

Role of CCS for ASEAN towards Carbon Neutrality: Model analysis with cost-minimization approach

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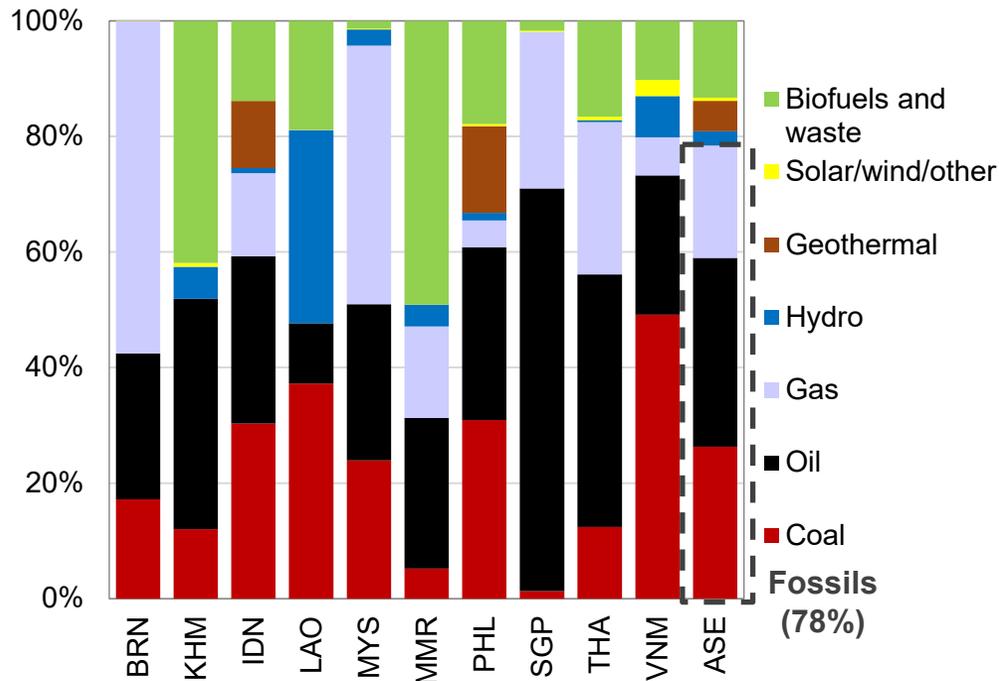
Energy and economy in ASEAN

ASEAN's energy and economy are characterized by;

- High dependent on fossil fuels (78% in 2021) and young fossil fuel fleets
- Domestic production of fossil fuels
- Uneven distribution of renewable energy resources
- Strong economic growth

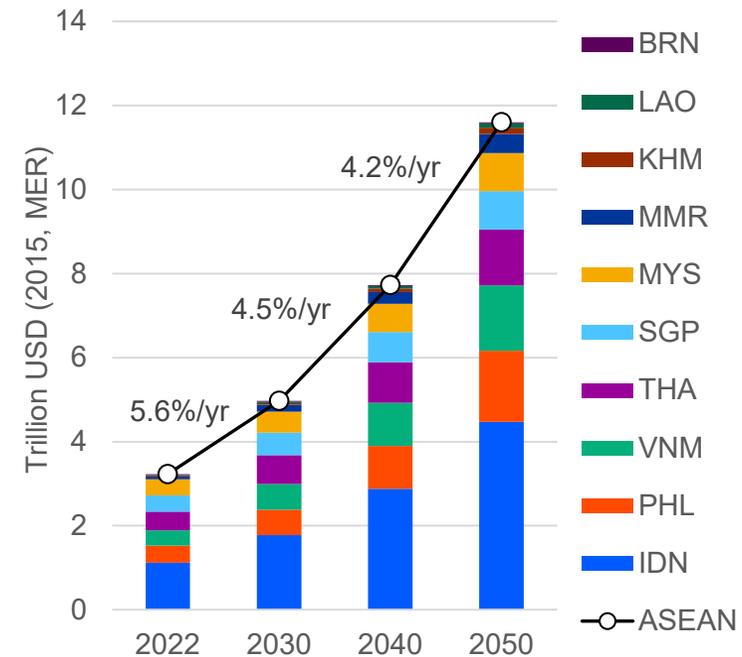
+ High ambition towards carbon neutrality

Primary energy supply in ASEAN in 2021



Note) Exclude import and export of electricity
 Source) Created by IEEJ based on IEA (2023). World Energy Balances

Outlook of GDP growth in ASEAN



Source) Created by IEEJ Based on ERIA (2021). Energy Outlook and Energy Saving Potential in East Asia 2020.

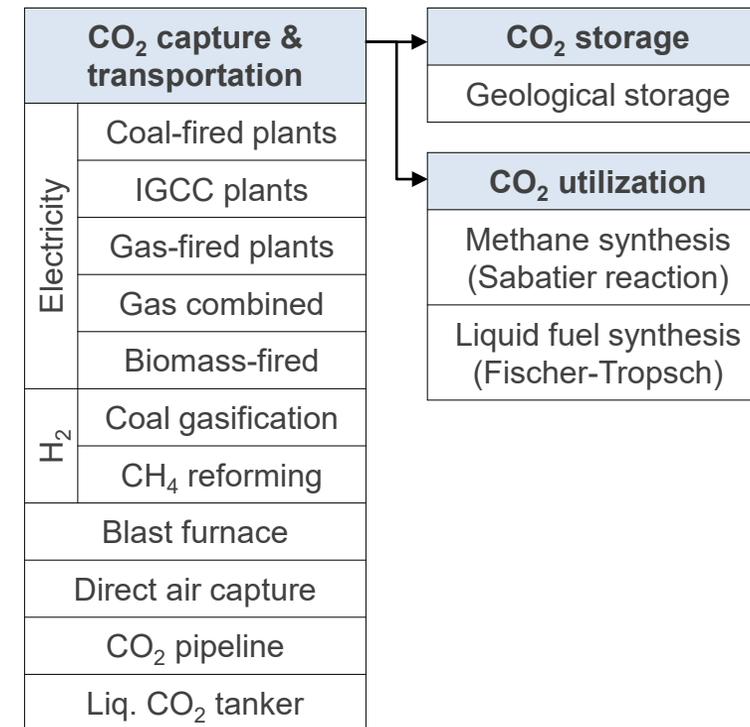
Framework of the analysis

A cost-optimal combination of energy technologies is simulated using a linear programming model¹⁾ that covers the entire energy system of ASEAN 10 countries. Energy-related CO₂ emissions constraints reflect each country's long-term target with a consideration of natural carbon sinks (CN by 2060 for ASEAN). CCUS technologies are explicitly considered.

Framework of the analysis

Regional division	10 ASEAN countries (10 nodes)
Time period	2017-2060 (2017, 2030, 2040, 2050 and 2060)
Discount rate	8%
Temporal resolution	4-hourly resolution (2190 time slices) per year for electricity supply and demand
End-use sector	<ul style="list-style-type: none"> • Industry: Iron & Steel, Cement, Chemicals, Paper & pulp, Other industries • Transport: Light-duty vehicle, Bus & truck, Rail, Aviation, Navigation, Other transport • Residential: Light and appliances, Space cooling, Water heating, Kitchen • Commercial: Light and appliances, Space cooling, Water heating & Kitchen • Other: Agricultural and other energy demand

Considered CCUS technologies

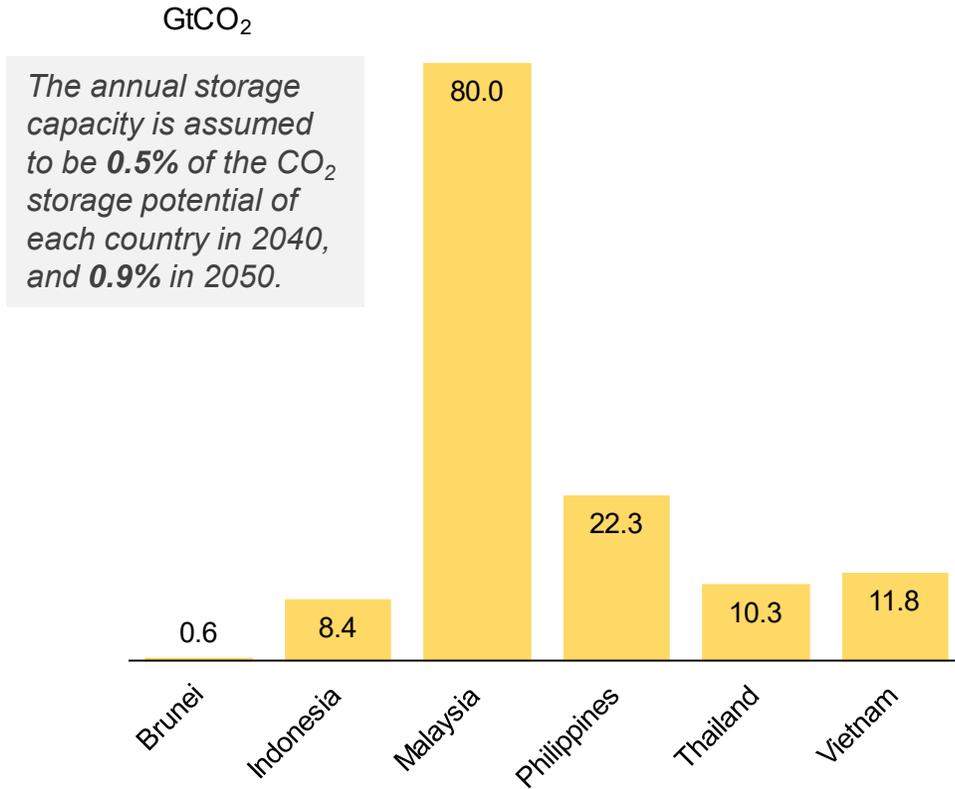


1) For example, Otsuki et al (2022). Energy mix for net zero CO₂ emissions by 2050 in Japan. *Electr Eng Jpn*.

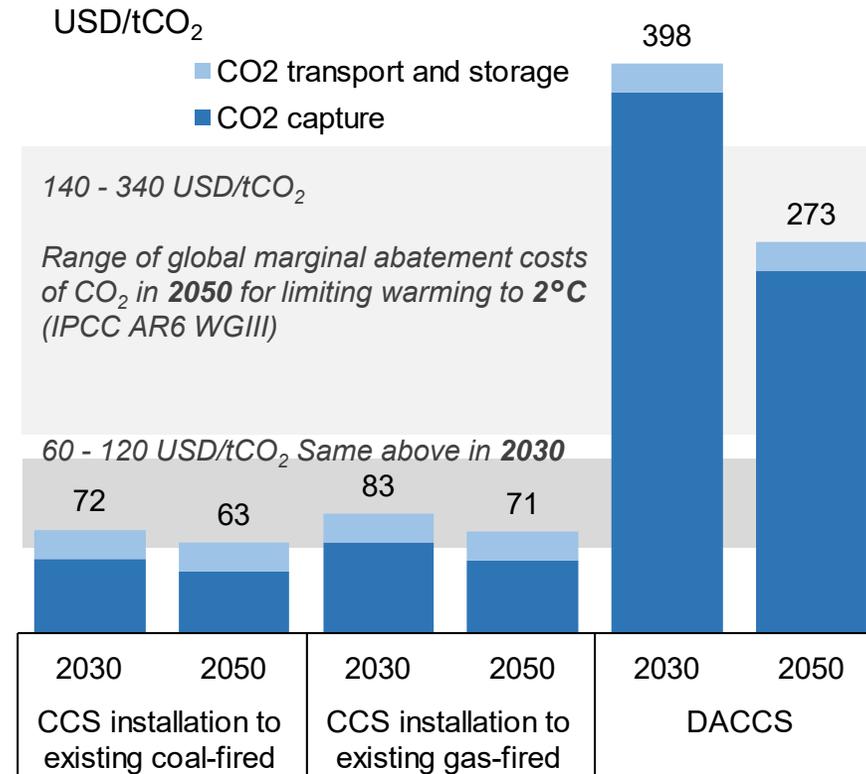
Assumptions for CCS

- | Southeast Asia is a promising area for CO₂ storage.
 - | CCS installation to existing thermal power would be cost-competitive in the short- to mid-term. DACCS would be so in the long-term with high carbon prices aiming for CN.
- DACCS: direct air carbon dioxide capture and storage

CO₂ storage potential in ASEAN



Estimated cost of CCS in ASEAN



Source) Created by IEEJ based on IEA (2021). Carbon Capture, Utilisation and Storage: The Opportunity in Southeast Asia

Source) Estimated by IEEJ based on Indonesia's power technology catalogue, etc.

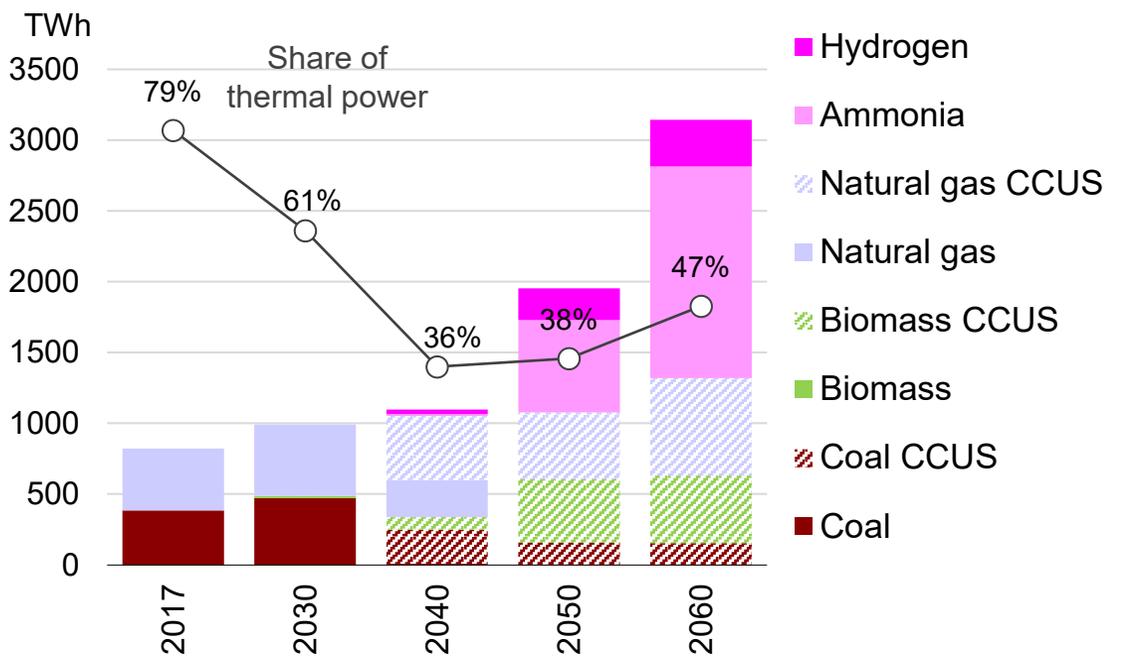
Thermal power generation and CO₂ emissions

Although its share would drop, thermal power would continue to play a role in ASEAN by backing up variable renewable energy and/or covering electricity demand growth that can't be met by renewable energy alone. CCS and clean fuel are essential for reducing emissions from thermal power.

In addition to a substantial emissions reduction compared to the case without CN targets, CDR methods such as BECCS and DACCS are required to offset hard-to-abate emissions.

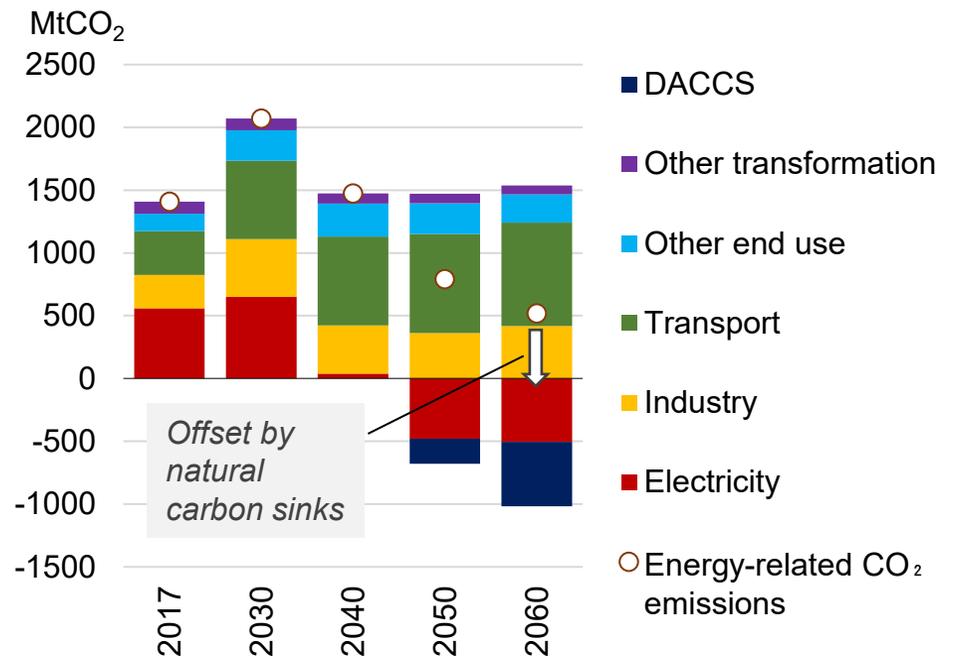
CDR: carbon dioxide removal, BECCS: bioenergy with carbon dioxide capture and storage

Thermal power generation by fuel type in ASEAN



Note) Hydrogen, ammonia, and biomass include those co-fired.

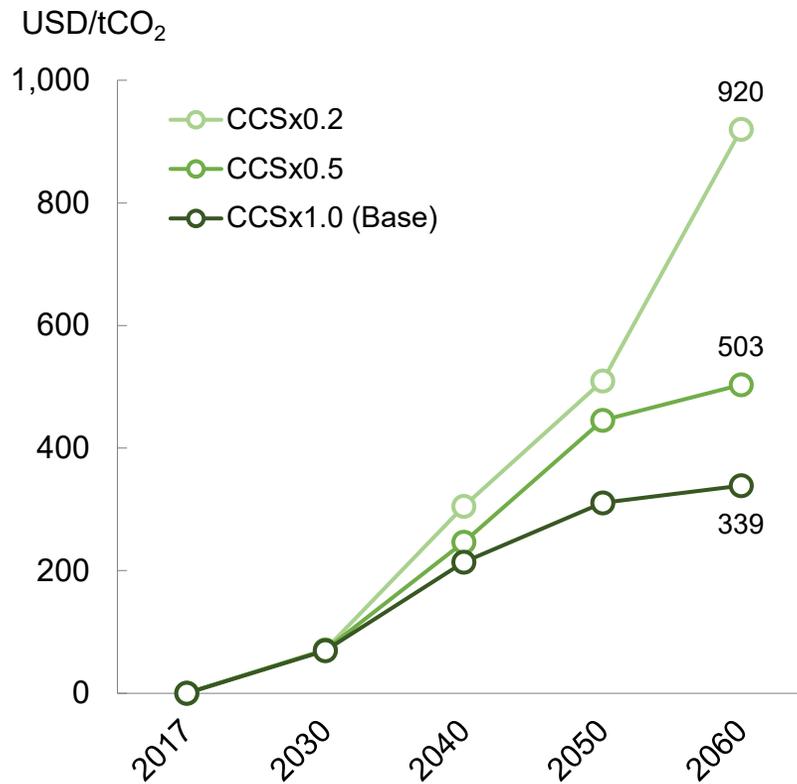
Sectoral CO₂ emissions in ASEAN



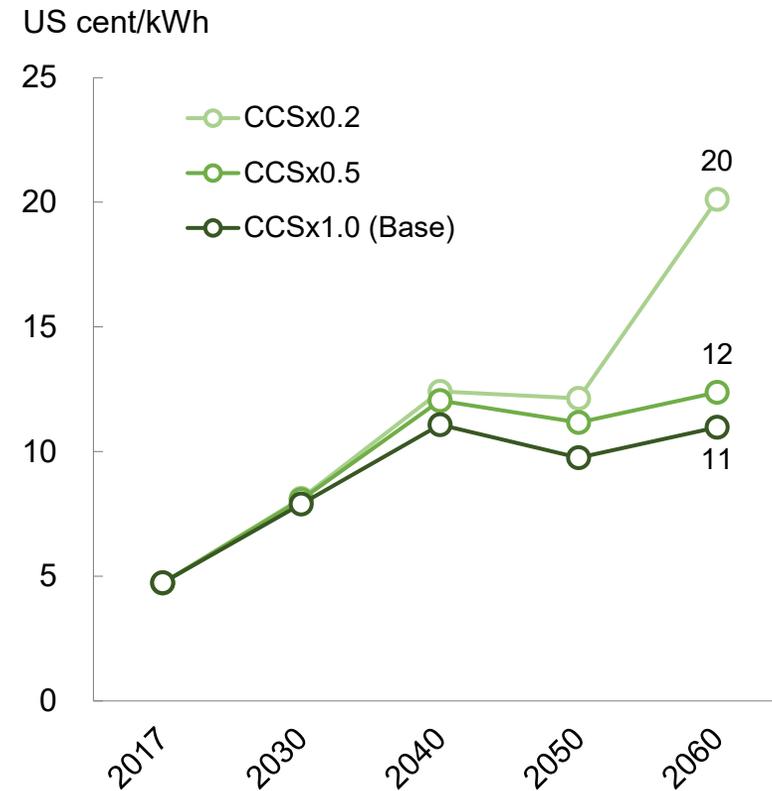
Costs for achieving CN

- Simulation results imply significant economic challenges associated with CN.
- According to sensitivity analysis on CO₂ storage capacity or annual upper limit, CCS availability has a large impact on the costs for achieving CN in the mid- to long-term.

Marginal abatement costs of CO₂ in ASEAN
(weighted average)



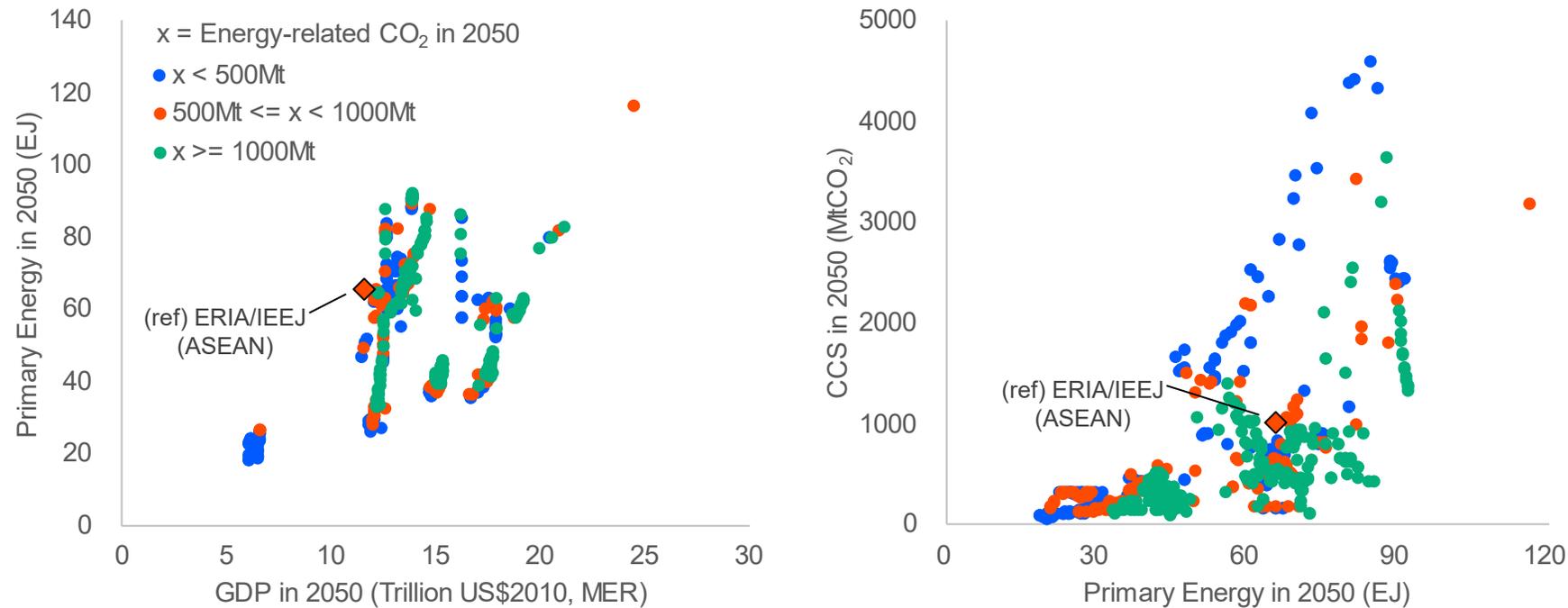
Marginal electricity costs in ASEAN
(weighted average)



Comparison among AR6 scenarios

- | Energy demands tend to correlate with economic growth while acknowledging the importance of energy efficiency.
- | As the energy demands grow, CCS becomes an increasingly important option to meet climate targets.

Comparison among AR6 scenarios for “Other countries of Asia” consistent with Paris targets



Note) Scenarios include those in line with 1.5°C or 2°C targets. “Other countries of Asia” doesn’t include Cambodia, Laos, and Vietnam.
 Source) Created by IEEJ based on Byers et al., AR6 Scenario Explorer hosted by IIASA, 2022

Conclusions

CCS is a **cost-competitive option** to address ASEAN's or even global situations/challenges towards CN. Further efforts including international cooperation are needed from technical and regulative perspectives to expand CCS in the region.

ASEAN's situations/challenges towards CN

Abundant and young fossil fuel facilities

Uneven distribution of RE resources
Strong economic growth (but currently low tolerance to energy price increases)

Domestic production of fossil fuels

Global challenges {
 Hard-to-abate sectors
 Pursuing the 1.5°C target

Heavy Industry with CCUS

CC(U)S solutions

- implications from simulation results

Existing facilities with CCS
 - **All CO₂ emissions from coal-fired are captured after 2040**

Newly installed facilities with CCS
 - **Natural gas-fired with CO₂ capture accounts for 10% of total power generation or almost 700 TWh in 2060**
 - **Blast furnace with CO₂ capture is installed by 2030**

Blue hydrogen or its derived fuels for domestic use or export

CDR by CCS
 - **BECCS and DACCS capture 1 GtCO₂ in 2060**