki CO ₂ Capture (KCC) technology to capture and separate CO ₂ using an amine-coated solid sorbent, enabling low-temperature regeneration and reduced energy consumption compared to conventional systems	https://global.kawasaki.com/en/energy/equipment/co2sr/
6	<i>IHI Corporation</i>	1853	Develop technology to capture CO ₂ from combustion exhaust gases with the use of the chemical absorption method with an absorbent liquid that can reduce energy consumption for CO ₂ separation by approximately 40%	https://www.ihico.jp/en/technology/sdgs/topic02/
7	<i>Mitsubishi Heavy Industries</i>	1950	Develop and deploy advanced post-combustion CO ₂ capture systems using proprietary KM CDR Process™ and solvent technologies to absorb and regenerate CO ₂ from flue gases, enabling high-efficiency capture across power, industrial, and modular applications for CCUS deployment	https://www.mhi.com/products/engineering/co2plants_process.html
8	<i>Eplus</i>	2012	Develop the CCFR (Carbon dioxide Capture Fuel Recycle) process, which enhances absorption with amine fluid through electrical and electrode effects to improve efficiency, enabling the recovered CO ₂ to be reused as a resource for fuel production and other decarbonization applications	http://eplus32.co.jp/technology/324/

Introduction of Japanese Technology for CO₂ Utilization | CO₂ capture and separationOsaki CoolGen and Cosmo Engineering provide CO₂ capture and separation technology that effectively recovering high-purity CO₂

#	Company Name	Year Established	Technology related to CCU	HP
9	<i>Osaki CoolGen</i>	2009	Demonstrate CO ₂ capture and separation in the Osaki CoolGen Project by shifting coal gasification syngas to produce CO ₂ and H ₂ , then capturing high-purity CO ₂ (targeting over 90% capture and 99% purity) in an absorber for utilization	https://www.osaki-coolgen.jp/project/step2.html
10	<i>Cosmo Engineering</i>	1958	Develop CO ₂ recovery systems to capture and concentrate CO ₂ from combustion exhaust, industrial off-gas using absorption and membrane technologies effectively pretreating impurities (SO _x , NO _x , alcohol, etc.) in the raw gas, and recovering high-purity CO ₂	https://www.cosmoeng.co.jp/service/ctg01/co2recovery.html
11	<i>Chiyoda Corporation</i>	1948	Develop and demonstrate core solid sorbent material technology to cut the cost of separating and recovering low-concentration CO ₂ from gas turbine exhaust gases, aiming for economically viable low-carbon solutions for natural gas utilization	https://www.chiyodacorp.com/en/service/lowcarbon/ccs-ccu/
12	<i>Denso</i>	1949	Develop and implement a small, high-efficiency CO ₂ capture system using an electric-field method that leverages DENSO's mobility-derived technologies to extract low-concentration CO ₂ with lower energy input and compact size	https://www.denso.com/jp/ja/driven-base/project/carbon_recycle/

Introduction of Japanese Technology for CO₂ Utilization | CO₂ capture and separation

Companies like Crasus Chemical, Sumitomo Chemical, Air Water develop capture and separation technology for low-concentration emissions with lower cost

#	Company Name	Year Established	Technology related to CCU	HP
13	<i>Crasus Chemical, Nippon Steel Corporation</i>	<ul style="list-style-type: none"> • 2024 • 1970 	Develop and advance CO ₂ separation and capture technology using innovative PCF/MOF-based separating agents combined with catalyst technologies to efficiently extract CO ₂ from plant exhaust gases including low-concentration emissions and integrate this into a CO ₂ -based chemical product value chain	https://www.crasus.co.jp/technology/carbon_neutral.html
14	<i>Sumitomo Chemical</i>	1913	Develop a low-cost CO ₂ capture system using high-performance separation membranes to efficiently recover low-concentration CO ₂ from factory exhaust gases, enabling compact and energy-saving solutions for small- to medium-scale industrial emission sources	https://www.sumitomo-chem.co.jp/news/detail/20220513.html
15	<i>Air Water, Toda Kogyo Corp</i>	<ul style="list-style-type: none"> • 1929 • 1933 	Develop an innovative Na-Fe oxide-based solid sorbent CO ₂ capture technology to efficiently recover low-concentration, high-temperature CO ₂ from industrial exhaust while aiming to reduce capture costs to the 12 USD/ton-CO ₂ range and compact deployment	https://www.awi.co.jp/ja/business/news/news-90556933833682642010.html
16	<i>Air Water</i>	1929	Develop and deploy the "ReCO ₂ STATION" CO ₂ capture device that applies proprietary physical absorption technology to efficiently recover low-concentration CO ₂ from industrial boiler and furnace exhaust with low energy input	https://www.awi.co.jp/ja/research/outcome/reco2.html

Source: METI, NEDO, company websites

Introduction of Japanese Technology for CO₂ Utilization | CO₂ capture and separation

Toho Gas develop Cryo-Capture® using unused LNG cold energy to separate and recover CO₂ from low-pressure, low-concentration industrial and exhaust gases

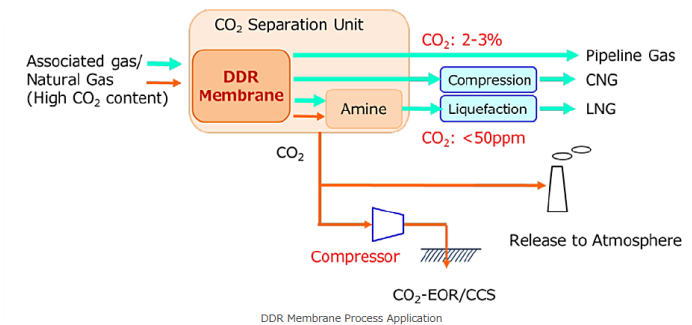
#	Company Name	Year Established	Technology related to CCU	HP
17	<i>Toho Gas</i>	1922	Develop the Cryo-Capture® CO ₂ capture technology that applies unused LNG cold energy to separate and recover CO ₂ from low-pressure, low-concentration industrial and exhaust gases with lower energy input than conventional chemical absorption, and will advance its development and pilot-scale demonstration toward social implementation by around 2030	https://www.tohogas.co.jp/corporate/approach/technologies/carbonneutral/separation/separation-02/

Case Study: CO₂ capture and separation | JGC Corporation & NGK Insulators, Ltd.

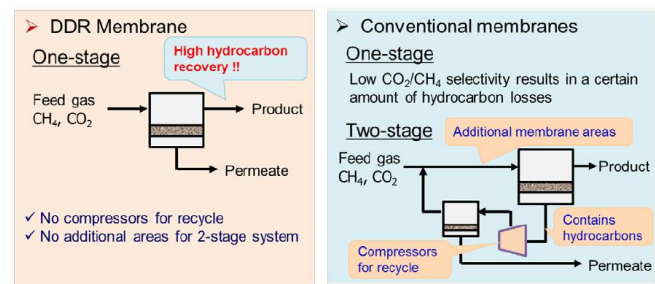
JGC Corporation is jointly developing DDR membrane process to separate CO₂ from associated gas in one stage

Overview of Technology

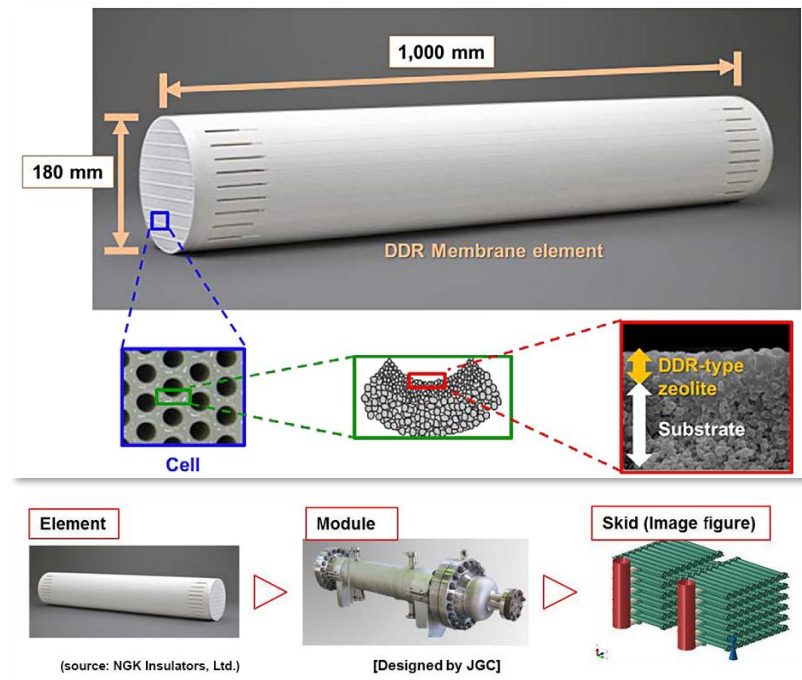
- JGC Corporation and NGK Insulators have developed DDR membrane process using DDR-type zeolite membrane capable of separating CO₂ from associated gas deriving from CO₂-EOR and natural gas with high CO₂ content. This DDR membrane achieves higher product yields through a high CO₂ and CH₄ selectivity in a one-stage system which reduces CH₄ loss compared with conventional polymeric membrane process



Process of DDR Membrane Application



Comparison between DDR Membrane and Conventional Polymeric Membrane



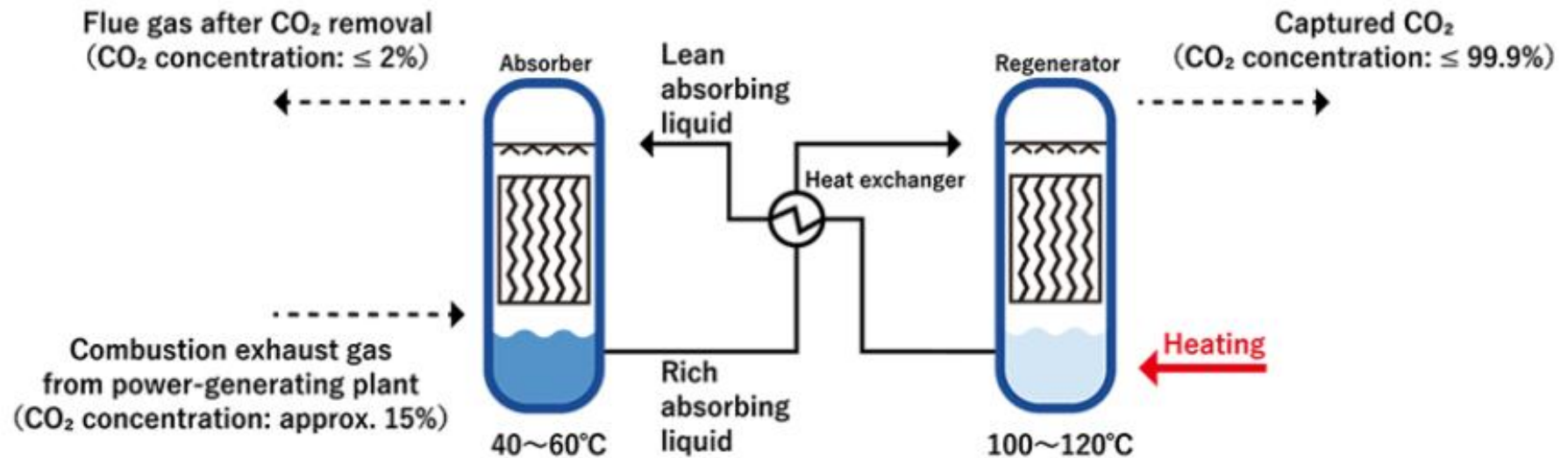
Picture of DDR Membrane Element

Case Study: CO₂ capture and separation | IHI

IHI efficiently captures and separates CO₂ while significantly reducing energy consumption with advanced chemical absorption technology

Overview of Technology

- IHI's CO₂ capture technology uses advanced chemical absorption to efficiently capture and separate CO₂ from industrial flue gases and other emission sources. Its proprietary solvent and process design help significantly reduce energy consumption during the separation step, around 40% less than conventional method, improving overall system efficiency. The high-purity CO₂ can then be utilized for fuels and chemical production, supporting carbon recycling initiatives.



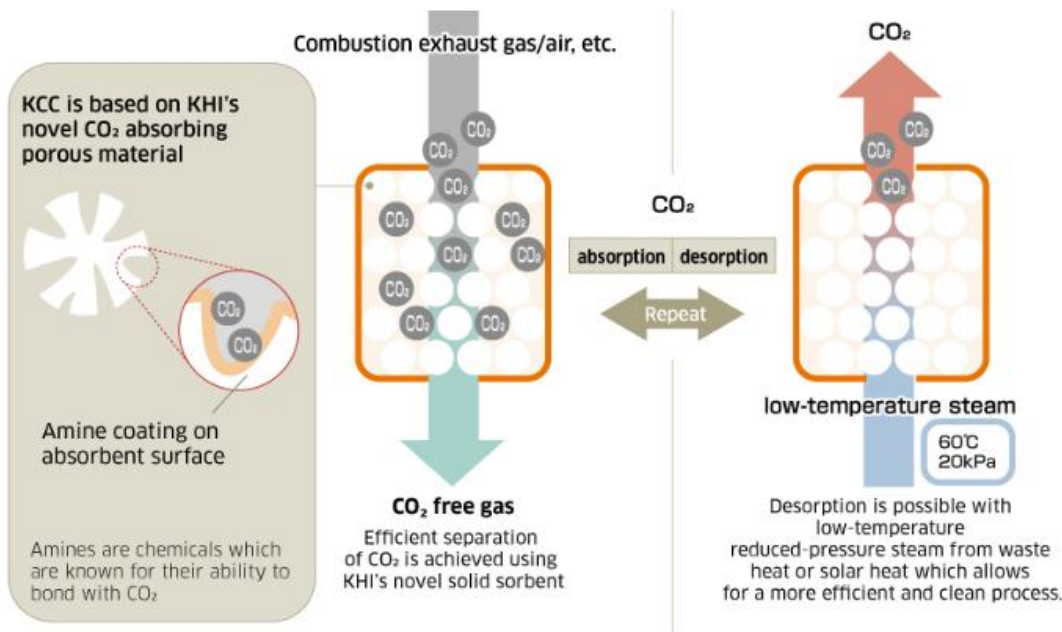
CO₂ chemical absorption method

Case Study: CO₂ capture and separation | Kawasaki Heavy Industries

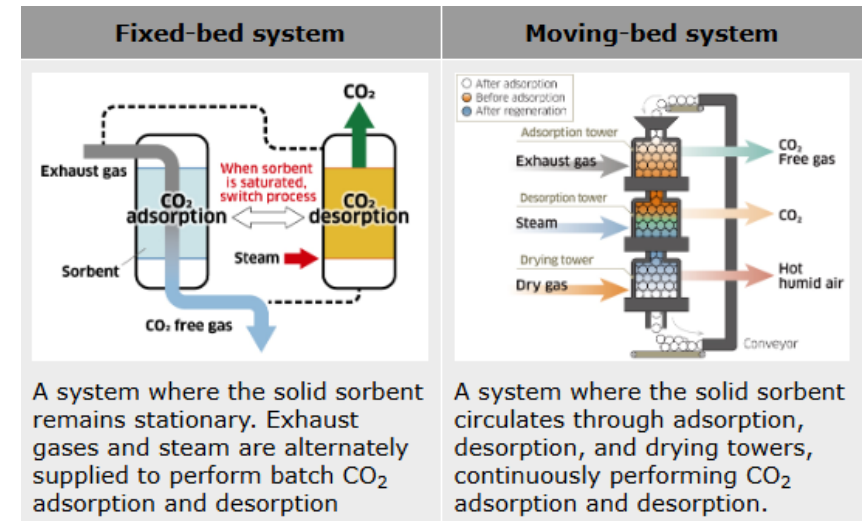
Kawasaki CO₂ Capture (KCC) technology enables energy-efficient CO₂ separation through low-temperature solid sorbent regeneration

Overview of Technology

- Kawasaki CO₂ Capture (KCC) technology uses a solid sorbent coated with amine on a porous material to selectively capture and separate CO₂ from exhaust gases with lower energy requirements than conventional liquid amine systems, allowing regeneration using low-temperature heat such as waste heat (≤ 100 °C). The process can be configured in fixed-bed or moving-bed systems for batch or continuous adsorption/desorption cycles



Kawasaki CO₂ Capture Process



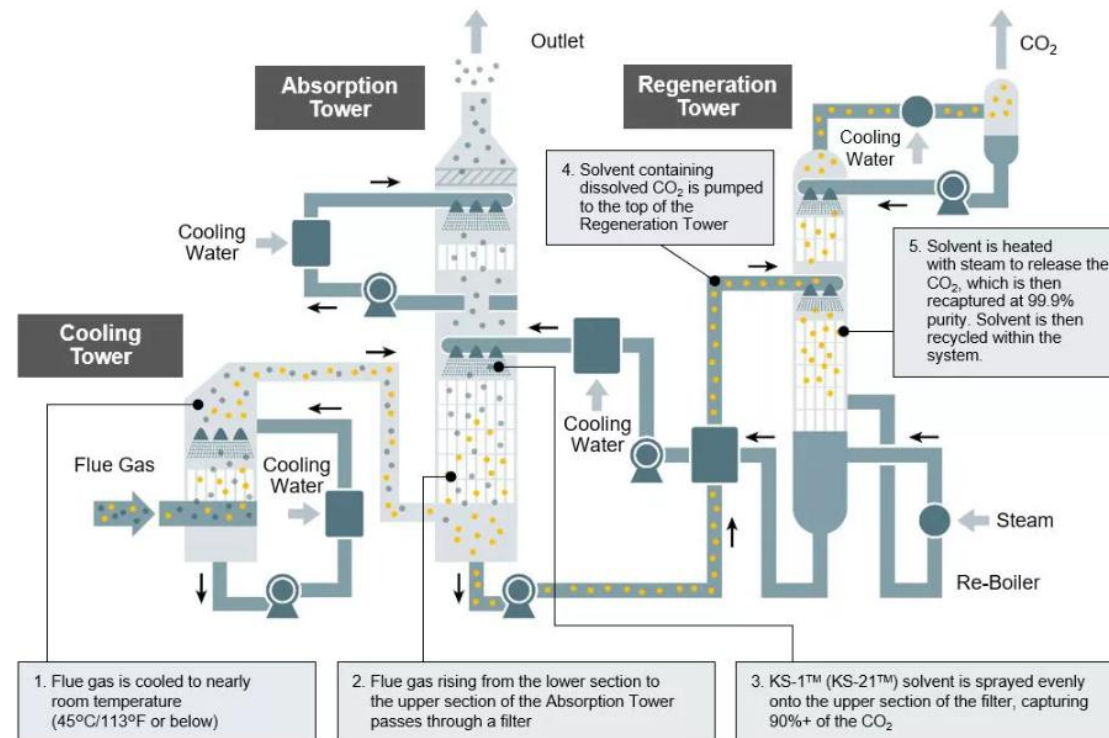
Configurations System Overview

Case Study: CO₂ capture and separation | Mitsubishi Heavy Industries

Mitsubishi Heavy Industries' advanced amine-based process enables high-efficiency CO₂ capture with reduced energy consumption

Overview of Technology

- Mitsubishi Heavy Industries's CO₂ capture technology uses a proprietary amine-based chemical absorption process to efficiently separate CO₂ from flue gas. Its advanced KM CDR Process™ reduces energy consumption during solvent regeneration while achieving high capture efficiency, delivering purified CO₂ for utilization or storage.



Process flow of KS-21™ technology



**Envision the value,
Empower the change**

Agenda

Executive Summary

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Appendix

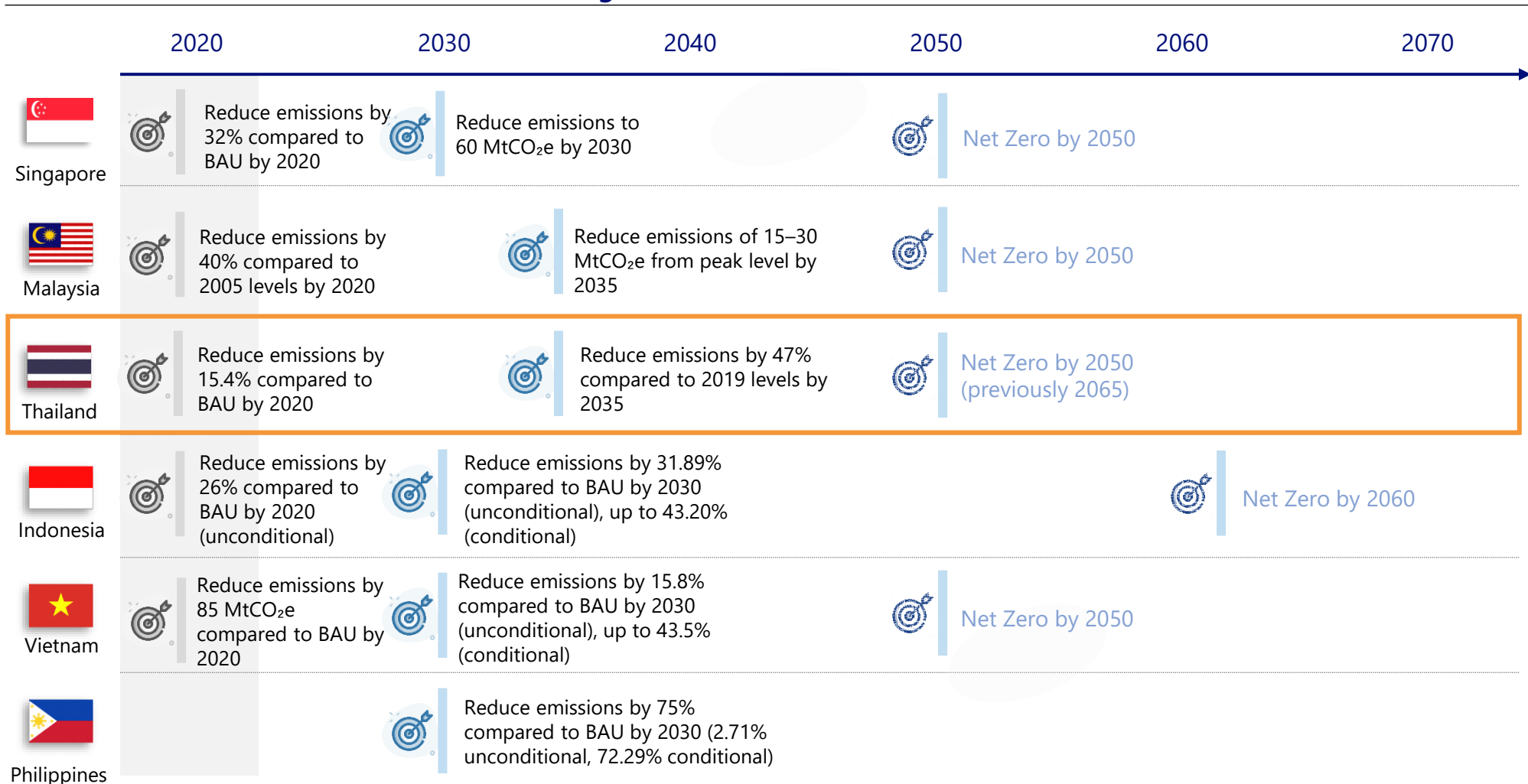


Situation for Decarbonization and CCU Adoption in Thailand

Decarbonization Targets in Thailand

As decarbonization efforts accelerate worldwide, Thai government set new target of net-zero emissions by 2050, 15 years earlier than the previous goal

ASEAN countries' GHG emission reduction targets



Note: BAU (Business as usual) refers to a natural state case without special measures)

Source: United Nations Climate Change, Government press release, News article

Market leaders have large scale emission and investment target while non-market leaders have relatively smaller emission volume and investment budget

Comparison of companies

○ = Set clear target △ = Considering and studying the feasibility × = No clear target

	Market leaders*	Non-market leaders
Net zero / carbon neutral target	<p>○</p> <p>Tend to have established ambitious net-zero targets covering all scopes</p>	<p>○</p> <p>May set net-zero or carbon neutrality targets to align with their parent companies if they are subsidiaries of foreign firms; however, these targets may not include Scope 3 emissions</p>
Timeline for CCU adoption	<p>○</p> <p>Tend to set timelines for CCU adoption aligned with Thailand CCUS Technology Roadmap, which typically is around 2030–2040</p>	<p>△ or ×</p> <p>Usually lack quantitative implementation milestone for CCU adoption and remain in a wait-and-see stage</p>
Planned budget for CCU investment	<p>○</p> <p>Tend to set preliminary budgets for CCU adoption, either by setting the CAPEX for construction, OPEX for capture and utilization, or expected returns (IRR)</p>	<p>×</p> <p>Generally have not allocated budgets for CCU adoption yet</p>
Emission volume	<p>Tend to have significantly higher CO₂ emissions due to their large production capacity, increasing the need to adopt CCU to close the decarbonization gap that cannot be addressed by other initiatives and to achieve ambitious targets</p>	<p>Typically have much lower emissions, resulting in a smaller need to rely on CCU for decarbonization</p>

Note: Market leaders refer to companies with top revenue whose main business is in the following industries: oil & gas, and power generation, cement, chemical, iron and steel

Source: Interview

Majority of companies implement cost-effective energy efficiency, while market leaders move further into advanced initiatives such as fuel transition and CCUS

Initiative for decarbonization for companies in Thailand in general

	Reduce energy usage	Reduce CO ₂ per energy usage	Remove the CO ₂
Market leaders	<p>Energy efficiency: implemented</p> <ul style="list-style-type: none"> • Most companies are already doing this initiative as the company can save cost with minimal budget and technology required • Standard measures are heat recovery, boiler/steam optimization, equipment upgrades etc. 	<p>Energy transition: activities ongoing for leveraging advanced energy transition in addition to mature technology</p> <ul style="list-style-type: none"> • Companies start increasing usage of renewable electricity and cleaner fuels e.g. LNG and biomass, as well as develop low-carbon products and recycle feedstocks • Some companies are exploring or piloting hydrogen as fuel or feedstock 	<p>CCUS: in study CO₂ offsetting: partially implemented</p> <ul style="list-style-type: none"> • Companies are developing targets and reaching out to potential partners for CCUS as pathway to address hard-to-abate emissions with current progress of initial and feasibility studies • Companies also plan to use verified carbon credits and nature-based solutions e.g. reforestation to compensate emissions
Non-market leaders	<p>Energy efficiency: implemented</p> <ul style="list-style-type: none"> • Smaller companies also implement energy efficiency measures due to low investment requirements and cost-saving benefits • Common actions include upgrading to more energy-efficient equipment 	<p>Energy transition: partially implemented mature technology</p> <ul style="list-style-type: none"> • Some companies adopt mature and relatively low-cost technologies for energy transition e.g., solar panels • Plans for other more advanced renewable energy remain unclear 	<p>CCUS: no clear plan CO₂ offsetting: partially implemented</p> <ul style="list-style-type: none"> • Most companies lack clear CCUS plans and have limited knowledge • CO₂ offsetting is largely limited to reforestation, not carbon credits

Many companies remain cautious on CCU from high costs. Foreign subsidiaries, export-driven firms, and association members may have interest in CCU more

Current situation of CCU adoption

Limited engagement beyond market leaders

- Only a small number of non-leading companies have shown concrete interest in CCU
- Most companies lack clear roadmaps or commitments for decarbonization

High investment and limited support

- Significant budget requirements and unclear returns remain major barriers for CCU adoption
- Subsidies and support from the government is still very limited as well

Cautious wait-and-see approach

- Companies are monitoring regulatory developments and movement/outcomes from large companies before deciding on further CCU investment

Example of companies with potential of interest in CCU



Foreign subsidiaries with parent company's decarbonization commitments

- Local subsidiaries aligning with parent companies' global net-zero and CCU roadmaps may adopt CCU to meet group targets



Companies facing external pressure from stakeholders and mandatory carbon pricing

- Companies selling to overseas buyers which demand suppliers to reduce CO₂ emission (e.g. buyers with scope 3 target or impacted by CBAM)
- Companies in industries subject to mandatory carbon pricing schemes (e.g. carbon tax, ETS) under the Climate Change Act




Consortium or association members

- Companies joining associations with sector-level decarbonization direction may follow collective CCUS direction e.g., Thai Cement Manufacturers Association Net Zero Roadmap

Across sectors, chemical products attract the strongest interest, driven by their high value and diverse applications

Interest in CCU product of each sector


 Common utilization need across sectors

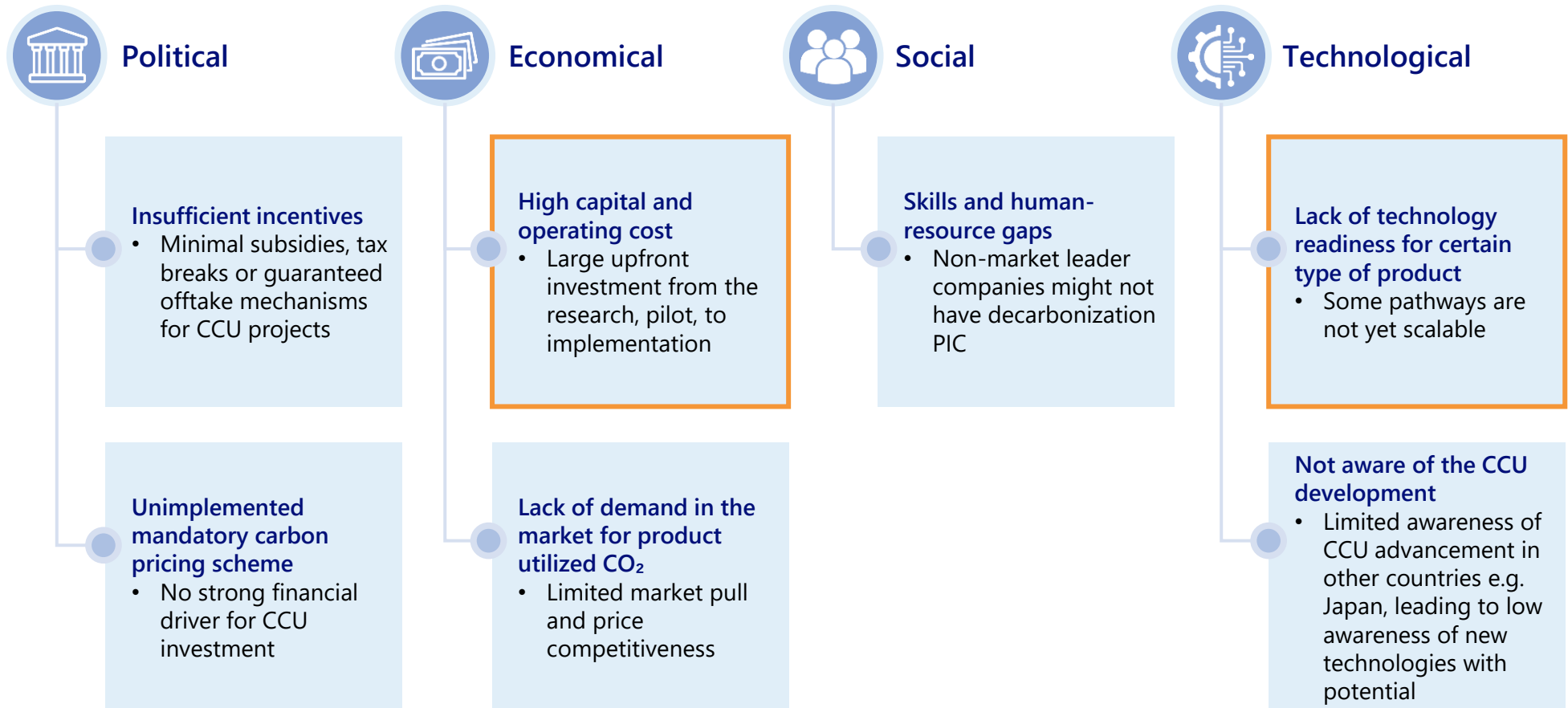
			Utilization				
			Fuel	Chemical	Mineral		
Sector for CO ₂ capture	High emission	Energy	Power generation	✓ (e-fuel, syn gas)	✓ (methanol, calcium carbonate)		
			Oil and Gas	✓ (e-fuel)	✓ (olefins, polycarbonate, calcium carbonate)		
		Industry	Cement		✓ (methanol)		✓ (cement)
			Chemical	✓ (e-fuel)	✓ (olefins, calcium carbonate)		
			Iron and steel		✓ (urea, polycarbonate, calcium carbonate)		
	Low emission		Pulp & paper	<i>Out of project scope</i>			
			Food & beverage				
			Textiles				

Source: Companies' official website, interview

Japanese companies have strong potential to support Thai companies in CCU adoption by addressing economic and technological challenges

Summarization of issues in CCU adoption

 Area which Japanese companies are able to support through technological solutions



Japanese companies have strong potential to support Thai companies in CCU adoption by addressing economic and technological challenges

Challenge in CCU adoption in Thailand

NRI's view

Economical challenge

- **High capital and operating costs** remain the main barriers to CCU adoption, particularly for companies that are not market leaders
- Implementing CCU **requires significant upfront investment across multiple stages**, including research and development, pilot projects, and full-scale deployment.
- For many companies, these costs create substantial financial risk, making it **difficult to justify investment without clear economic returns** or supportive policy incentives



- Japanese companies could support CCU adoption by partnering with local firms and sharing technology, expertise, and financial resources
- Through such collaborations, they can help **address key barriers such as high implementation costs.**
- In particular, **Japanese companies that possess technologies capable of reducing costs**, such as more efficient CO₂ capture systems, are **likely to attract strong interest from local companies seeking practical and economically viable solutions**

Technological challenge

- **Limited technology readiness** for certain products remains another key challenge for CCU adoption.
- While several CCU pathways have been demonstrated at pilot or demonstration scale, **many are not yet technologically mature or commercially scalable.**
- As a result, companies face uncertainty regarding performance, cost, and long-term viability, making it **difficult to commit to large-scale investment until these technologies have proven scalability**



- Compared to the Thai companies, Japanese companies have wider experience in research and pilot projects for technologies related to CCU
- Japanese companies have potential to support CCU development in Thailand by **leveraging advanced technologies covering both capture and utilization (e.g. fuel, chemicals, and minerals) which can comprehensively cover the Thai companies' industry of interest**
- **By sharing technical expertise, proven solutions, and operational know-how, Japanese companies could help accelerate technology readiness and facilitate the adoption of CCU solutions among Thai industries**

Key Takeaways

Japanese companies may prioritize market leaders first, followed by subsidiaries of foreign companies or firms facing international decarbonization pressure

Fact (desktop research and interview)

Decarbonization target

- **Market leaders have clear decarbonization plans, with many setting targets that cover all three scopes.** To achieve these ambitious targets, they are **exploring advanced decarbonization initiatives beyond energy efficiency**, such as advanced renewable energy (hydrogen, biomass, etc.) and CO₂ removal initiatives (CCUS, carbon credits, etc.)
- In contrast, **non-market leaders tend to have less clear decarbonization targets and plans.** Subsidiaries of foreign companies or companies exporting their products to oversea **may set long-term targets to align with their parent companies, but they often rely on mature and low-cost options** such as energy efficiency, while exploring limited renewable energy like solar panels and EVs

CCU plan and interest area

- **Market leaders often have, or are considering, clear plans and timelines for CCU implementation as a high-priority measure.** This includes conducting feasibility studies, collaborating with partners, and planning preliminary investment budgets. **Many are already engaging with Japanese companies on CCU technologies.** Market leaders show interest in Japanese technology for both capture and utilization, with CCU-derived chemical products attracting cross-industry interest from higher value and versatility
- In contrast, **non-market leaders often have limited plans for CCU adoption** and may lack sufficient understanding of the technology. Some companies with decarbonization targets may consider CCU, but typically only at an **early stage without clear timelines or budgets**, citing high costs and uncertain returns. Their interest in CCU products is also narrower, **often limited to products they already produce** rather than exploring new product types. Additionally, **until the mandatory carbon pricing scheme is implemented**, non-market leaders commented in the interviews that they are still wait and see, assessing carbon tax levels before deciding on CCU investment.

NRI's view

- Japanese companies should **prioritize engagement with market leaders** and develop early CCU projects with them, leveraging their stronger decarbonization commitments to **demonstrate the technical and economic viability of CCU.** Early collaborations as reference can build credibility in the Thai market
- Japanese companies should **treat non-market leaders as a longer-term opportunity**, as many remain in a wait-and-see stage and may continue **prioritizing lower-cost decarbonization measures instead of investing in CCU in short or mid term**
- Thai companies are currently in a wait-and-see situation given that mandatory carbon pricing (e.g. carbon tax) is still being developed. However, **if mandatory carbon price reaches a standard which impact towards current business is significant, Thai companies will be driven to compare mandatory cost for CO₂ emission and cost for implementing technology to abate CO₂ including advanced solutions such as CCU**
- Japanese companies should **deepen partnerships with market leaders through feasibility studies and pilot projects**, as these companies are already allocating resources and exploring collaboration
- Japanese companies should **approach non-market leaders through awareness-building and low-commitment engagement**, as many remain in a wait-and-see stage due to regulatory uncertainty and may delay CCU investment until carbon pricing and related policies become clearer



Reference: Regulation for CO₂ Emission in Thailand

Air emissions from cement plants should not exceed contamination limits in the regulations

Regulations on contamination level

By type of kiln

	Cement					
	Grey cement kiln	White cement kiln	Clinker cooler	Clinker grinding mill	Coal grinding mill	Others
NOx (ppm)	<500	<500	-	-	-	• Have combustion: <400
SOx (ppm)	<50	<500	-	-	-	• Have combustion: <700
PM (mg/m ³)	<120	<120	<120	<120	<120	• No combustion: 400 • Have combustion: <320

Note:

- Regulation for cement is "Air Emission Standards for Cement Kilns 2006"
- Cement kiln is a high-temperature industrial furnace used in cement manufacturing to thermally process raw materials, such as limestone and clay, to produce clinker, the primary intermediate product in cement production

Source: Ministry of Industry

Air emissions from iron and steel plants and natural gas plants should not exceed contamination limits in the regulations

Regulations on contamination level

By type of product

	Emission sources by fuel	Iron & Steel		Natural gas
		Primary Iron & steel	Reinforcing steel bar and small billet	
NOx (ppm)	Coal-fired	<400	<180	<150
	Oil-based	<200		
	Biomass	<200		
	Others	<200		
SOx (ppm)	Coal-fired	<700	<500	<50
	Oil-based	<950		
	Biomass	<60		
	Others	<60		
PM (mg/m ³)	Coal-fired	<320	<50	<60
	Oil-based	<240		
	Biomass	<320		
	Others	<320		

Note:

- Regulation for primary iron and steel is "Air Emission Standards on pollution discharged from factory stack 2006"
- Regulation for reinforcing steel bar and small billet is "Air Emission Standards for Reinforcing Steel Bar and Small Billet 2021"
- Regulation for natural gas is "Air Emission Standards for Natural Gas separation plant 2016"

Source: Ministry of Industry

Air emissions from power generation plants should not exceed contamination limits in the regulations

Regulations on contamination level

Emission sources by fuel

	Power generation					
	Coal-fired	Oil-based	Natural gas	Biomass	Biogas	Waste
NOx (ppm)	<ul style="list-style-type: none"> Less than 100 Megawatt: <200 More than 100 Megawatt: <200 	<130	<80	<200	<200	<150
SOx (ppm)	<ul style="list-style-type: none"> Less than 100 Megawatt: <150 More than 100 Megawatt: <150 	<50	<15	<30	<200	<25
PM (mg/m³)	<ul style="list-style-type: none"> Less than 100 Megawatt: <50 More than 100 Megawatt: <30 	<30	<20	<90	<30	<50

Note:

- Regulation for power generation is "Air Emission Standards for Power Generation Plants 2024"
- This contamination level applies only to new power plants that obtained "Factory license, and Expansion license", "Electricity production license", and power plants that notified machine modification to replace thermal energy since 26 November 2023

Air emissions from oil refinery plants should not exceed contamination limits in the regulations

Regulations on contamination level

By type of unit

	Emission sources by fuel	Oil refinery			
		Furnace, Boiler, Furnace, Boiler, and Non-catalytic cracking unit	Gas Turbine unit	Fluid Catalytic Cracking Unit (FCCU)	Sulfur recovery unit
NOx (ppm)	Oil	<200	<200	<400	<200
	Gas	<200			
	Mixed oil & gas fuel	<200			
SOx (ppm)	Oil	<950	<60	<300	<500
	Gas	<60			
	Mixed oil & gas fuel	<950			
PM (mg/m ³)	Oil	<240	<60	<320	-
	Gas	<60			
	Mixed oil & gas fuel	<240			

Note: Regulation for oil refinery plant is "Air Emission Standards for Oil Refinery plant 2010"

Air emissions from chemical plant should not exceed contamination limits in the regulations

Regulations on contamination level

By location

	Emission sources by fuel	Chemicals	
		Thailand*	Bangkok*
NOx (ppm)	Coal-fired	<400	<160
	Oil-based	<200	
	Biomass	<200	
	Others	<200	
SOx (ppm)	Coal-fired	<700	<60
	Oil-based	<950	
	Biomass	<60	
	Others	<60	
PM (mg/m ³)	Coal-fired	<320	<ul style="list-style-type: none"> • Gaseous fuel: <60 • Liquid fuel/Solid fuel: <90
	Oil-based	<240	
	Biomass	<320	
	Others	<320	

Note:

- Thailand means areas excluding Bangkok
- Regulation for Thailand is "Air Emission Standards on pollution discharged from Factory stack 2006"
- Regulation for Bangkok area is "Air Emission Standards on pollution from boiler in factory located in Bangkok 2026" which will be effective from 1 July 2026

Source: Ministry of Industry

Ministry of Industry tightens emission controls from factories in Bangkok by expanding type of factories required to install CEMS

Recent regulation on emission control

Title	Ministerial Notification of the Ministry of Industry: Requirement for Factories in Bangkok to Install Special Instruments or Equipment for Reporting Air Pollution Emissions from Factory Stacks, B.E. 2569 (2026)
Status	Implemented
Government Organization	Ministry of Industry
Detail	Factories in Bangkok of all production sizes are required to install a Continuous Emission Monitoring System (CEMS) and transmit data to the Department of Industrial Works' main system every hour, 24 hours a day to monitor NOx, SOx and PM emission . The data transmitted must cover at least 80% of the daily operating hours
Effective date	<ul style="list-style-type: none"> Factories registered after 12 February 2026: The requirement is effective immediately. Factories registered before 12 February 2026: CEMS must be installed by 1 October 2026
Implemented factories	<ol style="list-style-type: none"> Electric power generation plant: Thermal power generation unit* Boilers with fuel combustion in all factories* Fuel combustion unit of all factories* Cement, lime, or plaster plant: 1) Kiln 2) Clinker cooler Pulp or paper plant: 1) Recovery furnace 2) Lime kiln Primary production of iron or steel plant: 1) Smelting furnace 2) Melting furnace 3) Preheating processes unit Non-ferrous metal basic industries and Industrial waste recycling plant: 1) Smelting furnace 2) Melting furnace Non-ferrous metal basic industries and Industrial waste recycling plant: Lead smelting unit in a furnace Central waste treatment plant: 1) Municipal solid waste incinerator 2) Infectious waste incinerator Chemicals, chemical products, or chemical materials (excluding fertilizers) plant: Sulfuric acid production units Glass, glass fiber, or glass product: Heat fired furnace (excluding heat from electric booster and heat recovery)

Notes: Factories using gaseous fuels and boilers that use electric power or are excluded

Source: Ministry of Industry

Agenda

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Chapter 1: Identification of Japanese Technologies

Chapter 2: Identification of Issues by Thai Companies

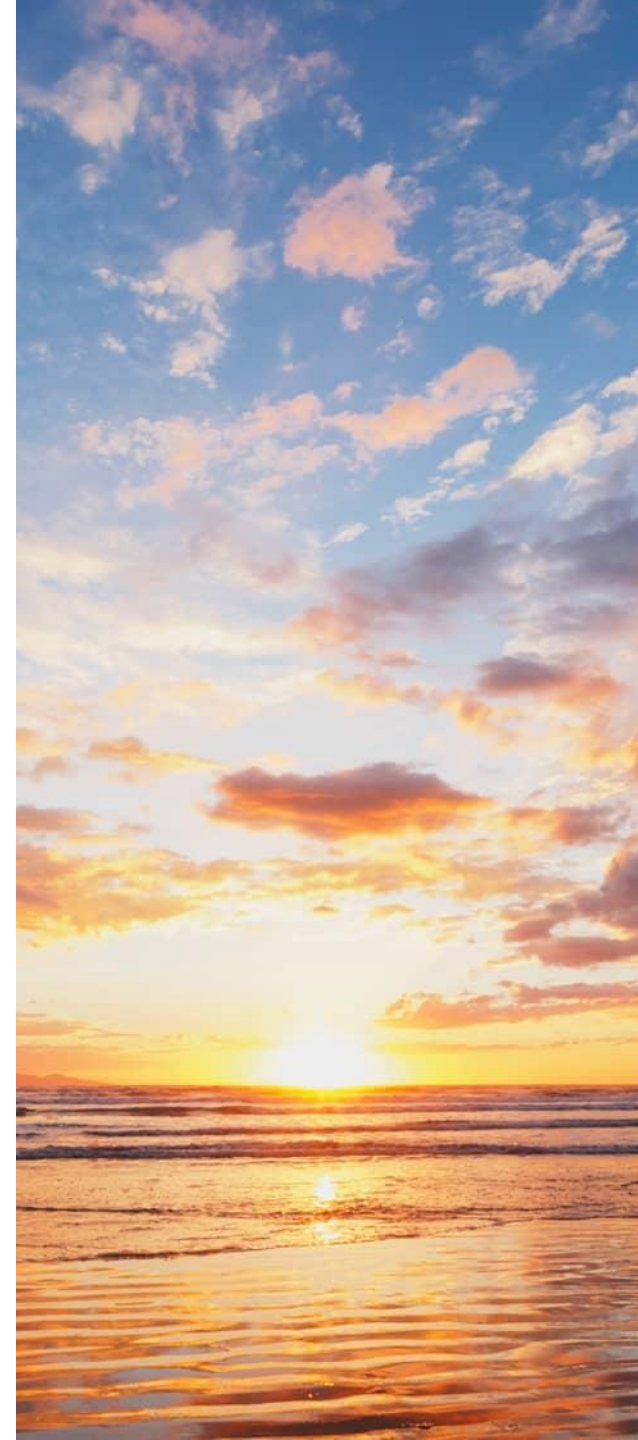
Chapter 3: Basic Information for Japanese Companies

Appendix

タイにおけるCCU/CCSに関する 日系企業向け基礎情報の取り纏め

NRI Consulting & Solutions (Thailand) Co., Ltd.

2026年2月



本基礎資料が作成された背景・目的

本基礎資料は、タイにおける脱炭素の潮流やCCUに関する現地政府・企業の動向を明らかにすることを目的として作成された

背景

- 近年、ASEAN地域におけるCCUS事業の展開に向けた動きが現地企業と日系企業の双方において活発化。
- その中で、CO₂の貯留（storage）のみならず利活用（utilization）に関する関心が現地企業において高まっており、要素技術を有している日系企業との連携を模索する動きが見られている。
- 一方、タイにおけるCCUにおける現地企業の動向について取り纏められた資料は限定的となっている。

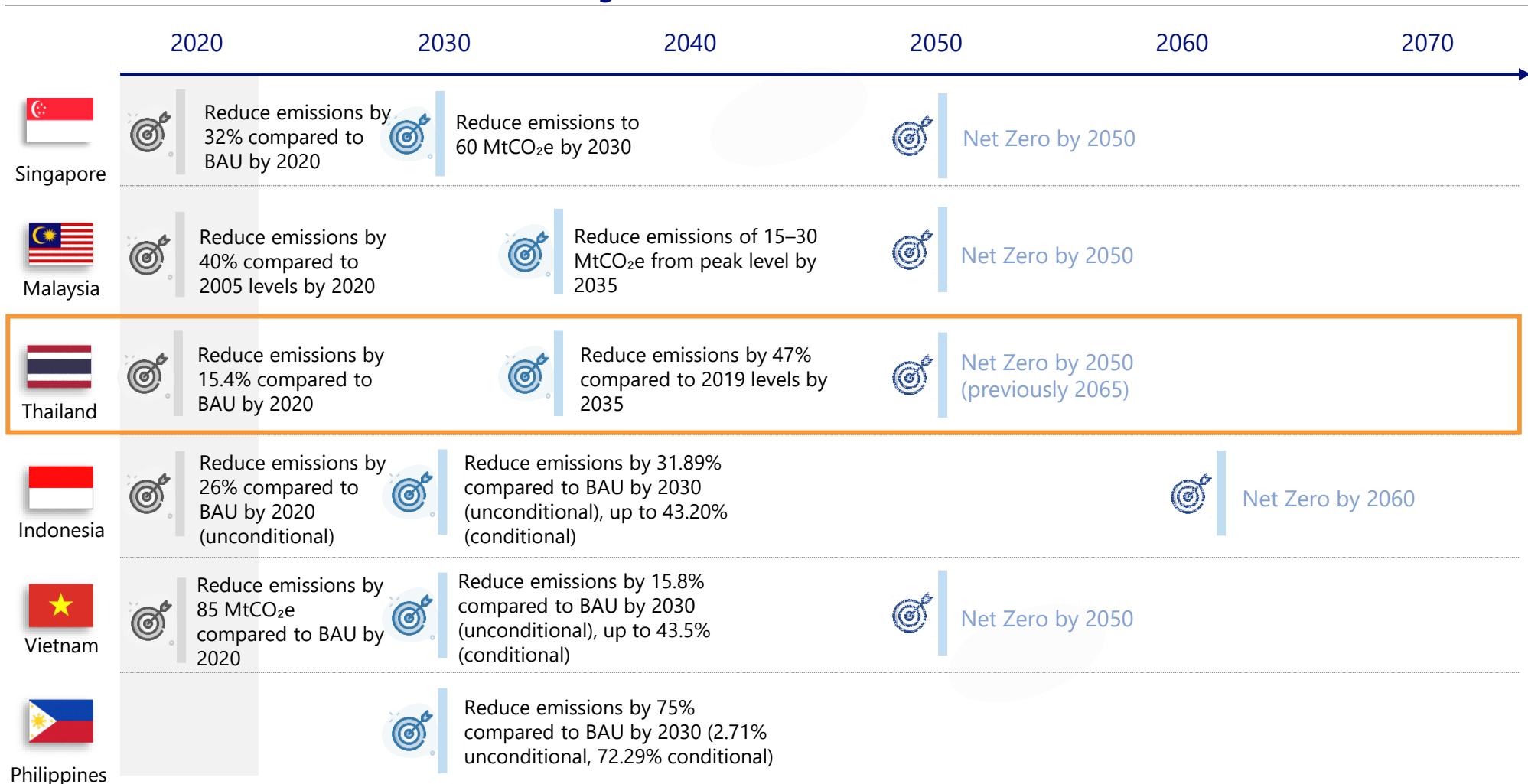
目的

- 上記の背景を踏まえて、以下を目的として本基礎資料が作成された。
 - タイにおける脱炭素に関する潮流の整理
 - CCUに関するタイ現地の動向の整理

Decarbonization Targets in Thailand

As decarbonization efforts accelerate worldwide, Thai government set new target of net-zero emissions by 2050, 15 years earlier than the previous goal

ASEAN countries' GHG emission reduction targets



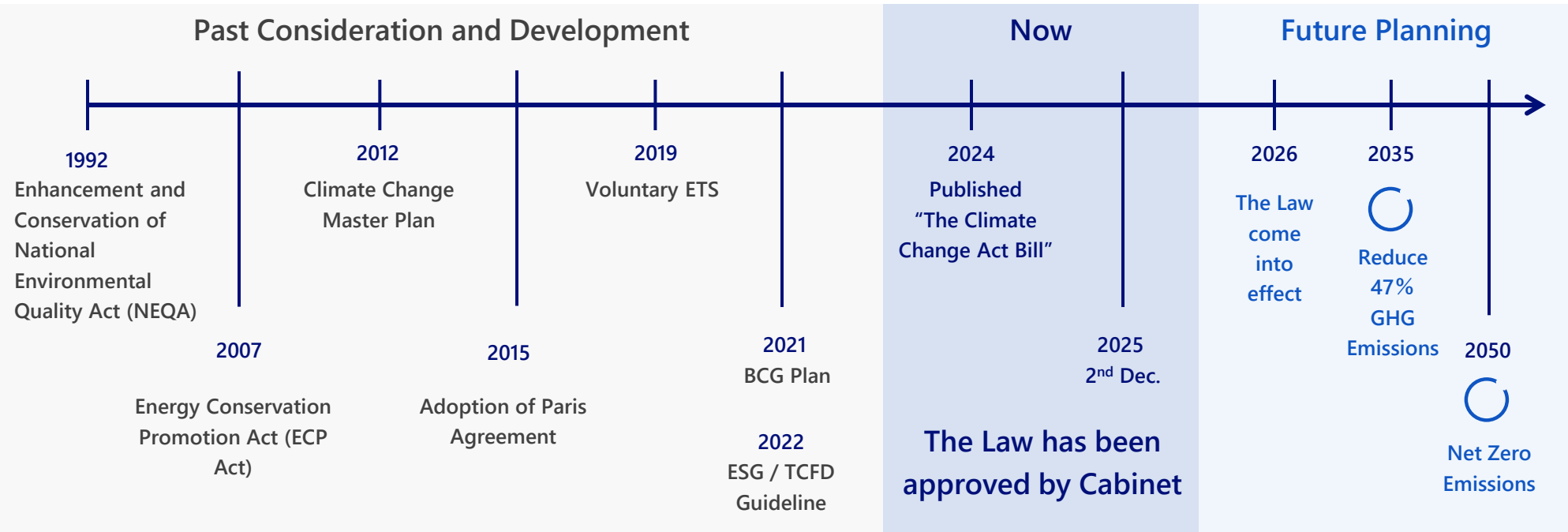
Note: BAU (Business as usual) refers to a natural state case without special measures)

Source: United Nations Climate Change, Government press release, News article

To achieve target, Climate Change Act, the first national climate framework law, is introduced with Carbon Mechanism in Thailand

Climate Change Act transitions and goals in Thailand

- The Thailand Climate Change Act becomes Thailand's first "climate framework law" for climate policy and carbon pricing.
- As for the latest update on 2nd December 2025, this act has been approved by the Cabinet and will proceed to the next step in parliament before implementation.



Climate Change Act will require all companies in Thailand to comply, with penalties like ETS and carbon tax for those not complying with the law

Requirement of Climate Change Act for all the companies in Thailand

	Greenhouse gas (GHG) data reporting	Carbon Border Adjustment Mechanism (CBAM) for imports	Emissions Trading Scheme (ETS)	Carbon tax on high-emission products	Carbon credits for business/used
Company's Obligations	Must report emissions yearly.	<ul style="list-style-type: none"> Must submit emissions data Pay carbon price via "Adjustment Certificates" 	Must hold allowances equal to their emissions	Must pay carbon tax	Must register before operating businesses/service providers for carbon credit
Definition	Report GHG emission yearly data	A fee on carbon-intensive products	Sets a limit on GHG emissions, then trades emission permits	Tax collected by Excise and Customs	Carbon credits are property and can be traded
Target	The company under control list *1	Importer of the listed product *2	The company under control list *1	Manufacturers and importers of products that emit GHG during use	The companies that would like to enter the carbon credit market
Penalties	<ul style="list-style-type: none"> Maximum 5 million THB of fine Three times the value of the benefit from such action 		Fine not exceeding three times the price of emission during those years	<ul style="list-style-type: none"> Imprisonment not more than three years Maximum 400,000 THB of fine 	<ul style="list-style-type: none"> Maximum 100,000 THB of fine An additional fine of 1,000 THB per day

*1 The control list companies will be published later.

*2 The list of imported products will be published later.

Source: DCCE

Climate Change Act is planned to be applied in 3 phases according to the target industries, with providing the benefits

Impact, implementation details, and benefits from Climate Change Act

Impact on all companies in Thailand – Production costs are expected to increase due to carbon taxes and ETS introduced by the new act. Especially, the high-GHG-emission industry.

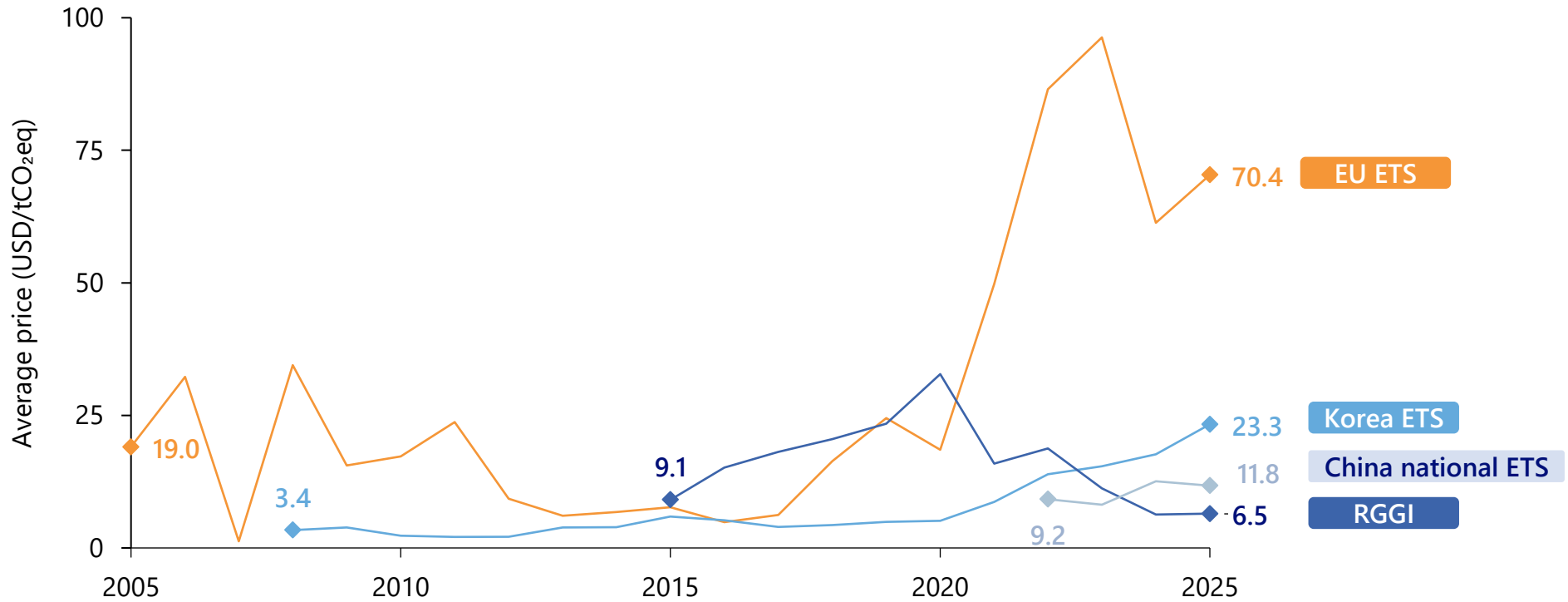
Period	2026 (Effective Period)	Future *1	
	<u>Phase I</u>	<u>Phase II</u>	<u>Phase III</u>
Affected Industry	<ul style="list-style-type: none"> • Transport • Public utility • Metal • Non-metal 	<ul style="list-style-type: none"> • Petroleum products • Rubber and plastics • Chemicals coal mining • Paper 	<ul style="list-style-type: none"> • Agriculture • Food and Beverages • Computers • Electrical equipment
Total Value of Industry	<ul style="list-style-type: none"> • 1.71 Trillion THB • Equivalent 10% of GDP *2 	<ul style="list-style-type: none"> • 1.77 Trillion THB • Equivalent 10% of GDP 	<ul style="list-style-type: none"> • 3.02 Trillion THB • Equivalent 17% of GDP
Benefits for Company	<p>Financial Support:</p> <ul style="list-style-type: none"> • Access to Green Loans from a financial institution. • Tax exemption from BOI. <p>Supply Chain Benefit:</p> <ul style="list-style-type: none"> • Better positioning in export markets and multinational supply chains that require emissions data. 		

*1 There has been no official announcement yet. Phase II and III are forecasting that the act will expand the target industries as shown.

*2 Calculation based on 2022 GDP data

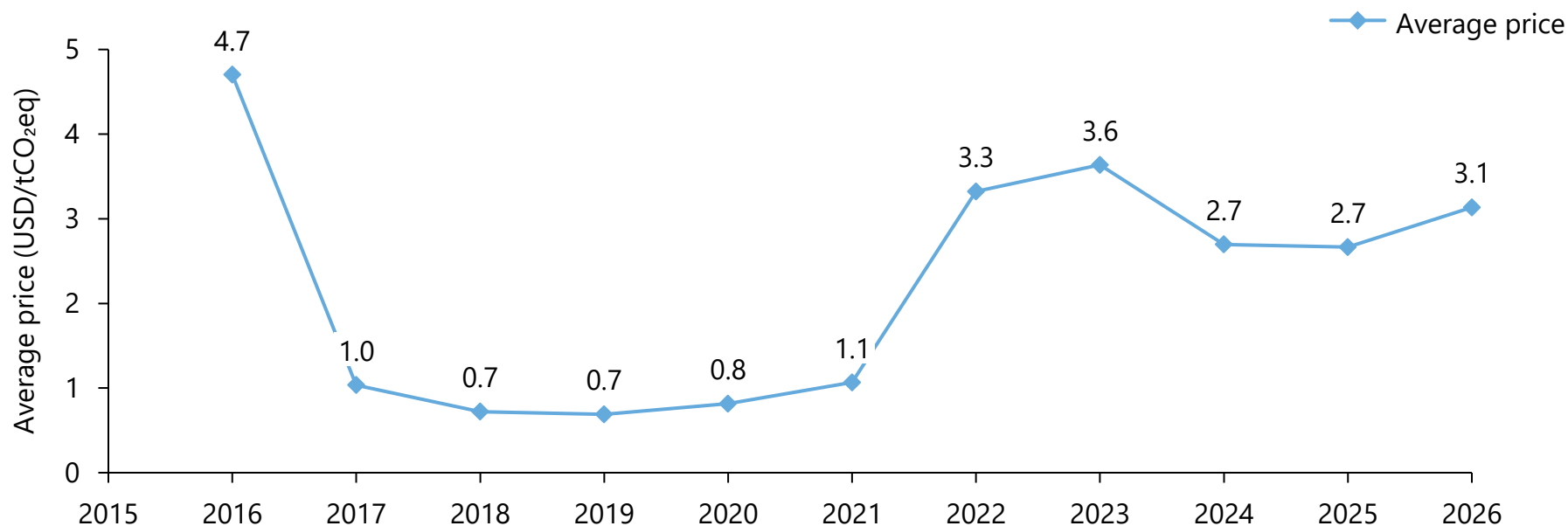
The mandatory carbon credit price in the EU is significantly higher than other regions including the US and Asian markets

Average yearly price of ETS (Data updated as of 1 Apr 2025)



Carbon credit prices under T-VER are relatively low, and the scheme currently operates on a voluntary basis

Average price of T-VERs trading by calendar year (Data updated as of 31 Jan 2026)



- **T-VER** (Thailand Voluntary Emission Reduction Project) is Thailand's **voluntary carbon crediting program** developed by Thailand Greenhouse Gas Management Organization (TGO) to **encourage GHG reduction projects across the country**
- T-VER operates on a **project-based mechanism**, where emission reductions are measured, reported, and verified according to methodologies approved by TGO

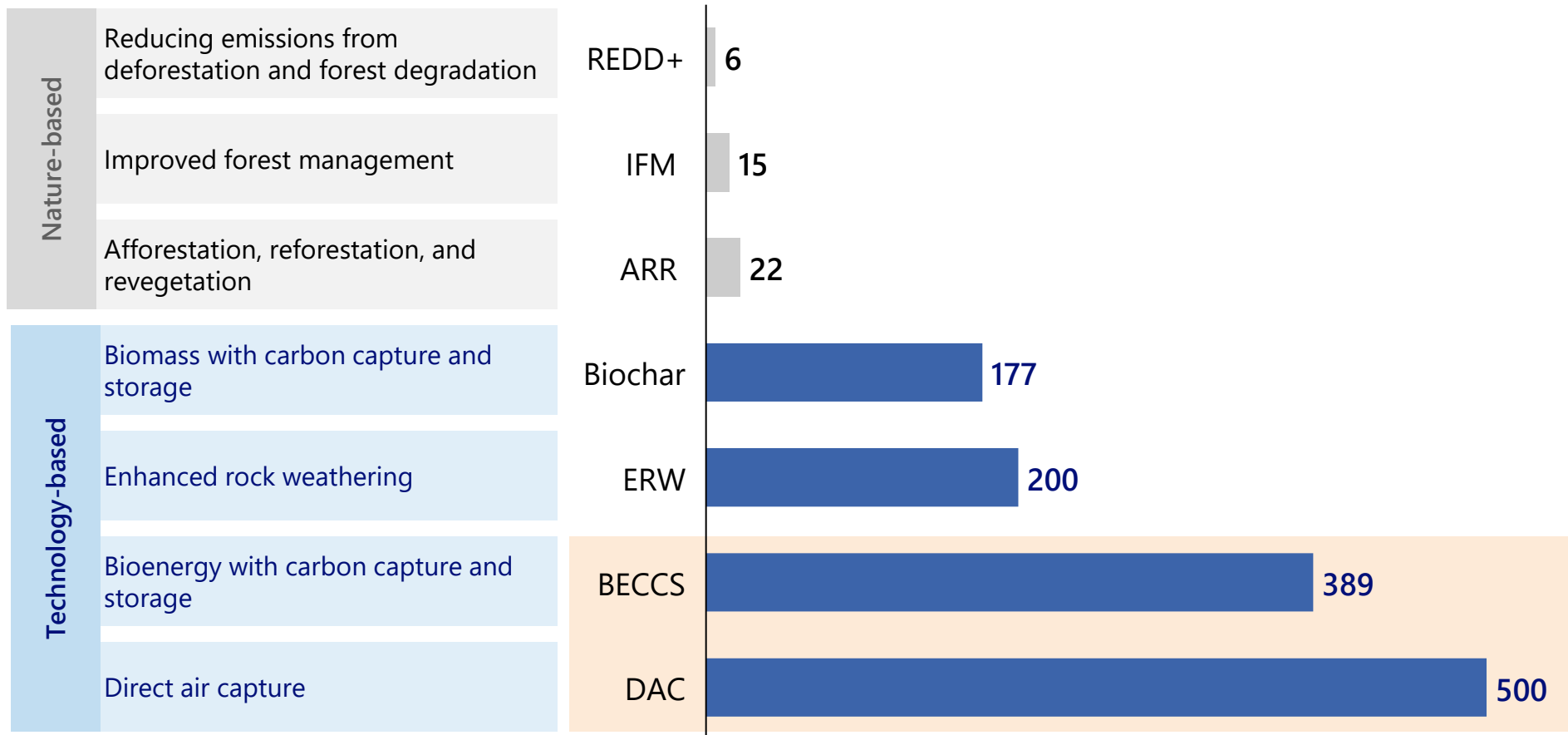
THB to USD conversion rate: 1 USD = 31.9 THB (as of 9 March 2026)

Source: TGO

Technology-based carbon removal methods (e.g., DAC, BECCS) tend to have higher prices than other methods due to their stronger permanence

Current carbon offset market price per tonne by project type

USD/ ton



Government has identified CCUS as one of the core actions for carbon neutrality, in which various ministries collaborate to drive the long-term implementation

Thailand's Plans Regarding CCS Development

Rank: Plan Sub-Plan

Type	Plan	Responsible ministry	Overview	CCU point discussion
Plan	<p>Long-Term Low Greenhouse Gas Emission Development Strategy (launched in Nov 2022 and <u>currently being updated starting from Jan 2026 to align with new NDC target</u>)</p>	<ul style="list-style-type: none"> Ministry of Natural Resources and Environment - The Office of Natural Resources and Environmental Policy and Planning (ONEP) 	<ul style="list-style-type: none"> Providing long-term mitigation actions in key sectors (energy, industrial processes and product use, waste, agriculture and forestry) 	<ul style="list-style-type: none"> CCUS are identified as potential negative emission technologies to support decarbonization efforts in the energy Aim to deploy CCUS technologies in power generation by 2040 to achieve the Carbon Neutrality in 2050. Mitigation technology biomass-based power plants equipped with CCS/CCUS will be applied from 2050 for achieving net zero GHG emissions in 2065. Aim to apply CCUS in cement industry by 2040.
Plan	<p>Thailand CCUS Technology Roadmap (launched in Jan 2024)</p>	<ul style="list-style-type: none"> Ministry of Higher Education, Science, Research and Innovation - National Science and Technology Development Agency – National Nanotechnology Center (NANOTEC) 	<ul style="list-style-type: none"> To analyze the development status of CCUS technology, technology trends, market information and the needs of the energy and industrial sectors in Thailand. To prioritize CCUS Key technology and to propose important policy issues, goals, directions, guidelines for research and development of CCUS technology Collaboration with Ministry of Energy, Ministry of Industry, Ministry of Natural Resources and Environment and Thailand greenhouse gas management organization (TGO). Target for CCU application in each phase are as follows <ul style="list-style-type: none"> ✓ Short term (2023-2030): Carbonate, concrete ✓ Mid term (2030-2040): Urea, methanol, formic acid, light olefin ✓ Long term (2040-2050): SAF, high-value materials and chemical 	

Government has identified CCUS as one of the core actions for carbon neutrality, in which various ministries collaborate to drive the long-term implementation

Thailand's Plans Regarding CCS Development

Rank: Plan Sub-Plan

Type	Plan	Responsible ministry	Overview	CCU point discussion
Plan	The National Energy Plan 2024 (in drafting process, expected to launch by 2026)	<ul style="list-style-type: none"> Ministry of Energy - Energy Policy and Planning Office (EPPO) 	<ul style="list-style-type: none"> Providing the guidelines for 5 energy development plans: PDP, Renewable and Alternative Energy Development Plan, Energy Efficiency Plan, Gas Plan and Oil Plan. 	<ul style="list-style-type: none"> Define to study and prepare the development plan for CCUS in power generation.
Sub-Plan	Power Development Plan 2024 (in drafting process, expected to launch by 2026)	<ul style="list-style-type: none"> Ministry of Energy - Energy Policy and Planning Office (EPPO) 	<ul style="list-style-type: none"> Providing Thailand's plan regarding power generation to foster energy efficiency and to bring energy security, also with the aim to reach Carbon Neutrality and Net Zero Carbon. 	<ul style="list-style-type: none"> Applying CCUS technology is defined as one of the five mitigation actions to lead to Carbon Neutrality.

Overview of High Potential Sectors for CCU Areas

The hard-to-abate industries within energy sector and industrial sector are the areas which there is high interest in Thailand for CO₂ capture

Hard-to-abate industry

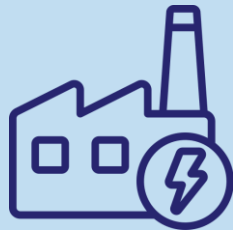
- Hard-to-abate industry is industries where emissions are difficult to eliminate with conventional decarbonization methods (e.g., cement, iron & steel, chemicals, oil & gas, power generation)
- These sectors generate unavoidable process emissions, making CCU an important pathway to reduce and utilize CO₂

Energy sector



Oil and gas

Oil and gas operations generate significant CO₂ emissions from refining and processing activities



Power generation

Power generation remains hard to abate where conventional fuels dominate the energy mix

Industrial sector



Cement

Cement production inherently releases CO₂ from limestone calcination



Chemical

Many chemical production processes generate unavoidable process emissions in addition to energy-related emissions.



Iron and steel

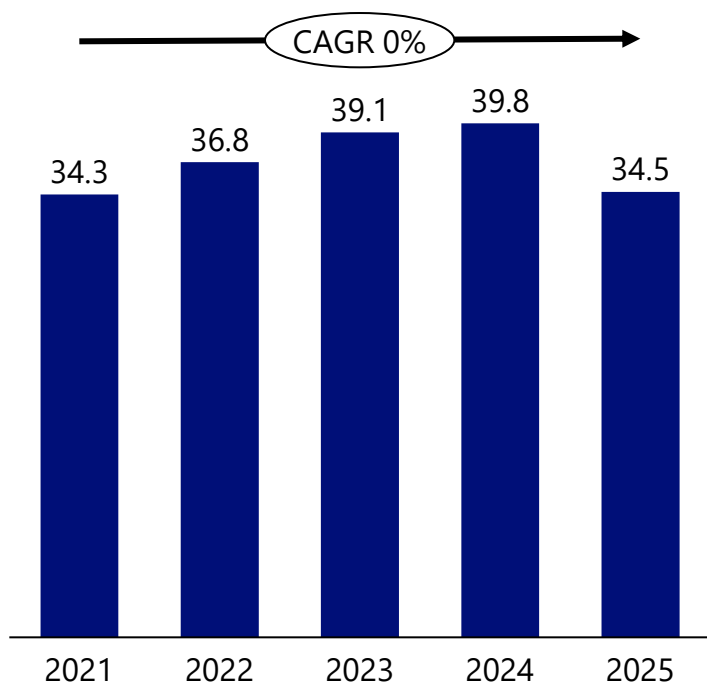
CO₂-intensive blast furnace and utilization of iron ore using coke can create large amount of CO₂ in iron and steel production

① Energy Sector | Oil refining industry

Thai oil refining industry has production volume at around 34-39 million tonnes per year during 2020-2024

2021-2025 Production volume

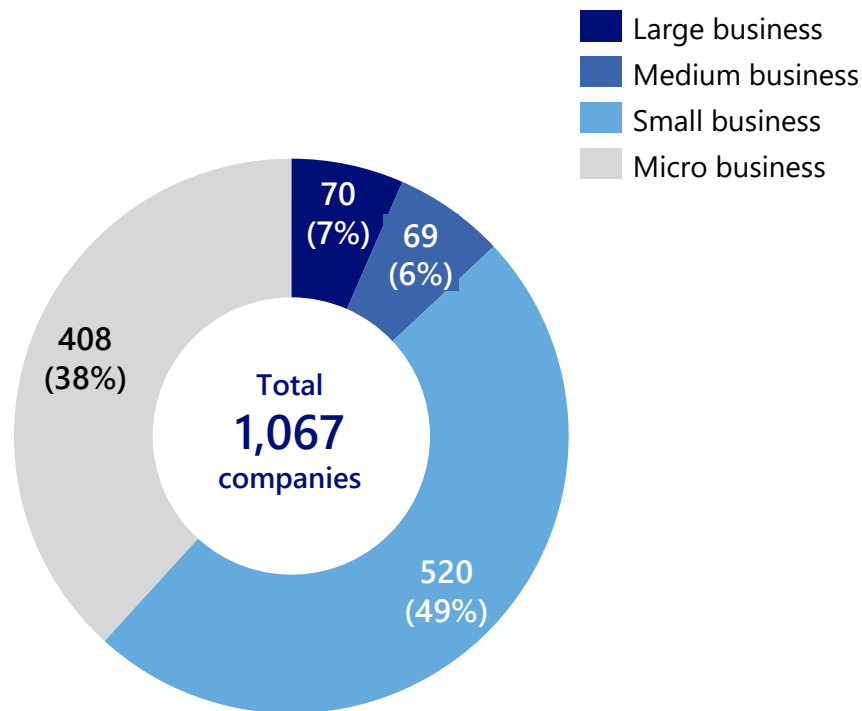
Unit: Million tonnes ■ Production volume



Note: The above production volume includes only product under TSIC 19201 (Manufacture of refinery petroleum products) and TSIC 19209 (Manufacture of other petroleum products, not elsewhere classified) due to data limitation of product under other TSIC code

Source: The Office of Industrial Economics, Corpus X

Number of companies by company size



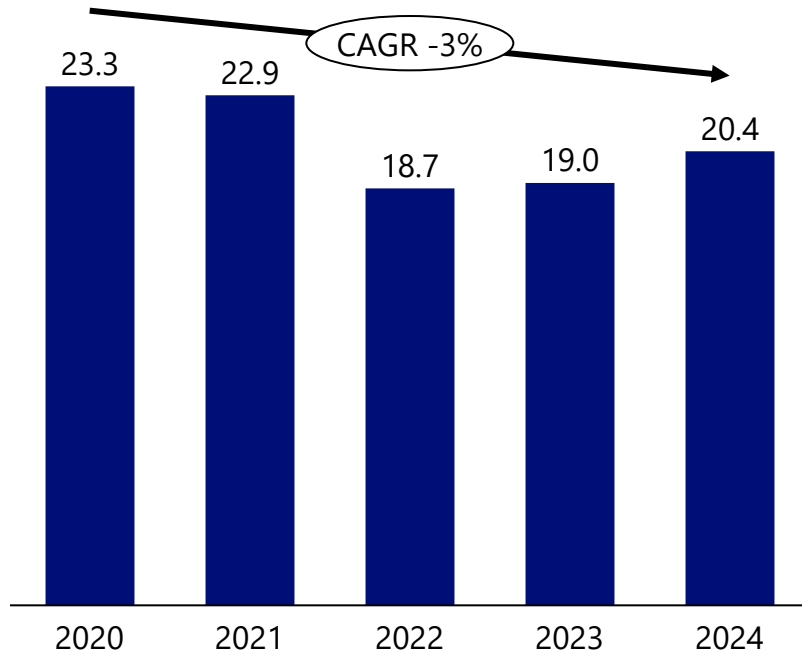
Note: Number of small and micro business may have duplicates due to errors in database, reflecting in potential of higher numbers than actuals

① Energy Sector | Natural gas processing industry

Thai natural gas production has volume at around 18-23 million tonnes per year during 2020-2024

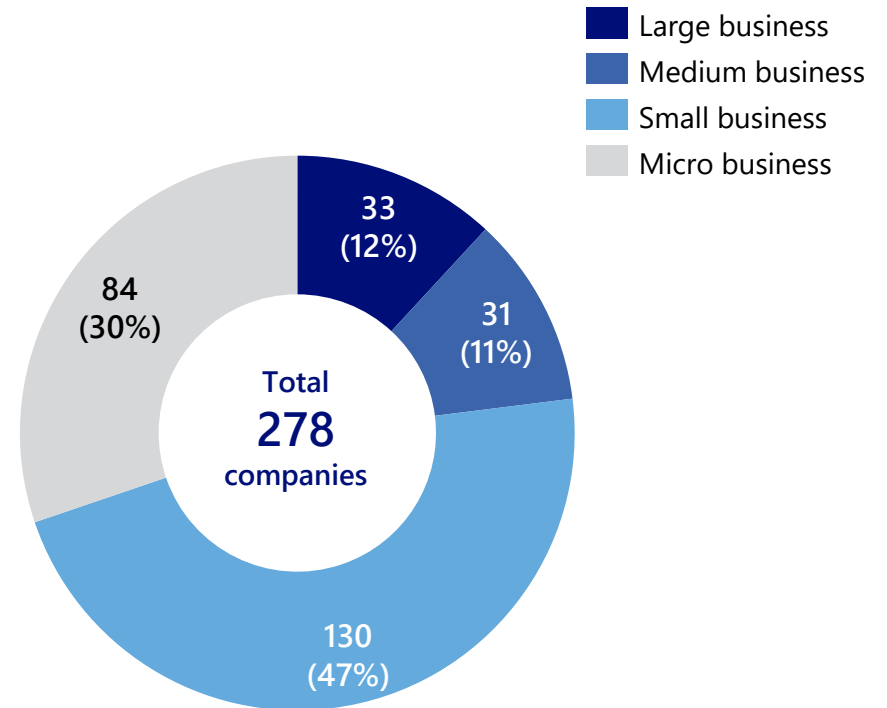
2020-2024 Production volume

Unit: Million tonnes ■ Production volume



Note: Production volume is converted from MMSCFD (Million standard cubic feet per day of gas) to MTPA (Million Tonnes per Annum of Liquefied Natural Gas or LNG) with conversion rate of 140 MMSCFD = 1 MTPA

Number of companies by company size



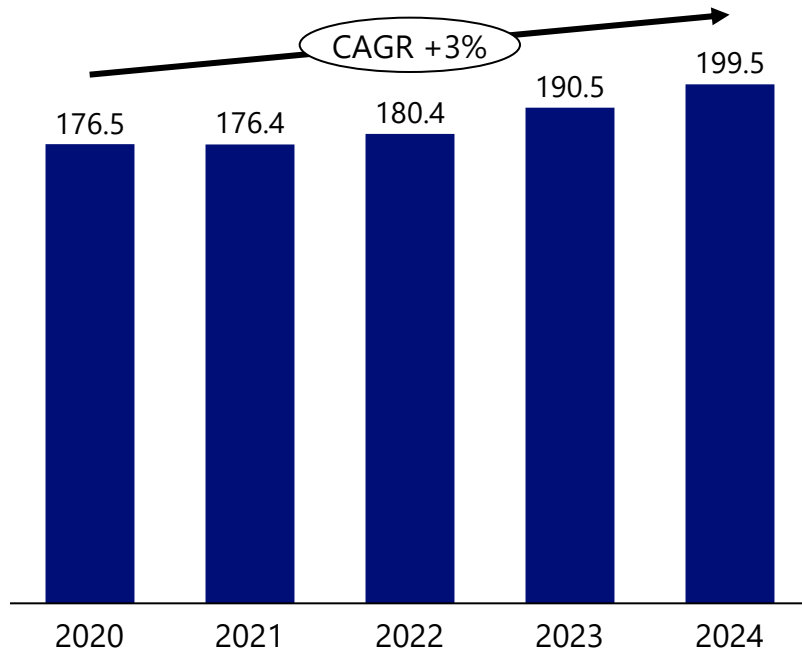
Note: Number of small and micro business may have duplicates due to errors in database, reflecting in potential of higher numbers than actuals

① Energy Sector | Power generation industry

Thai power generation industry has production volume at around 176.5-199.5 TWH per year during 2020-2024

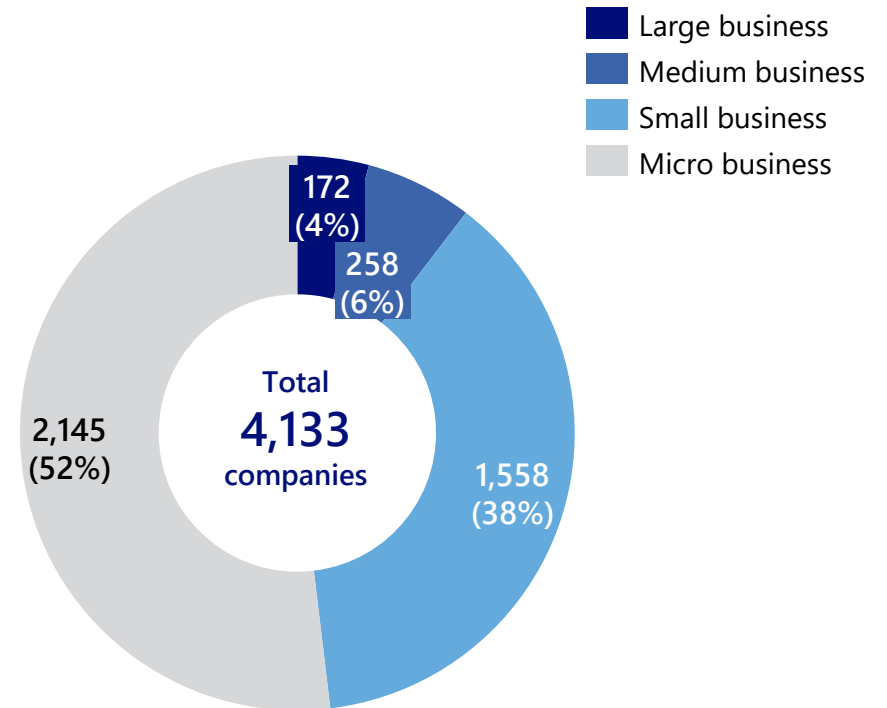
2020-2024 Power generation volume

Unit: TWH* ■ Production volume



Note: TWh refers to terawatt-hour. 1 TWh = 1,000 GWh
(Power generation includes volume from EGAT, all VSPP, SPP, and IPP that is on EGAT's system. However, it does not include imported electricity)

Number of companies by company size



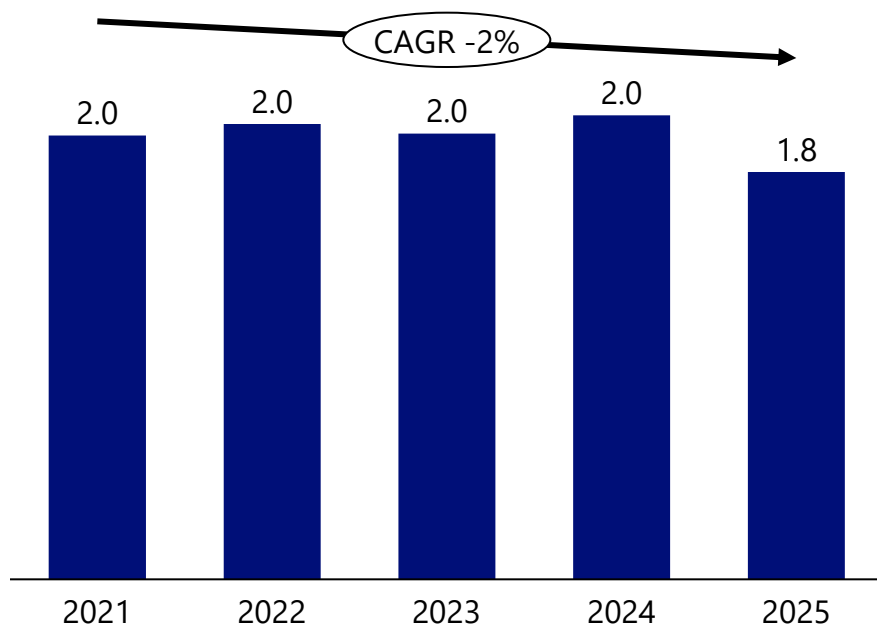
Note: Number of small and micro business may have duplicates due to errors in database, reflecting in potential of higher numbers than actuals

② Industrial Sector | Chemical industry

Thai chemical industry has production volume at around 2 million tonnes per year during 2021-2025

2021-2025 Production volume

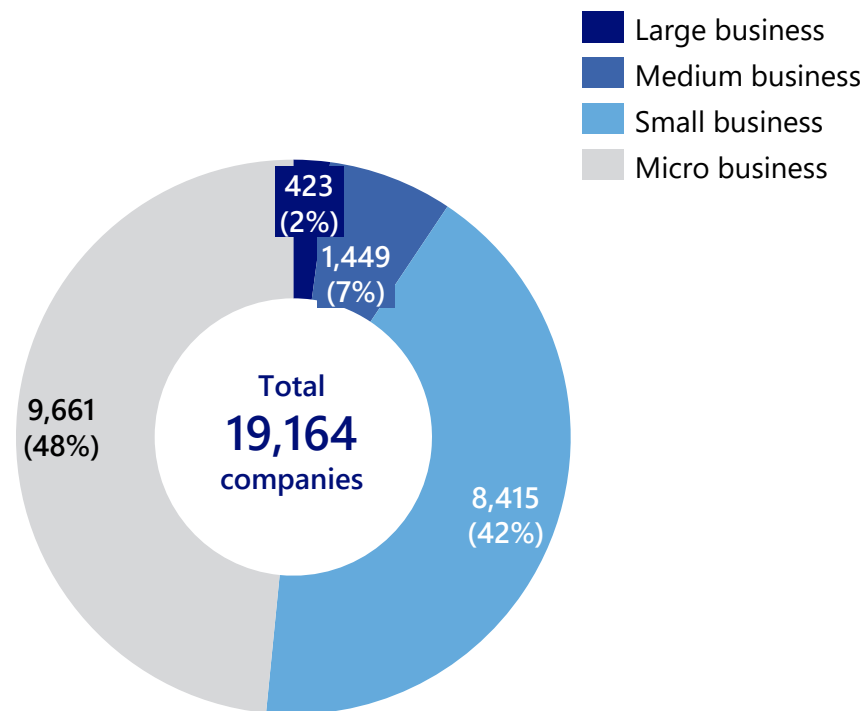
Unit: Million tonnes ■ Production volume



Note: The above production volume includes only product under TSIC 20110 (Manufacture of basic chemicals) due to data limitation of product under other TSIC code. Basic chemicals refers to Caustic soda, Chlorine, and Hydrochloric acid

Source: The Office of Industrial Economics, CorpusX

Number of companies by company size



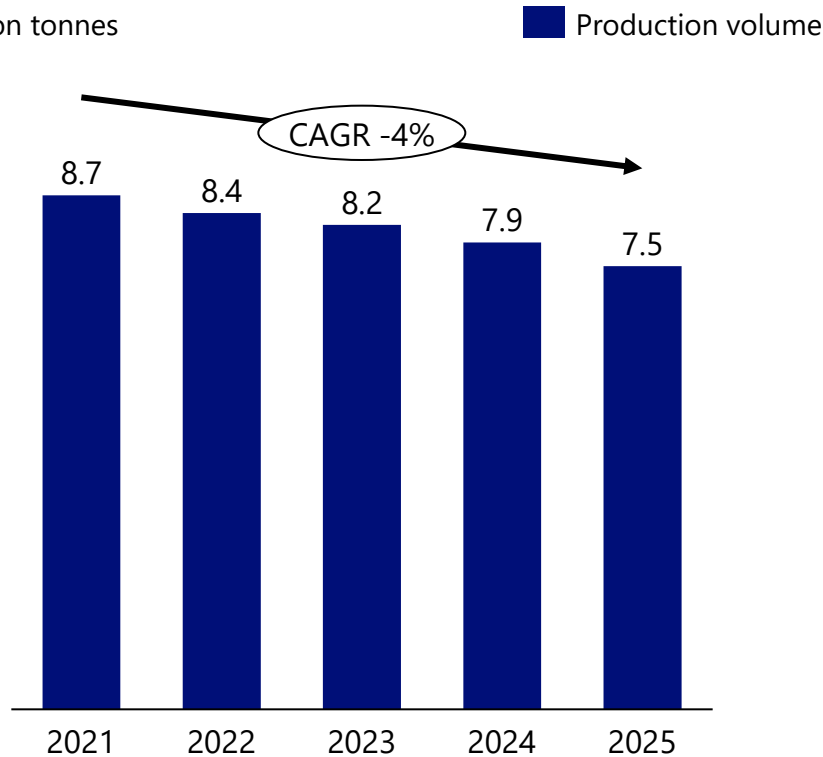
Note: Number of small and micro business may have duplicates due to errors in database, reflecting in potential of higher numbers than actuals

② Industrial Sector | Iron and steel industry

Thai iron and steel industry has production volume at around 7-8 million tonnes per year

2021-2025 Production volume

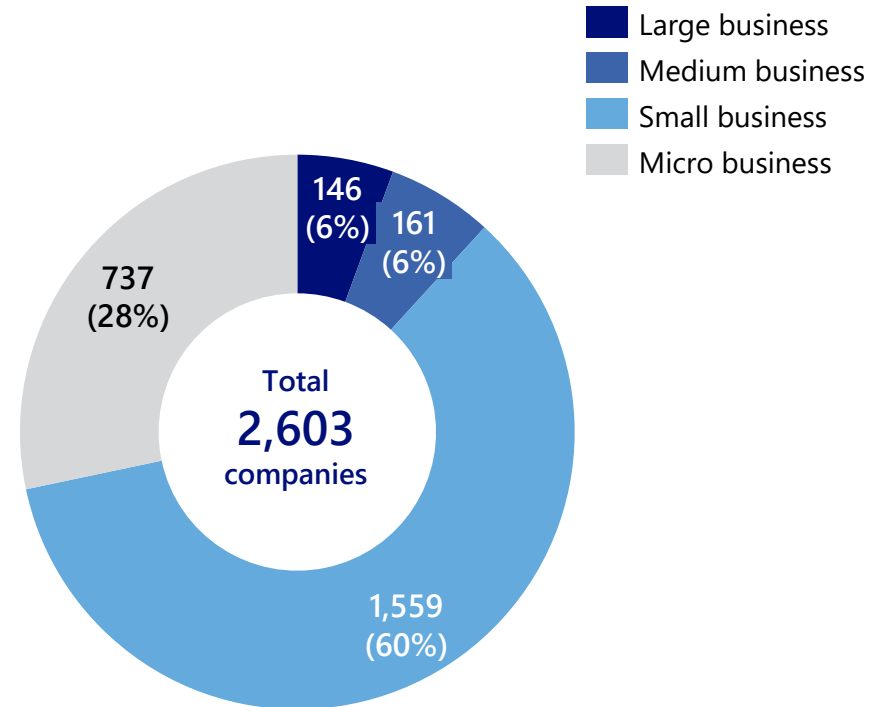
Unit: Million tonnes



Note: Production volume of product includes product under TSIC 24102 (Manufacture of iron and steel sheets), TSIC 24103 (Manufacture of iron and steel tubes, pipes, hollow profiles and related fixtures) and TSIC 24109 (Manufacture of other basic iron and steel, not elsewhere classified)

Source: The Office of Industrial Economics, Corpus X

Number of companies by company size



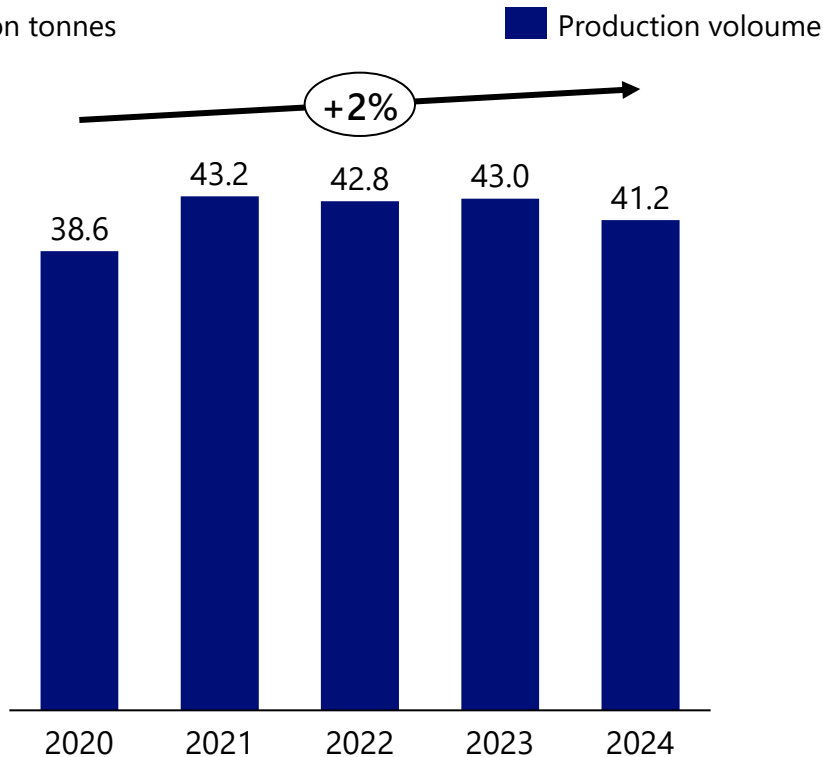
Note: Number of small and micro business may have duplicates due to errors in database, reflecting in potential of higher numbers than actuals

② Industrial Sector | Cement industry

Thai cement industry has production volume at around 40 million tonnes per year during 2020-2024

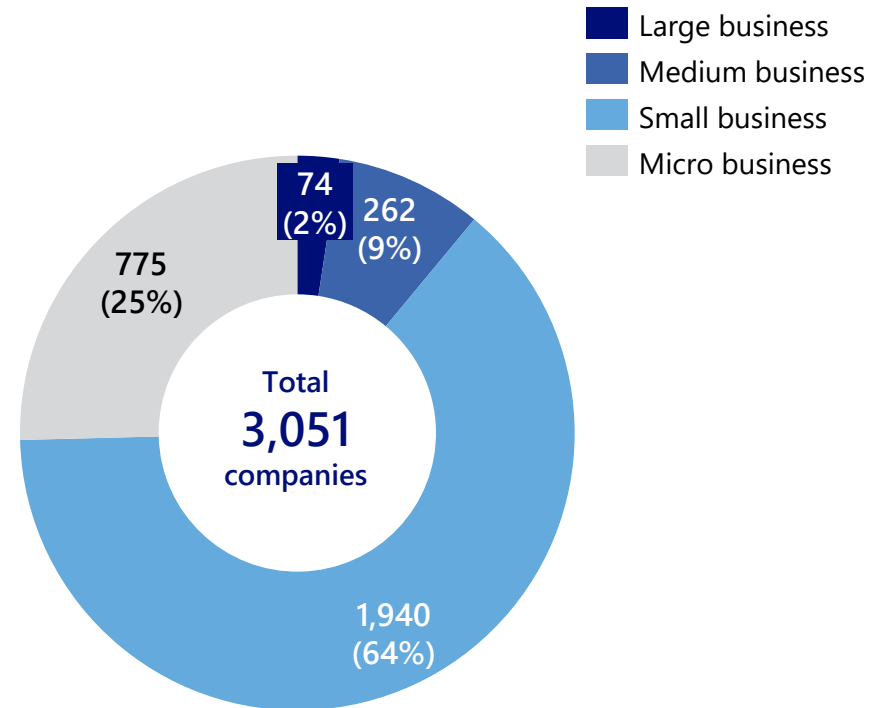
2020-2024 Production volume

Unit: Million tonnes



Note: The above production volume shows the overall production value of cement industry

Number of companies by company size



Note: Number of small and micro business may have duplicates due to errors in database, reflecting in potential of higher numbers than actuals

CCU Initiatives of Market Leaders in each Industry

Across all industries, market leaders have set or considering net zero by 2050 as long-term target, aiming to adopt CCU by starting study with partners

Overview and CCU initiatives of market leaders

	PTT	SCG	SSI	PTTGC
Industry	Oil and gas	Cement	Iron and steel	Chemical
Business overview	<ul style="list-style-type: none"> National oil & gas company and largest energy conglomerate Operate across upstream to downstream gas, LNG, petroleum 	<ul style="list-style-type: none"> Thailand's largest cement producer and building materials company. Produce cement, ready-mix concrete, and construction materials 	<ul style="list-style-type: none"> Thailand's largest flat steel producer, focused on hot-rolled coils for construction and industrial use Operate as key player in domestic steel supply 	<ul style="list-style-type: none"> Thailand's largest petrochemical and refining company (PTT subsidiary) Produce petrochemical e.g. olefins, polymers
2024 Consolidated revenue (bTHB)	3,140.0	533.2	26.6	598.2
Decarbonization target	<ul style="list-style-type: none"> Mid term: Carbon neutrality (scope 1 and 2) by 2030-2035 Long term: Net zero (scope 1 and 2) by 2050 	<ul style="list-style-type: none"> Mid term: Reduce 25% of GHG emissions (scope 1 and 2) by 2030 and reduce 25% of scope 3 by 2031 Long term: Net zero by 2050 	<ul style="list-style-type: none"> N/A: Currently considering target 	<ul style="list-style-type: none"> Mid term: Reduce 20% of GHG emissions (scope 1 and 2) by 2035 Long term: Net zero by 2050 (scope 1 and 2) and reduce 50% of scope 3
Example of CCU related initiatives	<ul style="list-style-type: none"> Studied CCU project to capture CO₂ from natural gas separation and convert into methanol Explored a CCU pilot with partners e.g. MHI to make methane from CO₂ 	<ul style="list-style-type: none"> Signed MOU with Nippon Steel Engineering to study CCU for cement plants Conducted a pre-feasibility study for a CCU facility at its cement plants to make chemical products 	<ul style="list-style-type: none"> Joined the CCUS Consortium with BCG eTEC, Chulalongkorn University, and major industry players to develop CCU technologies 	<ul style="list-style-type: none"> Joined the CCUS Consortium with BCG eTEC, Chulalongkorn University, and major industry players to develop CCU technologies

Source: Companies' official website, interview, news article, Corpus X

CCU Initiatives of Non-Market Leaders

Many companies remain cautious on CCU from high costs. Foreign subsidiaries, export-driven firms, and association members may have interest in CCU more

Current situation of CCU adoption

Limited engagement beyond market leaders

- Only a small number of non-leading companies have shown concrete interest in CCU
- Most companies lack clear roadmaps or commitments for decarbonization

High investment and limited support

- Significant budget requirements and unclear returns remain major barriers for CCU adoption
- Subsidies and support from the government is still very limited as well

Cautious wait-and-see approach

- Companies are monitoring regulatory developments and movement/outcomes from large companies before deciding on further CCU investment

Example of companies with potential of interest in CCU



Foreign subsidiaries with parent company's decarbonization commitments

- Local subsidiaries aligning with parent companies' global net-zero and CCU roadmaps may adopt CCU to meet group targets



Companies facing external pressure from stakeholders and mandatory carbon pricing

- Companies selling to overseas buyers which demand suppliers to reduce CO₂ emission (e.g. buyers with scope 3 target or impacted by CBAM)
- Companies in industries subject to mandatory carbon pricing schemes (e.g. carbon tax, ETS) under the Climate Change Act




Consortium or association members

- Companies joining associations with sector-level decarbonization direction may follow collective CCUS direction e.g., Thai Cement Manufacturers Association Net Zero Roadmap

Across sectors, chemical products attract the strongest interest, driven by their high value and diverse applications

Interest in CCU product of each sector


 Common utilization need across sectors

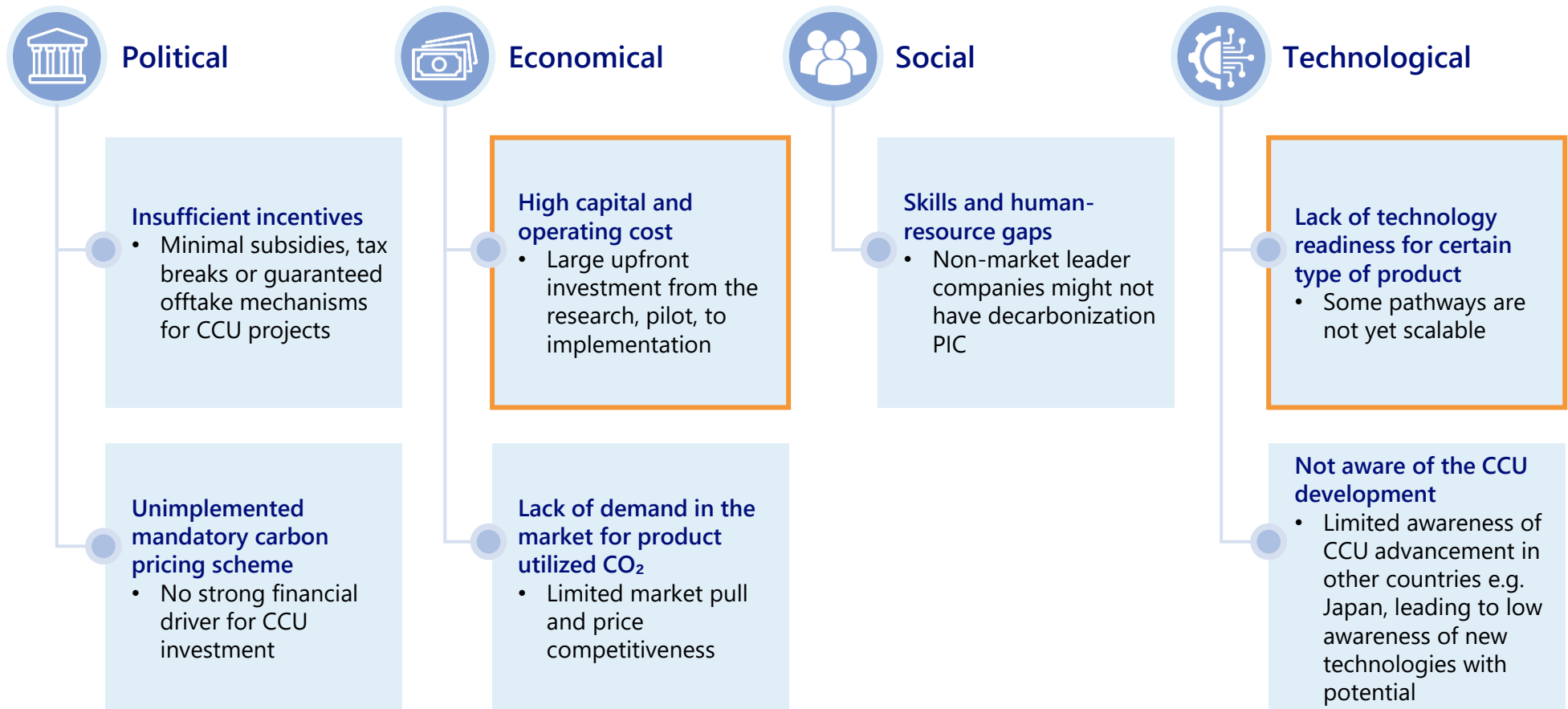
			Utilization				
			Fuel	Chemical	Mineral		
Sector for CO ₂ capture	High emission	Energy	Power generation	✓ (e-fuel, syn gas)	✓ (methanol, calcium carbonate)		
			Oil and Gas	✓ (e-fuel)	✓ (olefins, polycarbonate, calcium carbonate)		
		Industry	Cement		✓ (methanol)		✓ (cement)
			Chemical	✓ (e-fuel)	✓ (olefins, calcium carbonate)		
			Iron and steel		✓ (urea, polycarbonate, calcium carbonate)		
	Low emission	Pulp & paper	<i>Out of project scope</i>				
		Food & beverage					
		Textiles					

Source: Companies' official website, interview

Japanese companies have strong potential to support Thai companies in CCU adoption by addressing economic and technological challenges

Summarization of issues in CCU adoption

 Area which Japanese companies are able to support through technological solutions



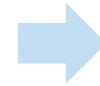
Japanese companies have strong potential to support Thai companies in CCU adoption by addressing economic and technological challenges

Challenge in CCU adoption in Thailand

NRI's view

Economical challenge

- **High capital and operating costs** remain the main barriers to CCU adoption, particularly for companies that are not market leaders
- Implementing CCU **requires significant upfront investment across multiple stages**, including research and development, pilot projects, and full-scale deployment.
- For many companies, these costs create substantial financial risk, making it **difficult to justify investment without clear economic returns** or supportive policy incentives



- Japanese companies could support CCU adoption by partnering with local firms and sharing technology, expertise, and financial resources
- Through such collaborations, they can help **address key barriers such as high implementation costs.**
- In particular, **Japanese companies that possess technologies capable of reducing costs**, such as more efficient CO₂ capture systems, are **likely to attract strong interest from local companies seeking practical and economically viable solutions**

Technological challenge

- **Limited technology readiness** for certain products remains another key challenge for CCU adoption.
- While several CCU pathways have been demonstrated at pilot or demonstration scale, **many are not yet technologically mature or commercially scalable.**
- As a result, companies face uncertainty regarding performance, cost, and long-term viability, making it **difficult to commit to large-scale investment until these technologies have proven scalability**



- Compared to the Thai companies, Japanese companies have wider experience in research and pilot projects for technologies related to CCU
- Japanese companies have potential to support CCU development in Thailand by **leveraging advanced technologies covering both capture and utilization (e.g. fuel, chemicals, and minerals) which can comprehensively cover the Thai companies' industry of interest**
- **By sharing technical expertise, proven solutions, and operational know-how, Japanese companies could help accelerate technology readiness and facilitate the adoption of CCU solutions among Thai industries**



**Envision the value,
Empower the change**

Agenda

Executive Summary

Chapter 1: Identification of Japanese Technologies

Chapter 2: Identification of Issues by Thai Companies

Chapter 3: Basic Information for Japanese Companies

Appendix

Source list

Agenda

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Appendix

Source list

Source List (Created on Mar 6, 2026)

Chapter	Organization	Item	Link	Page Number in Report
Executive summary	National Climate Change Secretariat	Overview of Singapore Climate Targets	https://www.nccs.gov.sg/singapores-climate-action/singapores-climate-targets/overview/	3
		Malaysia's Third Iteration of The Nationally Determined Contribution	https://unfccc.int/sites/default/files/2025-10/Malaysia%20NDC%203.0%20to%20UNFCCC%202025%20final.pdf	3
	The United Nations Framework Convention on Climate Change	Mid-century, Long-term Low Greenhouse Gas Emission Development Strategy THAILAND	https://unfccc.int/sites/default/files/resource/Thailand_LTS1.pdf#:~:text=The%20COP%2C%20by%20its%20decision%201/CP%2021%2C,Article%204%2C%20paragraph%2019%2C%20of%20the%20Agreement.&text=In%20line%20with%20the%20Paris%20Agreement%2C%20Thailand,technology%20and%20capacity-building%20to%20achieve%20this%20ambition.	3, 7
		Thailand's NDC 3.0	https://unfccc.int/sites/default/files/2025-11/TH%20NDC%203.0.pdf	3
		Second Nationally Determined Contribution Republic of Indonesia	https://unfccc.int/sites/default/files/2025-10/Indonesia_Second%20NDC_2025.10.24.pdf	3
	Climate Action Tracker	Vietnam - Main Climate Targets	https://climateactiontracker.org/countries/vietnam/targets/	3
		Philippines - Main Climate Targets	https://climateactiontracker.org/countries/philippines/	3

Source List (Created on Mar 6, 2026)

Chapter	Organization	Item	Link	Page Number in Report
Executive summary	Department of Climate Change and Environment	NDC Action Plan on Mitigation 2021-2030	https://www.dcce.go.th/wp-content/uploads/2025/08/English_NDC-Action-Plan-on-Mitigation_clean.pdf	4, 5, 6
		Climate Change Act	https://www.dcce.go.th/datacenter/3350/	4, 5, 6
		Draft of Climate Change Act	https://www.dcce.go.th/wp-content/uploads/2024/06/ร่าง_พ.ร.บ.การเปลี่ยนแปลงสภาพภูมิอากาศ-พ.ศ.-.-รับฟังความคิดเห็นครั้งที่-2.pdf	4, 5, 6
	Kasikorn Research Center	Thailand is preparing to submit a draft Climate Change Act by mid-2024 to achieve its Net Zero climate change target by 2065	https://www.kasikornresearch.com/th/analysis/k-social-media/Pages/SBUvol3No7-FB-2024-04-04.aspx	6
	National Science and Technology Development Agency	CCUS seminar: carbon capture, utilization, and storage — advancing CCUS toward carbon neutrality through the development of Thailand's CCUS technology roadmap	www.nstda.or.th/nac/2023/wp-content/uploads/2023/04/se25-present-1500.pdf	7
	Energy News Center	The draft of the new PDP is expected to be completed in May 2026 and submitted to the new government for approval	https://www.energynewscenter.com/%E0%B8%84%E0%B8%B2%E0%B8%94%E0%B8%A3%E0%B9%88%E0%B8%B2%E0%B8%87%E0%B9%81%E0%B8%9C%E0%B8%99pdp%E0%B9%83%E0%B8%AB%E0%B8%A1%E0%B9%88%E0%B9%80%E0%B8%AA%E0%B8%A3%E0%B9%87%E0%B8%88-%E0%B8%9E-%E0%B8%84-2569/	8

Source List (Created on Mar 6, 2026)

Chapter	Organization	Item	Link	Page Number in Report
Executive summary	Thammasat University	Thailand's Net-Zero Emission 2050	https://www-iam.nies.go.jp/aim/aim_workshop/aimws_29/presentation/5-1_Bundit.pdf	8
	Department of Climate Change and Environment	Thailand's Climate Change Report 2024	https://www.dcce.go.th/wp-content/uploads/2025/07/Climate-Change-Report_Y1-E-book-June2025.pdf	8
	The Standard	Unveiling the PDP 2025 plan by Minister Attaphol, focusing on clean energy, starting with carbon neutrality control (CCS) and community solar projects	https://thestandard.co/pdp-2025-clean-energy-push/	8
	IEA	IEAGHG Technical Review 2021-TR05 August 2021 Towards improved guidelines for cost evaluation of carbon capture and storage	https://publications.ieaghg.org/technicalreports/2021-TR05%20White%20Paper%20Towards%20improved%20guidelines%20for%20cost%20evaluation%20of%20carbon%20capture%20and%20storage.pdf	9
	IEA	IEAGHG Technical Report 2022-04 March 2022 From Carbon Dioxide to Building Materials – Improving Process Efficiency	https://publications.ieaghg.org/technicalreports/2022-04%20From%20Carbon%20Dioxide%20to%20Building%20Materials%20E2%80%93%20Improving%20Process%20Efficiency.pdf	9

Source List (Created on Mar 6, 2026)

Chapter	Organization	Item	Link	Page Number in Report
Executive summary	International Finance Corporation	Environmental, Health, and Safety Guidelines for Natural Gas Processing	https://www.ifc.org/content/dam/ifc/doc/2000/2007-natural-gas-processing-ehs-guidelines-en.pdf	9
	United Nations Industrial Development Organization	Carbon Capture and Storage in Industrial Applications: Technology Synthesis Report	https://www.unido.org/sites/default/files/2010-12/synthesis_final_0.pdf	9
	PTTGC	GHG Reduction Initiatives	https://sustainability.pttgcgroup.com/en/environment/climate-strategy/ghg-reduction-initiatives	10
	PTT	GHG Reduction Initiatives	https://www.pttplc.com/th/sustainability/RXdvOCUyZk1WJTJiZ21JVGZPTFhFTXZTeFEIM2QIM2Q	10
	IRPC	Climate Change Policy	https://irpc.co.th/wp-content/uploads/2025/10/นโยบายการเปลี่ยนแปลงสภาพภูมิอากาศ-1.pdf	10
	SCG	Net Zero development	https://www.scg.com/sustainability/sustainability-development#	10
		Climate report 2024	https://file.scgsustainability.com/wp-content/uploads/2025/04/28100902/SCG-Climate-Report-2024-1.pdf	10
Chapter 1	METI	Roadmap for Carbon Recycling Technologies	https://www.enecho.meti.go.jp/category/others/carbon_recycling/pdf/20190607002-2.pdf	19

For reference of each company's technology, please refer to links in table of the pitchbook

Source List (Created on Mar 6, 2026)

Chapter	Organization	Item	Link	Page Number in Report
Chapter 2	National Climate Change Secretariat	Overview of Singapore Climate Targets	https://www.nccs.gov.sg/singapores-climate-action/singapores-climate-targets/overview/	66
		Malaysia's Third Iteration of The Nationally Determined Contribution	https://unfccc.int/sites/default/files/2025-10/Malaysia%20NDC%203.0%20to%20UNFCCC%202025%20final.pdf	66
	The United Nations Framework Convention on Climate Change	Mid-century, Long-term Low Greenhouse Gas Emission Development Strategy THAILAND	https://unfccc.int/sites/default/files/resource/Thailand_LTS1.pdf#:~:text=The%20COP%2C%20by%20its%20decision%201/CP%2021%2C,Article%204%2C%20paragraph%2019%2C%20of%20the%20Agreement.&text=In%20line%20with%20the%20Paris%20Agreement%2C%20Thailand,technology%20and%20capacity-building%20to%20achieve%20this%20ambition.	66
		Thailand's NDC 3.0	https://unfccc.int/sites/default/files/2025-11/TH%20NDC%203.0.pdf	66
		Second Nationally Determined Contribution Republic of Indonesia	https://unfccc.int/sites/default/files/2025-10/Indonesia_Second%20NDC_2025.10.24.pdf	66
	Climate Action Tracker	Vietnam - Main Climate Targets	https://climateactiontracker.org/countries/vietnam/targets/	66
		Philippines - Main Climate Targets	https://climateactiontracker.org/countries/philippines/	66

Source List (Created on Mar 6, 2026)

Chapter	Organization	Item	Link	Page Number in Report
Chapter 2	PTTGC	GHG Reduction Initiatives	https://sustainability.pttggroup.com/en/environment/climate-strategy/ghg-reduction-initiatives	68
	PTT	GHG Reduction Initiatives	https://www.pttplc.com/th/sustainability/RXdvOCUyZk1WJTJiZ21JVGZPTFhFTXZTeFEIM2QIM2Q	68
	IRPC	Climate Change Policy	https://irpc.co.th/wp-content/uploads/2025/10/นโยบายการเปลี่ยนแปลงสภาพภูมิอากาศ-1.pdf	68
	SCG	Net Zero development	https://www.scg.com/sustainability/sustainability-development#	68
		Climate report 2024	https://file.scgsustainability.com/wp-content/uploads/2025/04/28100902/SCG-Climate-Report-2024-1.pdf	68
	Ministry of Industry	Regulation for cement	https://www.diw.go.th/webdiw/wp-content/uploads/2021/07/law-fac-env-31102549-2.pdf	74
		Regulation for primary iron & steel	https://www.diw.go.th/webdiw/wp-content/uploads/2021/07/law-fac-env-31102549.pdf	75
		Regulation for reinforcing steel bar and small billet	https://www.diw.go.th/webdiw/wp-content/uploads/2021/07/law-fac-env-19072564.pdf	75
		Regulation for natural gas	https://www.diw.go.th/webdiw/wp-content/uploads/2021/07/law-fac-env-06022560.pdf	75
		Regulation for power generation	https://www.diw.go.th/webdiw/wp-content/uploads/2025/02/a18022568-01.pdf	76

Source List (Created on Mar 6, 2026)

Chapter	Organization	Item	Link	Page Number in Report
Chapter 2	Ministry of Industry	Regulation for oil refinery	https://www.diw.go.th/webdiw/wp-content/uploads/2021/07/law-fac-env-20122553.pdf	77
		Regulation for chemical (Thailand)	https://www.diw.go.th/webdiw/wp-content/uploads/2021/07/law-fac-env-31102549.pdf	78
		Regulation for chemical (Bangkok)	https://th.gb-planet.com/environmental-regulatory-update/news-2026021301.html	78
		Recent regulation on emission control	https://ratchakitcha.soc.go.th/documents/104958.pdf	79
Chapter 3	National Climate Change Secretariat	Overview of Singapore Climate Targets	https://www.nccs.gov.sg/singapores-climate-action/singapores-climate-targets/overview/	83
	The United Nations Framework Convention on Climate Change	Malaysia's Third Iteration of The Nationally Determined Contribution	https://unfccc.int/sites/default/files/2025-10/Malaysia%20NDC%203.0%20to%20UNFCCC%202025%20final.pdf	83
		Mid-century, Long-term Low Greenhouse Gas Emission Development Strategy THAILAND	https://unfccc.int/sites/default/files/resource/Thailand_LTS1.pdf#:~:text=The%20COP%2C%20by%20its%20decision%201/CP%2021%2C,Article%204%2C%20paragraph%2019%2C%20of%20the%20Agreement.&text=In%20line%20with%20the%20Paris%20Agreement%2C%20Thailand,technology%20and%20capacity-building%20to%20achieve%20this%20ambition.	83, 90
	Thailand's NDC 3.0	https://unfccc.int/sites/default/files/2025-11/TH%20NDC%203.0.pdf	83	

Source List (Created on Mar 6, 2026)

Chapter	Organization	Item	Link	Page Number in Report
Chapter 3	The United Nations Framework Convention on Climate Change	Second Nationally Determined Contribution Republic of Indonesia	https://unfccc.int/sites/default/files/2025-10/Indonesia_Second%20NDC_2025.10.24.pdf	83
	Climate Action Tracker	Vietnam - Main Climate Targets	https://climateactiontracker.org/countries/vietnam/targets/	83
		Philippines - Main Climate Targets	https://climateactiontracker.org/countries/philippines/	83
	Department of Climate Change and Environment	NDC Action Plan on Mitigation 2021-2030	https://www.dcce.go.th/wp-content/uploads/2025/08/English_NDC-Action-Plan-on-Mitigation_clean.pdf	84, 85, 86
		Climate Change Act	https://www.dcce.go.th/datacenter/3350/	84, 85, 86
		Draft of Climate Change Act	https://www.dcce.go.th/wp-content/uploads/2024/06/ร่าง_พ.ร.บ.การเปลี่ยนแปลงสภาพภูมิอากาศ-พ.ศ.-.-รับฟังความคิดเห็นครั้งที่-2.pdf	84, 85, 86
	Kasikorn Research Center	Thailand is preparing to submit a draft Climate Change Act by mid-2024 to achieve its Net Zero climate change target by 2065	https://www.kasikornresearch.com/th/analysis/k-social-media/Pages/SBUvol3No7-FB-2024-04-04.aspx	86
	World bank	Carbon pricing	https://carbonpricingdashboard.worldbank.org/about#do_wnload-data	87

Source List (Created on Mar 6, 2026)

Chapter	Organization	Item	Link	Page Number in Report
	TGO	Average price of T-VERs	https://carbonmarket.tgo.or.th/index.php?lang=en	88
	Sylvera	Carbon offset market price per tonne by project type	https://www.sylvera.com/blog/carbon-offset-price	89
	National Science and Technology Development Agency	CCUS seminar: carbon capture, utilization, and storage — advancing CCUS toward carbon neutrality through the development of Thailand’s CCUS technology roadmap	www.nstda.or.th/nac/2023/wp-content/uploads/2023/04/se25-present-1500.pdf	90
Chapter 3	Energy News Center	The draft of the new PDP is expected to be completed in May 2026 and submitted to the new government for approval	https://www.energynewscenter.com/%E0%B8%84%E0%B8%B2%E0%B8%94%E0%B8%A3%E0%B9%88%E0%B8%B2%E0%B8%87%E0%B9%81%E0%B8%9C%E0%B8%99pdp%E0%B9%83%E0%B8%AB%E0%B8%A1%E0%B9%88%E0%B9%80%E0%B8%AA%E0%B8%A3%E0%B9%87%E0%B8%88-%E0%B8%9E-%E0%B8%84-2569/	91
	Thammasat University	Thailand’s Net-Zero Emission 2050	https://www-iam.nies.go.jp/aim/aim_workshop/aimws_29/presentation/5-1_Bundit.pdf	91
	Department of Climate Change and Environment	Thailand’s Climate Change Report 2024	https://www.dcce.go.th/wp-content/uploads/2025/07/Climate-Change-Report_Y1-E-book-June2025.pdf	91

Source List (Created on Mar 6, 2026)

Chapter	Organization	Item	Link	Page Number in Report
Chapter 3	The Standard	Unveiling the PDP 2025 plan by Minister Attaphol, focusing on clean energy, starting with carbon neutrality control (CCS) and community solar projects	https://thestandard.co/pdp-2025-clean-energy-push/	91
	IEA	IEAGHG Technical Review 2021-TR05 August 2021 Towards improved guidelines for cost evaluation of carbon capture and storage	https://publications.ieaghg.org/technicalreports/2021-TR05%20White%20Paper%20Towards%20improved%20guidelines%20for%20cost%20evaluation%20of%20carbon%20capture%20and%20storage.pdf	92
		IEAGHG Technical Report 2022-04 March 2022 From Carbon Dioxide to Building Materials – Improving Process Efficiency	https://publications.ieaghg.org/technicalreports/2022-04%20From%20Carbon%20Dioxide%20to%20Building%20Materials%20E2%80%93%20Improving%20Process%20Efficiency.pdf	92
	International Finance Corporation	Environmental, Health, and Safety Guidelines for Natural Gas Processing	https://www.ifc.org/content/dam/ifc/doc/2000/2007-natural-gas-processing-ehs-guidelines-en.pdf	92
	United Nations Industrial Development Organization	Carbon Capture and Storage in Industrial Applications: Technology Synthesis Report	https://www.unido.org/sites/default/files/2010-12/synthesis_final_0.pdf	92

Source List (Created on Mar 6, 2026)

Chapter	Organization	Item	Link	Page Number in Report
Chapter 3	The Office of Industrial Economics	Oil production volume		93
		Chemical production volume	https://i.index.oie.go.th/industrialStatistics1.aspx	96
		Iron and steel production volume		97
	EPPO	Natural gas production volume	https://www.eppo.go.th/index.php/th/energy-information/static-energy/static-gas	94
	PTT	Conversion from MMSCFD to MTPA	https://www.thailand-energy-academy.org/assets/upload/coursedocument/file/Gas%20Business,%20Thai%20Economy%20Fundamental_1.pdf	94
	EPPO	Power generation production volume	https://www.eppo.go.th/index.php/en/en-energystatistics/electricity-statistic	95
	SCB EIC	Cement production volume	https://media.settrade.com/settrade/Documents/2025/Aug/20250815-SCB-EIC-Cement-Industry-update.pdf	98
	PTT	Decarbonization target	https://www.pttplc.com/th/sustainability/RXdvOCUyZk1WJTJiZ21JVZPTFhFTXZTeFEIM2QIM2Q	99
		Example of CCU related initiatives	https://www.pttplc.com/th/sustainability/RXdvOCUyZk1WJTJiZ21JVZPTFhFTXZTeFEIM2QIM2Q	99

Source List (Created on Mar 6, 2026)

Chapter	Organization	Item	Link	Page Number in Report
Chapter 3	SCG	Decarbonization target	https://file.scgsustainability.com/wp-content/uploads/2025/04/28100902/SCG-Climate-Report-2024-1.pdf	99
		Example of CCU related initiatives: MOU with Nippon Steel Engineering	https://www.scgnewschannel.com/en/scg-news/scg-signs-mou-with-nse-and-tns-to-study-carbon-capture-and-utilization-technology-from-cement-plants-in-thailand-and-southeast-asia-aims-to-achieve-net-zero-cement-concrete-by-2050/	99
		Example of CCU related initiatives: collaboration with IHI	https://www.scgchemicals.com/en/articles/news/1688433200	99
	PTTGC	Decarbonization target	https://sustainability.pttggroup.com/en/environment/climate-strategy/climate-change-strategy-and-target	99
		Thailand CCUS Consortium with PTTGC, SSI and other partner companies	https://sustainability.pttggroup.com/en/newsroom/news/886/gc-and-ptt-group-join-forces-with-national-level-educational-government-and-private-sector-partners-to-establish-the-thailand-ccus-consortium-to-reinforce-thailand-s-carbon-neutral-and-net-zero-goals	99



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