SOUTH EAST ASIA CCS ACCELERATOR WORKSHOP (SEACA)

Part III: Creating a Transnational Asian CCS Value Chain

Kuala Lumpur, Malaysia
28 August 2024

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THANK YOU TO OUR EVENT PARTNERS

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Asia Natural Gas & Energy Association

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SOUTH EAST ASIA CCS ACCELERATOR WORKSHOP (SEACA)

Part III: Creating a Transnational Asian CCS Value Chain

5. CARBON ACCREDITATION FOR CCS PROJECTS

The recognition and monetisation of abatement from any activity, including CCS require rigorous, transparent, and verifiable methods to calculate abatement delivered. This session will focus on methods and carbon accounting requirements relevant to an international asian CO_2 storage value chain, including the creation and ownership of carbon credits.

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5. CARBON ACCREDITATION FOR CCS PROJECTS

IETA

Takashi Hongo, Senior Fellow

Mitsui & Co. Global Strategic Studies Institute, and Co-Chair of Japan WG, IETA

Accounting and Sustainability for Monetization of CCS

South East Asia CCS Accelerator Workshop
Part III: Creating a Transnational Asian CCS Value Chain
27-28 August 2024

Accounting and Sustainability for Monetization of CCS

Takashi Hongo

Senior Fellow
Mitsui & Co. Global Strategic Studies Institute

Board of Directors & Co-chair of Japan WG
International Emission Trading Association

Carbon Markets and CCS

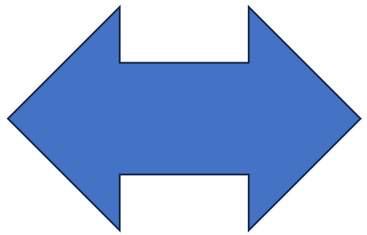
Overviews of carbon markets

Diversified carbon markets and the era of diversification of markets

Compliance markets

National Markets
(GX ETS, Indonesia, Malysia, Singapore etc.)

International Markets
(Article 6)



New & emerging markets

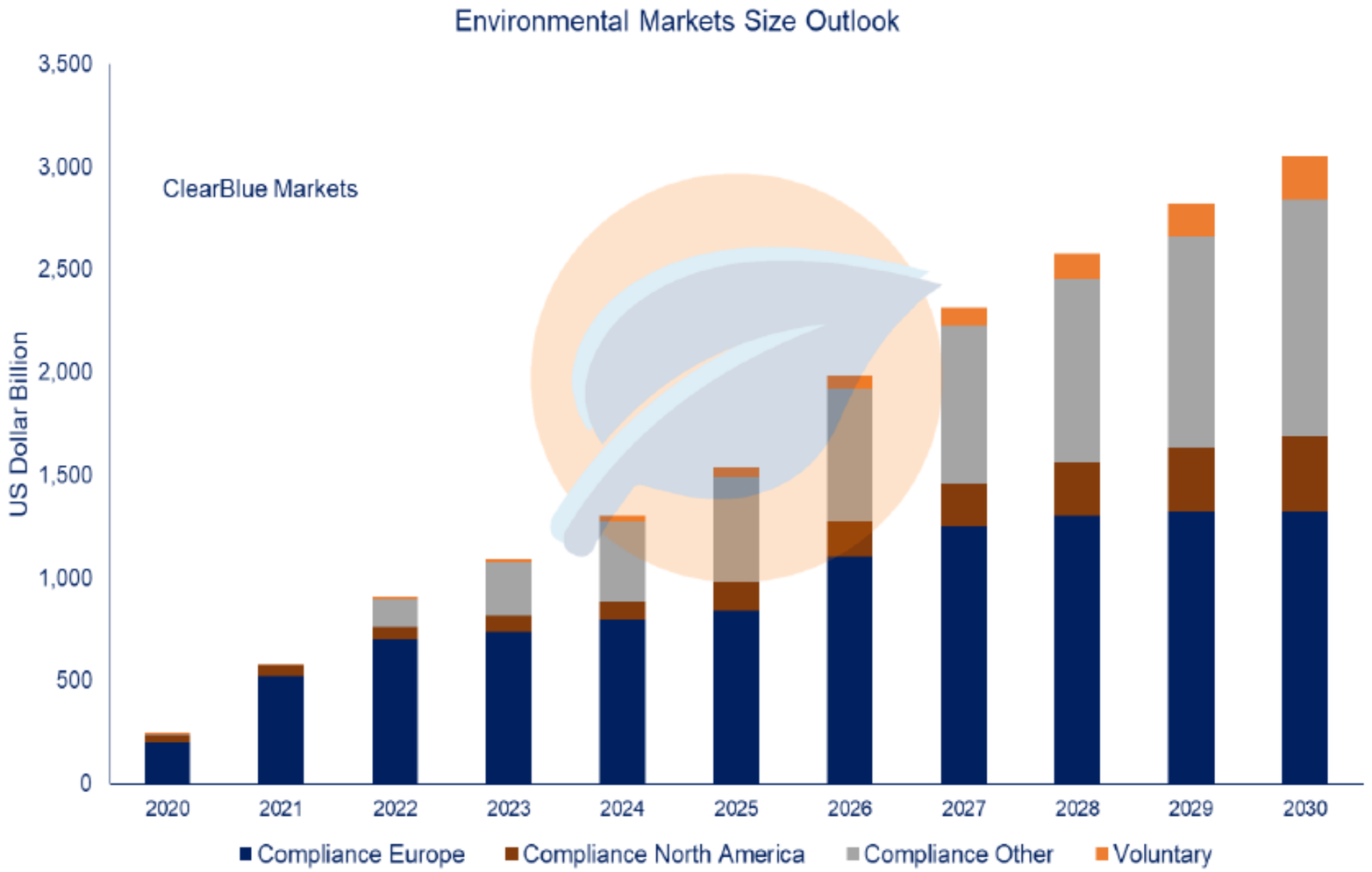
Technology removal
e.g. CCS, DAC

Nature base removal
e.g. soil carbon

Digital markets

Voluntary markets

Growth of Carbon Markets



Source: ClearBlue Markets (2023)

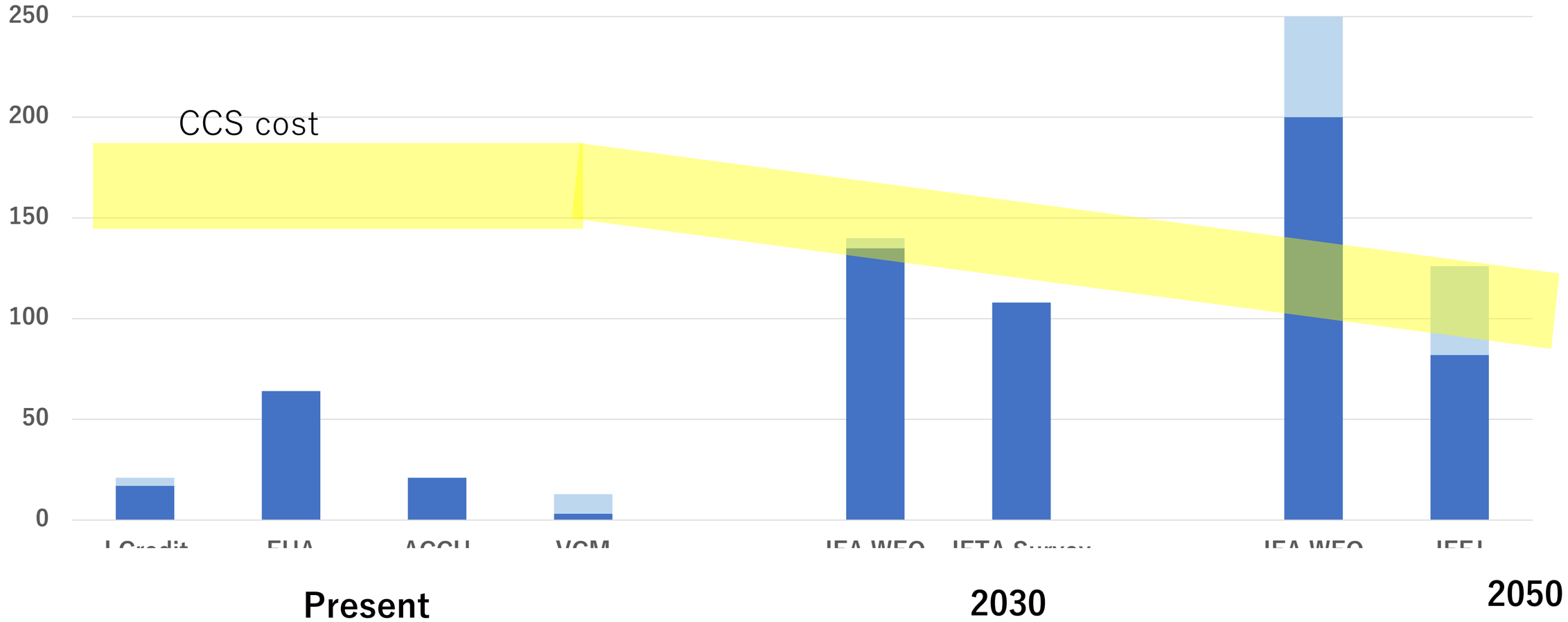
Asian carbon markets

- Emerging of national markets/fragmentation of carbon markets
- Markets = supply, demand and infra/platform; demand shortage
- New markets = CCS/Removal; science for quantification and inventory is needed

Commercial benefit of CCS/DAC – carbon price

USD/tCO2

- Carbon Price is necessary for CCS/DAC
- Is Carbon Price enough for cost recovery of CCS/DAC investment?



Note:
J Credit: RE=high, EE=low, VCM: Removal=high, Nature base=low, IEA: NZE=high, APS=low, IEEJ: power sector: zero emission :high, 70% reduction=low

IETA CCS High Level Criteria

Reference Negative opinions and concerns about CCS

◆ Effectiveness of CCS
- ✓ Insufficient information
- ✓ Maturity of technology
- ✓ Comparison with alternative technologies
- ✓ Energy loss
- ✓ Storage potential

◆ Emission Reduction Effects (quantification)
- ✓ Safe and long term containment
- ✓ Objective and scientific evaluation of safe and long term containment, and its assurance
- ✓ Measurement and monitoring of leakage (including permanence)
- ✓ Evaluation of total reduction effects

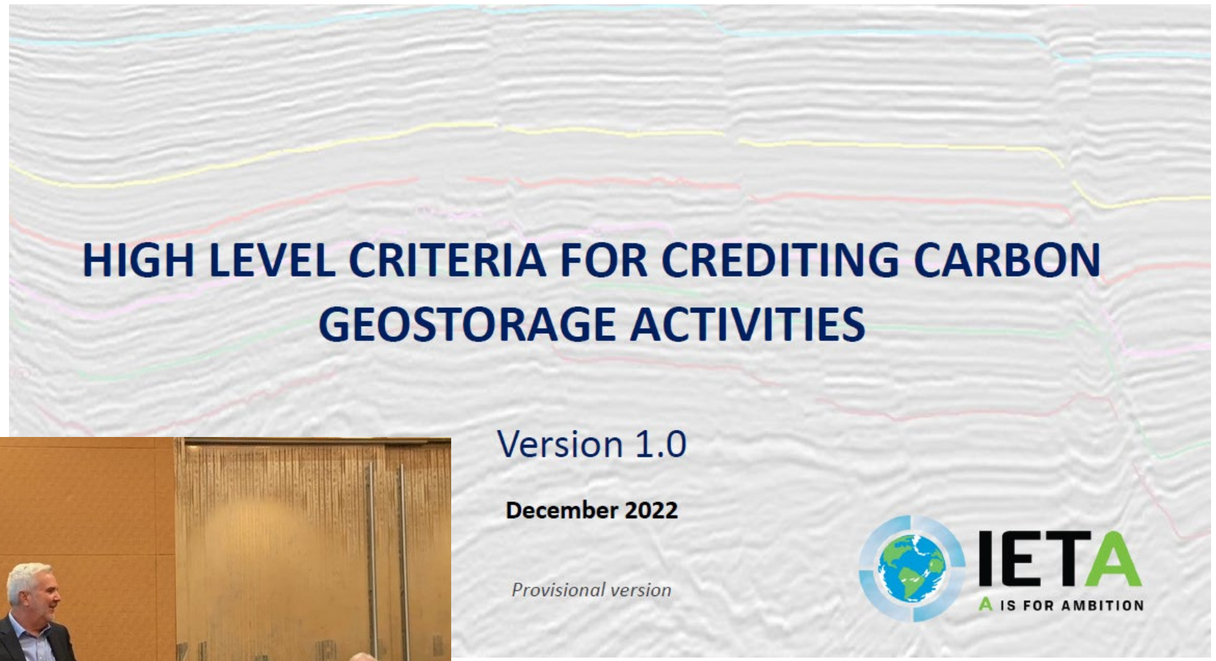
◆ Environment impacts (pollution, natural environment and social environment)
- ◆ Marine environment
- ◆ Ground water and air pollution
- ◆ Hazard waste
- ◆ Social impacts, such as accident and disaster

◆ Others
- ✓ Policy risk
- ✓ Impact on local economy (benefit)
- ✓ Large scale accident and its compensation

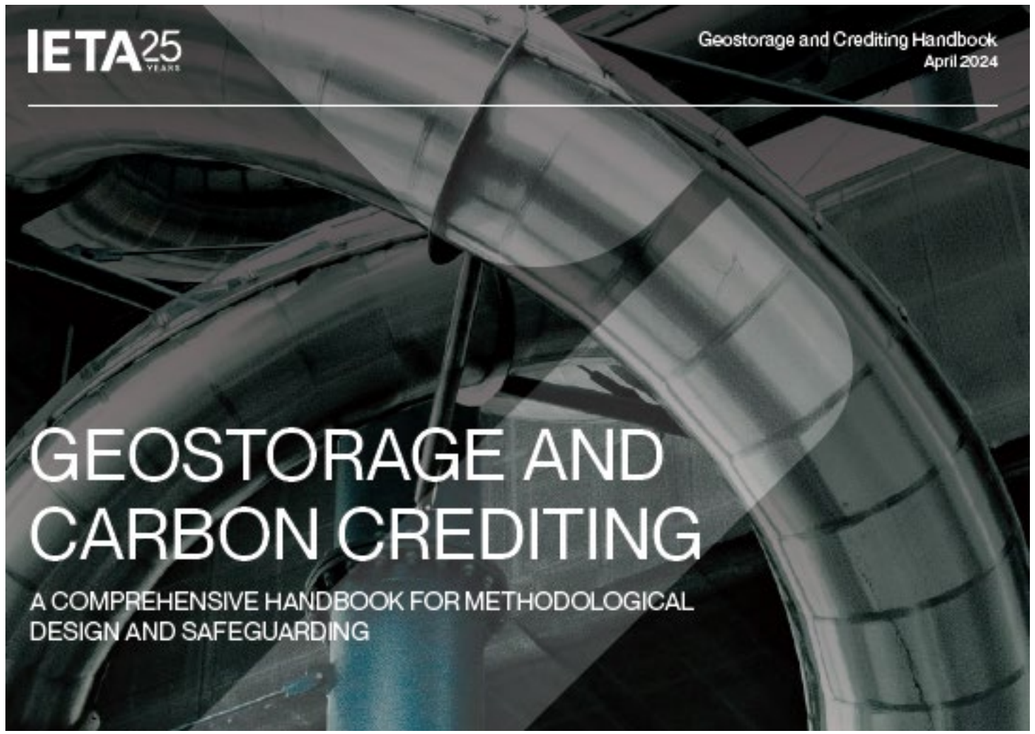
Note
Collecting information based experience of 30 CCS experts

CCS High Level Criteria

- Basic element to be reviewed for credits generation – detail methodologies and requirements are by each standard, ISO, regulation.
- Expected use: Support programs for CCS credits, checklist for stakeholders and information for regulation settings



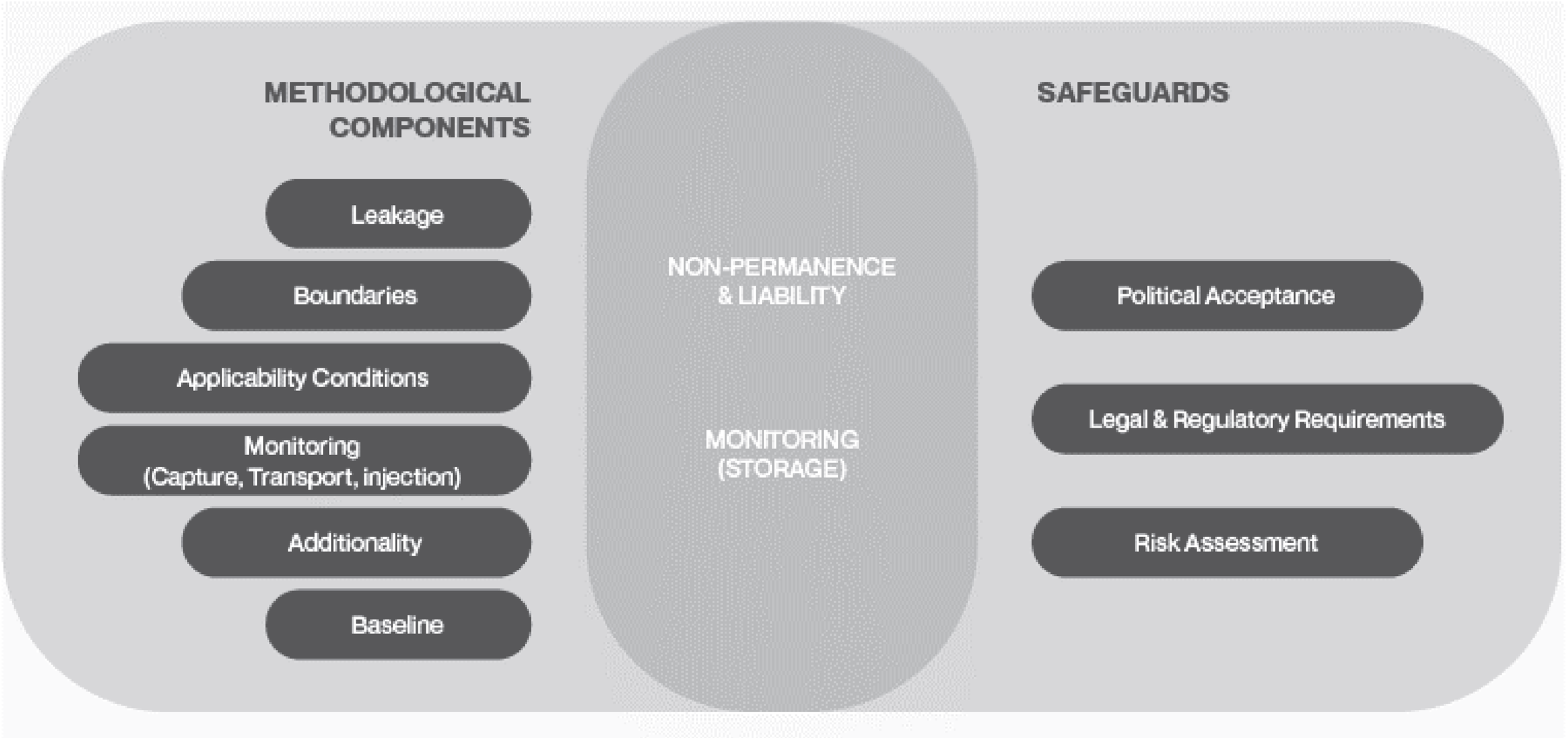
Launch event at Asia Climate Summit in Singapore
Dec. 2023



New version
April 2024, launch at European Climate Summit

IETA_GeoStorageCarbonCreditingHandbook_2024.pdf

Basic Structure of IETA HLC



METHODOLOGICAL COMPONENT		DESCRIPTION
01.	**APPLICABILITY CONDITIONS**	Defines the specific circumstances, attributes and other conditions that apply to eligible geological CO_2 storage activities. These can include the eligible sources of captured CO_2 (e.g. which types of CO_2 and from which sectors, both of which have implications for baseline selection; see below), the modes of transport, and the allowable storage media. Geographical and technical restrictions can also be applied (e.g. only countries with CCS laws; conditions on geostorage development/operations).
02.	**PROJECT BOUNDARY & LEAKAGE**	Defines the emissions by sources and removals by sinks that must be measured and accounted for across the capture>transport>storage chain (project boundary). Includes emissions occurring *outside* of the immediate control of the project operator (e.g. upstream emissions), but which are measurable and attributable to the project activity (i.e. 'leakage').
03.	**BASELINE**	Describes procedures and options to establish the *baseline scenario* and a methodology for calculating *baseline emissions.* The emissions from the project activity must be compared to the baseline to quantify the net emission reductions or carbon removals. Options include projection-based approaches (e.g. historical emissions, or estimated future emissions, without CO_2 capture) or standards-based approaches (e.g. using benchmark emissions of a comparable activity without CO_2 capture).
04.	**ADDITIONALITY**	Demonstration that the activity delivers emissions reductions/removals that would not have occurred absent of the incentive created by carbon credit revenues. Different approaches and tests exist for demonstrating additionality (e.g. first-of-a-kind (FOAK); regulatory surplus; financial additionality). The primary purpose of CO_2 capture is climate mitigation, which generally means that most projects will be additional. Novelty also means that FOAK or technology penetration rates can be used to rapidly demonstrate project additionality. Financial additionality testing may also be used to discern the value of crediting where other incentives (e.g. tax breaks) or benefits also exist (e.g. commercial CO_2 utilization).
05.	**NON-PERMANENCE & LIABILITY**	Methodologies should ensure that geological storage sites are appropriately characterized, selected, developed, managed and closed level to mitigate against the risk of carbon reversals (*quality assurance*). Liability to remedy the impacts of any carbon reversals must also be allocated *(liability allocation*). These safeguards can be implemented *either* by applying geographical applicability conditions (i.e. relying on local laws and regulations) and/or through other effective safeguards **(see safeguard criteria 05, 06, 07)**.
06.	**MONITORING**	Robust monitoring is needed to measure flows and emissions related to aboveground features of the activity and to check for CO_2 leaks in around the storage site. Results of monitoring are used to (i) quantify creditable reductions or removals and (ii) protect natural ecosystems and human health. The latter safeguard can be implemented *either* by applying geographical applicability conditions (i.e. relying on safety monitoring under local laws and regulations) and/or through other effective safeguards **(see safeguard criteria 08, 09)**.

SAFEGUARD AREA		HIGH LEVEL CRITERIA
POLITICAL ACCEPTABILITY	01.	SIGNIFICANT AND COST-EFFECTIVE FOR NATIONAL CLIMATE MITIGATION
	02.	ALIGNED WITH NATIONAL DEVELOPMENT PRIORITIES AND POLICY AIMS
	03.	PUBLIC ACCEPTANCE
LEGAL AND REGULATORY FRAMEWORK FOR SAFE STORAGE	04.	LEGAL BASIS FOR INJECTION AND STORAGE
	05.	EFFECTIVE SITE SELECTION AND DEVELOPMENT
	06.	ROBUST OVERSIGHT OF SITE OPERATION AND CLOSURE
	07.	LIABILITY FOR CARBON REVERSAL
ENVIRONMENTAL AND SOCIAL SAFEGUARDS	08.	RISK AND SAFETY ASSESSMENT
	09.	ENVIRONMENTAL AND SOCIAL IMPACTS
	10.	SUSTAINABILITY

SAFEGUARD AREA	HIGH LEVEL CRITERIA	DESCRIPTION	EXAMPLES OF EVIDENCE / CHECKPOINTS
POLITICAL ACCEPTABILITY	**01. SIGNIFICANT AND COST-EFFECTIVE FOR NATIONAL CLIMATE MITIGATION**	Technologies involving geostorage should be part of a host country's cost-optimized and Paris-aligned national mitigation pathway. The host country mitigation scenarios must have been developed cognizant of the UN Sustainable Development Goals (SDGs).	• Nationally Determined Contributions (i.e. inclusion of geostorage within mitigation scenarios and plans) • Long-term Low Emissions Development Strategies (i.e. inclusion of geostorage) • Techno-economic mitigation studies etc
	02. ALIGNED WITH NATIONAL DEVELOPMENT PRIORITIES AND POLICY AIMS	Technologies involving geostorage should be well aligned with the host country's national development plans, policies and sectoral programmes (e.g. economic development plans, energy sector development, industrial development strategy).	• Nationally Determined Contributions (i.e. demonstration of alignment with broader aims) • National development plans and strategies (e.g. economic development plans, energy sector development, industrial development strategy)
	03. PUBLIC ACCEPTANCE	Activities should only be credited where the host country government and political stakeholders accept the need for geostorage (e.g. undertaking of robust stakeholder consultation as part of national climate policy development).	• Nationally Determined Contributions (i.e. developed with broad public input) • Normal host country public consultation processes and procedures • *OECD Best Practice Principles on Stakeholder Engagement in Regulatory Policy*

SAFEGUARD AREA	HIGH LEVEL CRITERIA		DESCRIPTION	EXAMPLES OF EVIDENCE / CHECKPOINTS
LEGAL AND REGULATORY FRAMEWORK FOR SAFE STORAGE	**04.**	**LEGAL BASIS FOR INJECTION AND STORAGE**	Activities credited under international standards should be compliant with host country laws and regulations. The responsibility for governing the geological pore space into which CO_2 is injected and stored is typically vested into government (but sometimes the surface property owner). In some situations, protection of sub-surface resources may also trigger government permitting and oversight (e.g. groundwater protection). Appropriate permission must therefore be obtained to access and use geologic pore space for the purpose of storing CO_2.	• National laws (e.g. constitution; mineral laws etc that indicate ownership of geological pore space and procedure(s) by which access is conferred to economic operators/private entities). • *CDM CCS Modalities and Procedures* (requirements outlined in Appendix B)
	05.	**EFFECTIVE SITE SELECTION AND DEVELOPMENT**	In permitting the use of geological pore space for CO_2 storage, the pore space owner should ensure protection of natural resources and public health and safety. The safety and security of storage in a proposed geological storage site must be appropriately demonstrated prior to the granting of access and use permission (through e.g. robust site characterisation and selection reports and development, operation and closure plans).	• National laws and regulations (e.g. mineral or petroleum development laws; environmental protection laws; dedicated geological storage law) • *2006 IPCC Guidelines Volume 2, Chapter 5: Carbon Dioxide Transport, Injection and Geological Storage* (Requirements in Section 5.10 include reporting of site characterisation and selection, modelling, monitoring plan design, monitoring etc.) • *CDM CCS Modalities and Procedures* (Appendix B) • *ISO Standard 27914:2017 - Geological Storage*
	06.	**ROBUST OVERSIGHT OF SITE OPERATION AND CLOSURE**	Geological storage activities must be operated respecting the conditions specified in storage site permits with appropriate oversight of a competent body (i.e. modes of development, operation and closure).	• National laws and regulations (clarifying the competent authority and their regulatory powers)
	07.	**LIABILITY FOR CARBON REVERSAL**	Responsibility for CO_2 stored in geological formations must be appropriately allocated to ensure that remedial measures are implemented in the event of a leak/carbon reversal from a geological storage site.	• Liability arrangements (e.g. national laws on environmental liability; mineral/petroleum laws; geological CO_2 storage law) • Liability transfer arrangements (e.g. aligned with the cessation of monitoring described in the *2006 IPCC Guidelines Volume 2, Chapter 5*) • Non-permanence risk tool (NPRT) applied by registry operator

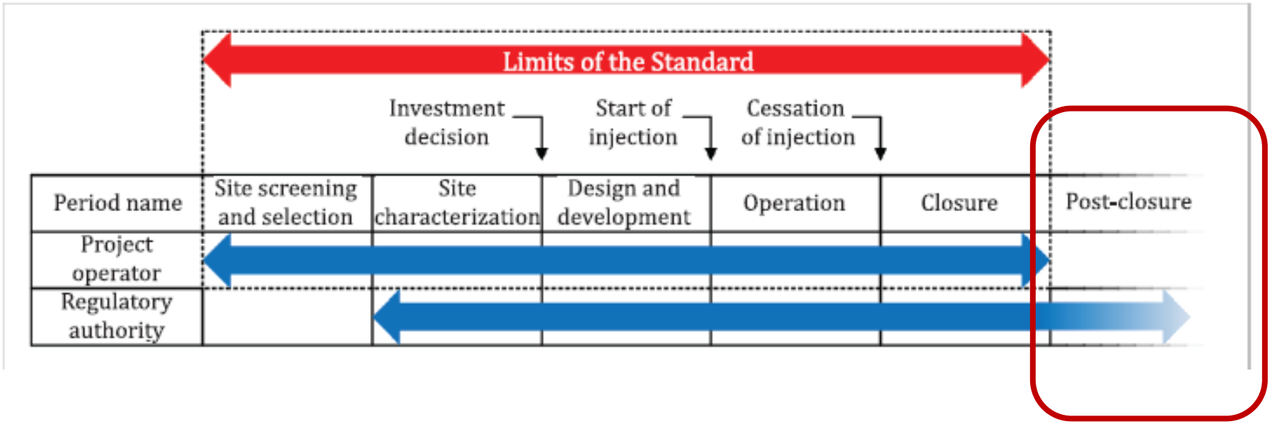
SAFEGUARD AREA	HIGH LEVEL CRITERIA	DESCRIPTION	EXAMPLES OF EVIDENCE / CHECKPOINTS
ENVIRONMENTAL AND SOCIAL SAFEGUARDS	**08. RISK AND SAFETY ASSESSMENT**	Geological domains are inherently heterogenous, each having unique characteristics that influence the safety, durability and non-permanence risk of storage. Risks from CO_2 leaks therefore need to be suitably assessed and managed on the basis of site-specific characteristics within a proposed geological storage site, its surrounding domains and the proposed modes of development and operation. Inherent uncertainty in geological analysis means that this must be based on scenarios of specific features and potential events and processes that could occur at the specific site in order to understand the scale and magnitude of potential impacts (i.e. risks).	• National laws and regulations • *ISO Standard 27914:2017 - Geological Storage* (Section 6: Risk Assessment) • *CDM CCS Modalities and Procedures* (Appendix B)
	09. ENVIRONMENTAL AND SOCIAL IMPACTS	The nature of the impacts of leaking CO_2 of an individual project needs to be understood in the context of the scenarios identified in the risk and safety assessment (e.g. communities, natural ecosystems). Measures must be taken to mitigate and mange such risks and impacts.	• National laws and regulations • *ISO Standard 27914:2017 - Geological Storage* (Section 6: Risk Assessment) • *IFC Performance Standards on Environmental and Social Sustainability (Performance Standard 1: Assessment and Management of Environmental and Social Risks and Impacts*)
	10. SUSTAINABILITY	Sustainability impacts and benefits of an individual project must be appropriately demonstrated (e.g. tangible co-benefits and/or contributing towards multiple United Nations SDGs). Corporate social responsibility should be part of project deployment (as appropriate to the project setting). For example, implementation could be accompanied by community support programmes and knowledge sharing, education and engagement actions relating to climate change and its mitigation through geologic CO_2 storage.	• *CDM Sustainable Development co-Benefits Tool* • *ISO Standard 37101:2016 - Sustainable development in communities* • Project-level standard requirements for sustainability (e.g. The Gold Standard requirement to deliver on at least 3 SDGs, including climate action (SDG 13))

Hot issues for crediting and IETA HLC

◆ Permanence/reversal risk

⇒ Methodological component 5: Non-permanence & Liability

✓ refer to ISO27914



ISO 27914 (Geological CCS)

4 Management systems
5 Site screening, selection, and characterization
6 Risk management
7 Well infrastructure
8 CO2 storage site injection operation
9 Monitoring and verification
10 Site closure
10.2 Criteria for site closure
10.3 Closure plan
10.4 Closure qualification process

◆ Negative views on the use of fossil fuel

⇒ Political acceptability:

✓ ‘should be part of a host country’s cost-optimized and Paris-aligned national mitigation Pathway’

✓ ‘should be aligned with host country’s national development plan’

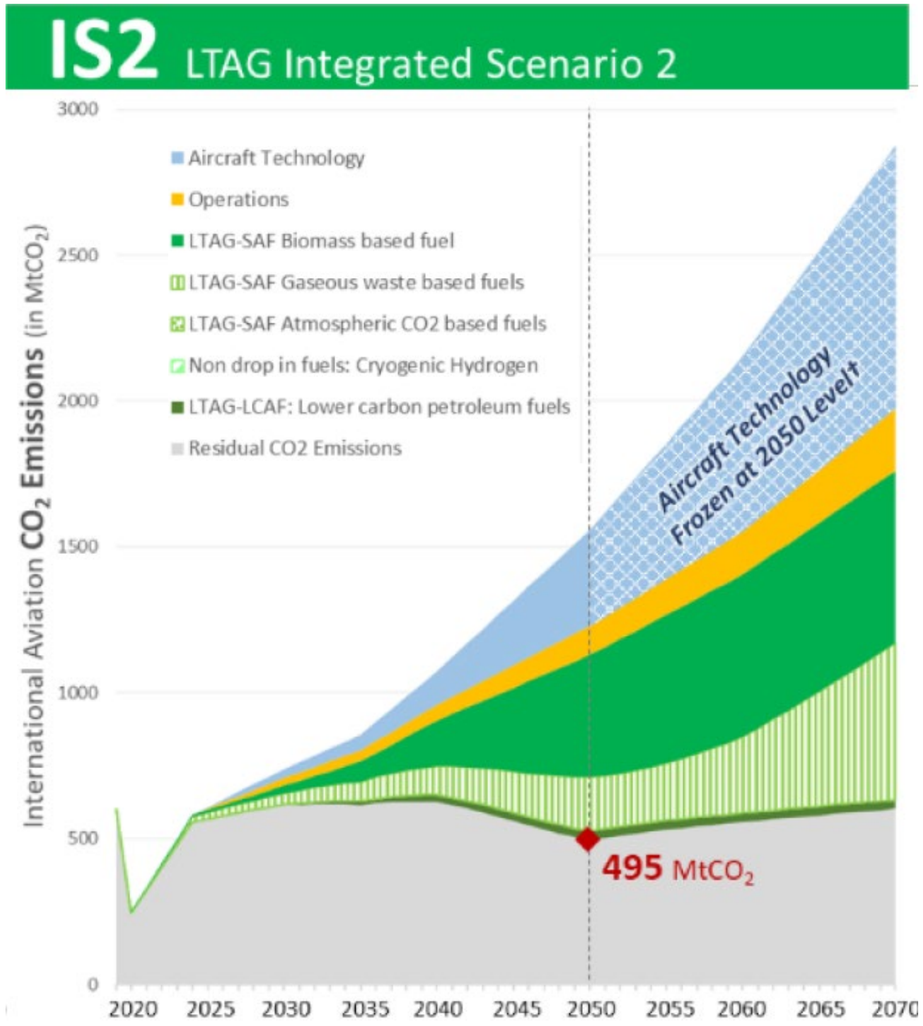
⇒ Environment safeguard & social acceptance

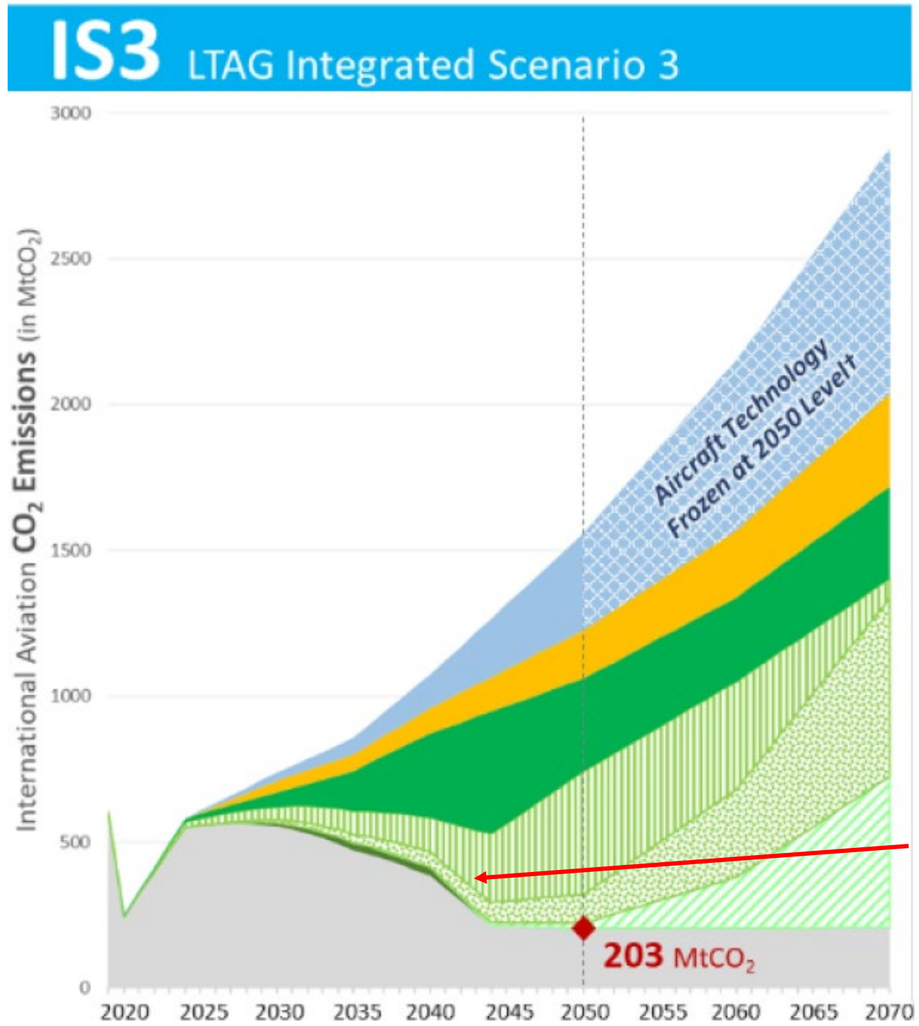
✓ Communication is a key

New opportunity for CCS
- Lower Carbon Aviation Fuel -

Case – International Aviation

- Zero or lower emission fuel plays important role. SAF＋CCS and LCAF are recognized as option.
- It is considered offset by credits from DACCS and BECCS will be used.





SAF
(SAF + CCS(ethanol production))

E-Fuel
(DAC + Hydrogen)

LCAF (Jet Fuel CCS)

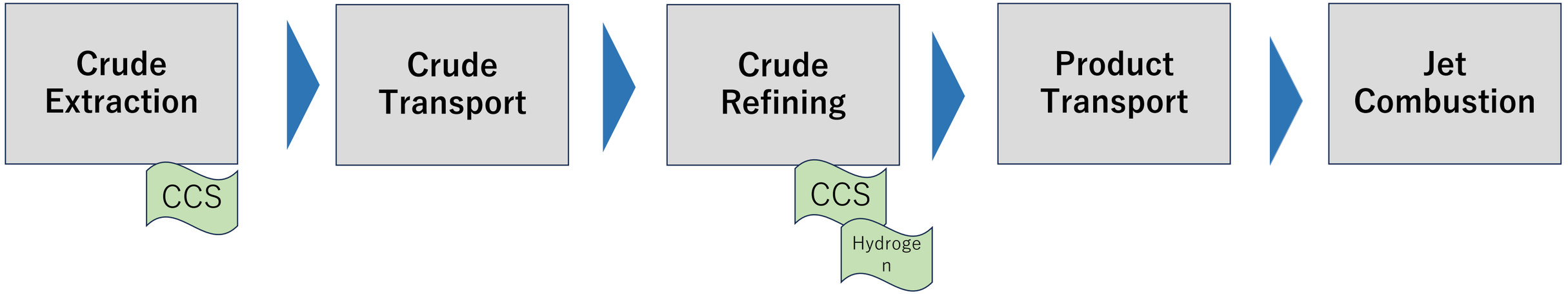
Offset by negative emission credits (DACCS, BECCS)

LCAF (Lower Carbon Aviation Fuel) and CCS

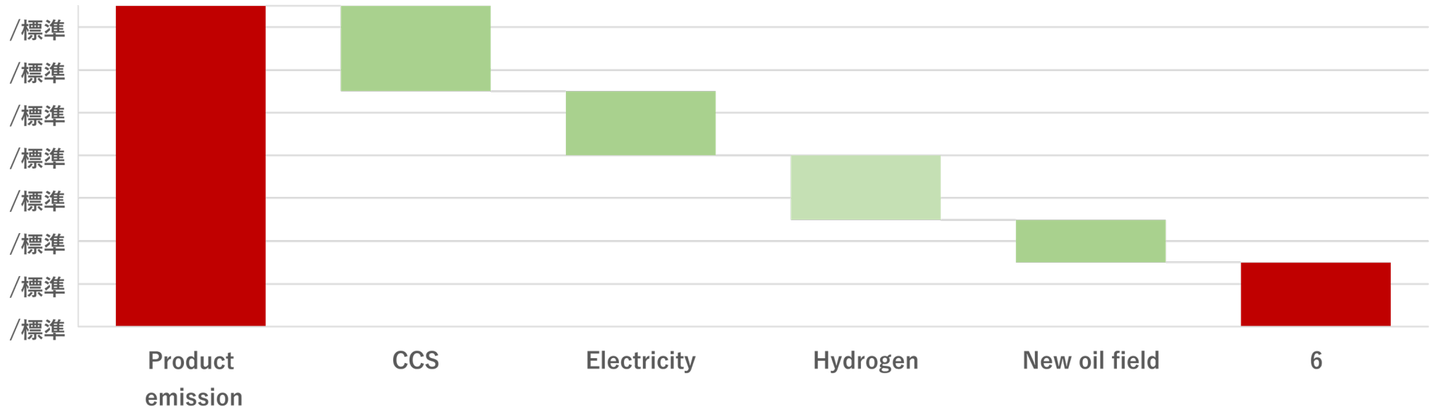
LCA emission (89gCO2/MJ)

Production emission (15gCO2/MJ)

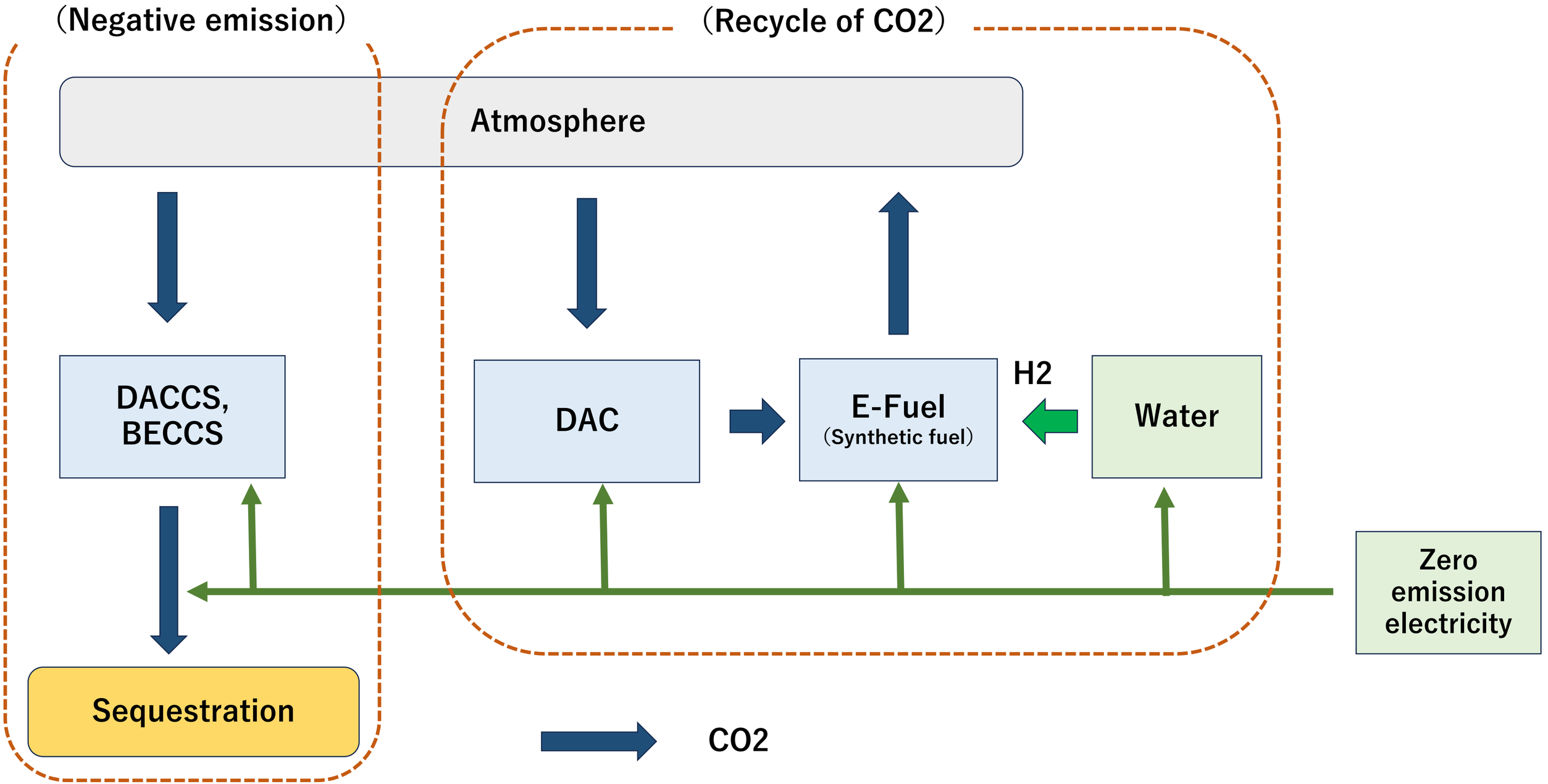
Fuel burn emission (74gCO2/MJ)



gCO2/MJ



CO2 Removal and recycle of CO2



CORSIA Sustainability Criteria for CORSIA Eligible Fuels

1. Greenhouse Gases (GHG)	CORSIA SAF should generate lower carbon emissions on a life cycle basis.
2. Carbon stock	CORSIA SAF should not be made from biomass obtained from land/aquatic systems with high biogenic carbon stock.
3. Greenhouse gas Emissions Reduction Permanence	Emissions reductions attributed to CORSIA SAF should be permanent.
4. Water	Production of CORSIA SAF should maintain or enhance water quality and availability.
5. Soil	Production of CORSIA SAF should maintain or enhance soil health.
6. Air	Production of CORSIA SAF should minimize negative effects on air quality.
7. Conservation	Production of CORSIA SAF should maintain biodiversity, conservation value, and ecosystem services.
8. Waste and Chemicals	Production of CORSIA SAF should promote responsible management of waste and use of chemicals.
9. Seismic and Vibrational Impacts	Not applicable
10. Human and labour rights	Production of CORSIA SAF should respect human and labour rights.
11. Land use rights and land Use	Production of CORSIA SAF should respect land rights and land use rights including indigenous and/or customary rights.
12. Water use Rights	Production of CORSIA SAF should respect prior formal or customary water use rights.
13. Local and social Development	Production of CORSIA SAF should contribute to social and economic development in regions of poverty.
14. Food security	Production of CORSIA SAF should promote food security in food insecure regions.

CORSIA Sustainability Criteria and IETA HLC

CORSIA Sustainability Criteria	IETA HLC
1. Greenhouse Gases (GHG)	Methodological Components, Safeguard – Political Acceptability
2. Carbon stock	Safeguards- Environment Social Impacts
3. Greenhouse gas Emissions Reduction Permanence	Methodological Components – Non-permanence & Liability, Safeguard – legal and regulatory framework
4. Water	Safeguards- Environment Social Impacts
5. Soil	Safeguards- Environment Social Impacts
6. Air	Safeguards- Environment Social Impacts
7. Conservation	Safeguards- Environment Social Impacts
8. Waste and Chemicals	Safeguards- Environment Social Impacts
9. Seismic and Vibrational Impacts	Safeguards- Environment Social Impacts
10. Human and labour rights	Safeguards- Sustainability
11. Land use rights and land Use	Safeguards- Sustainability
12. Water use Rights	Safeguards- Sustainability
13. Local and social Development	Safeguards- Sustainability
14. Food security	Safeguards- Sustainability

Conclusion - recommendation

Carbon market(s) can contribute to support CCS/CCUS, but it needs to further actions by governments for using carbon market

1/ Political recognition
- ✓ **Inclusion of CCS for NDC - Revie and submission of NDC before COP30 in 2025**

2/ Regulatory framework
- ✓ **Permanence – post closure liability and economic measures**

3/ Public acceptance
- ✓ **Communication with stakeholders**

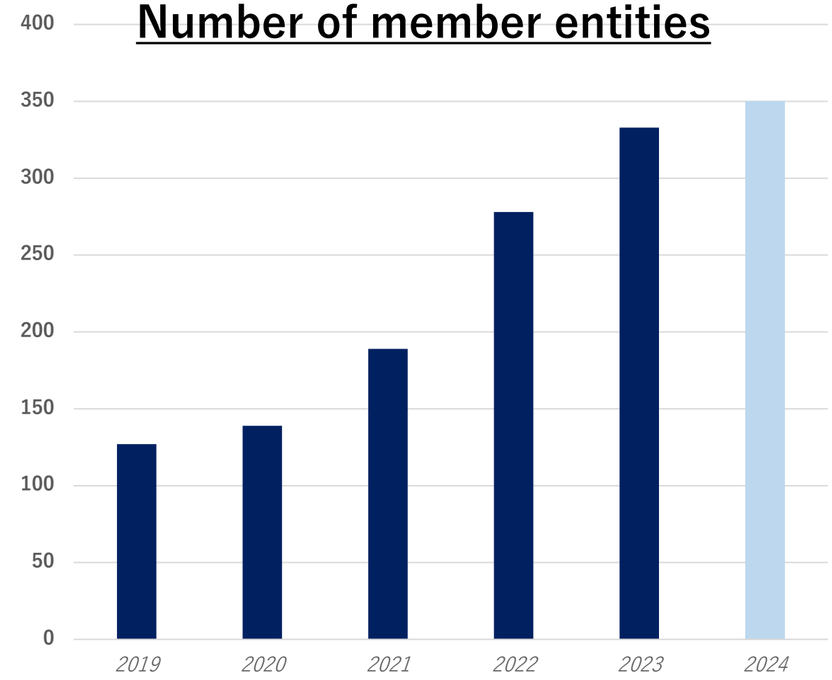
4/ Gap filling finance
- ✓ **Gap financing in addition to further cost reduction is needed**

5/ Rules of carbon accounting for cross boarder CCS
- ✓ **Proper accounting of National Inventories of both export and receiving countries**
  - **Corresponding Adjustment to avoid double accounting double accounting**

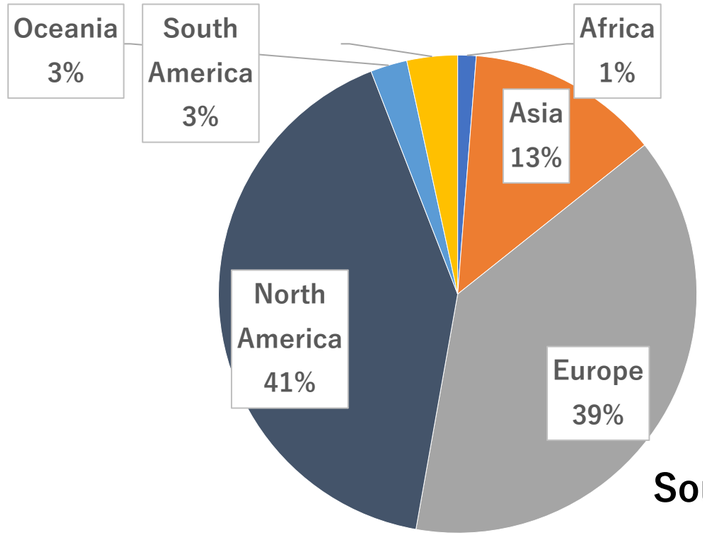
About IETA

Carbon markets and International Emission Trading Association

- **IETA'S MISSION IS TO:**
- Empower business to engage in climate action and pursue net zero ambitions to advance the Paris Agreement's objectives, and
- Establish effective market-based trading systems for GHG emissions and reductions that are environmentally robust, fair, open, efficient, accountable and consistent across national boundaries.



- **IN PURSUIT OF OUR MISSION, IETA WORKS IN COLLABORATION WITH OTHER STAKEHOLDERS TO:**
- Develop components of the GHG market and trading systems
- Develop a global GHG market
- Strengthen business capacity and embrace innovation
- Promote market-based solutions and broad participation in GHG markets



Source IETA,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cCarbon
CEEZER
cenovus ENERGY
centrica
CERCARBONO
cfp energy
Chevron
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citi
TRADE
CLEAR BLUE MARKETS
CLIMATE ACTION RESERVE
Climate Asset Management
Climate Collective
CLIFI
CLIMATE IMPACT PARTNERS
Climate Impact X
Climate Neutral Group
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GO2
Goldman Sachs
GreenAssets
GREENBOX THINKING
GSS Green Savings Scheme
GREEN STAR ROYALTIES
國泰君安國際
Hartree
HATCH
HEARTLAND GENERATION
HFW
HITACHI Inspire the Next
Hydro
Iberdrola
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Kepos Capital
Key Carbon
KIS Group SUSTAINABILITY
Kita
We Insure Carbon
klik
Foundation for Climate Protection and Carbon Offset KLIK
KOCH SUPPLY & TRADING
King & Spalding
KOSHER CLIMATE
KPMG
LafargeHolcim
LAND LIFE
LATHAM & WATKINS
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MEO
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NatWest
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千予CIQYH
Acorn
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Removall CARBON
ReNew
REPSOL
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Respira
RETURN
Revalue Nature
RioTinto
RBC
RUBICON CARBON
RUBY CANYON ENVIRONMENTAL
RWE
S&P Global Platts
Santos
aramco
SCB
SEAGRASS
SEFE MARKETING & TRADING
SheppardMullin
SilviCarbon
SOLSYSTEMS
south pole
Standard Chartered
Statkraft
STEEL WOOD
StoneX
STX
Sumitomo Corporation
SUNCOR ENERGY
SUSTAINCERT
Svante
SWEEP
Sylvera
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TC Energy
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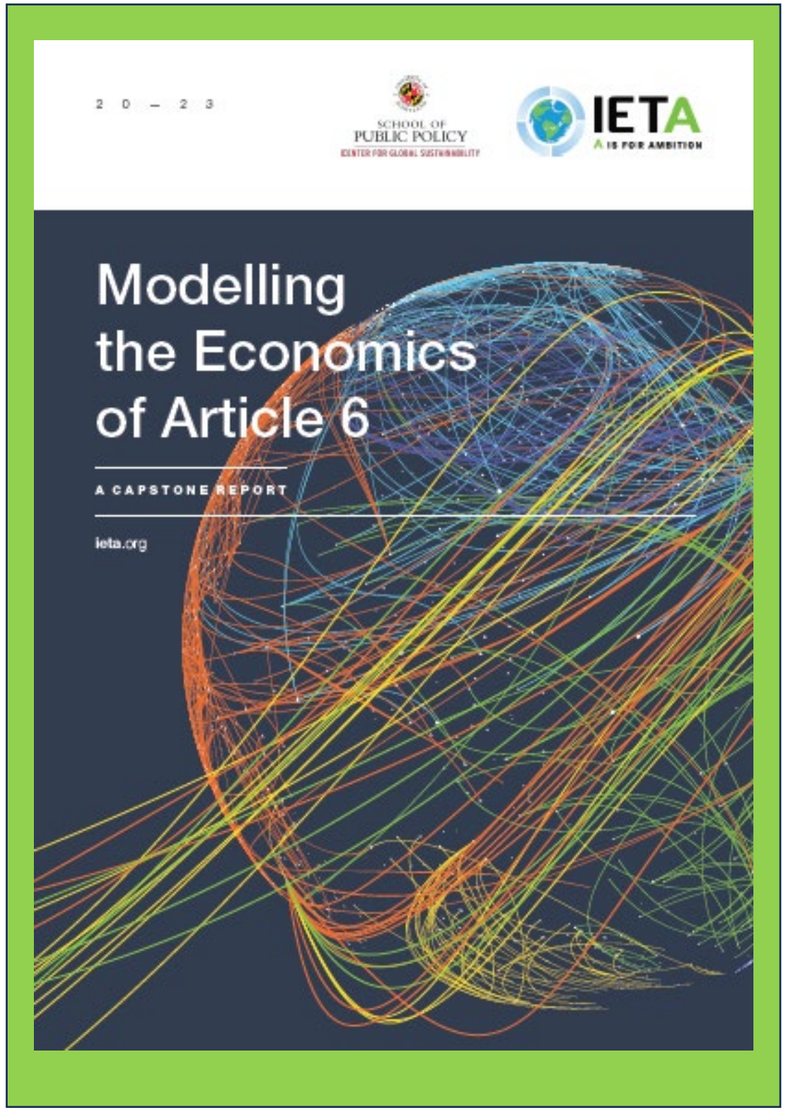
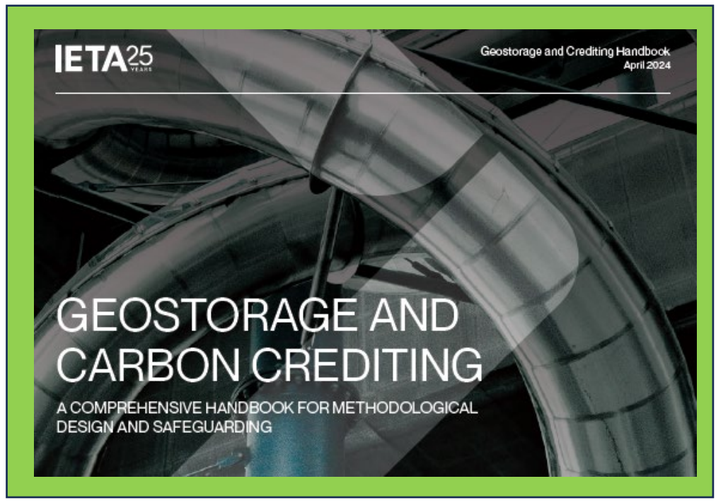
THE CLIMATE TRUST
TIMING CARBON
TOITŪ ENVIROCARE
TOKYO GAS
TotalEnergies
Toucan
TOURMALINE
Tradewater
Trafigura
Trailstone
UNICARBO
uniper
VALITERA
VATTENFALL
VERRA
VERTIS
veyt
vibrant planet
VIDA CARBON
viresco Solutions
viridios GROUP
ViridisTerra
Vitol
vivideconomics
VNV Advisory
VOLKSWAGEN CLIMATEPARTNER
wallaby
WasteBox
WILDLIFE WORKS
WOLF MIDSTREAM
Woodside
Xpansiv
永苔顧問股份有限公司 YC Holdings Inc.

IETA

Infrastructure for carbon market development



Economic model analysis



CCS High Level Criteria

Code of Best Practice for Digital Market

Integrity criteria

Meta registry

Policy Dialogue and Project Development

- ◆ Asia Climate Summit 2023 – October 2023 in Tokyo
- ◆ Over 550 participants from the world and both public and private sector

e.g. Japanese carbon market - GX ETS

⇒ Voluntary to regulation, price and demand, eligible credits, who participate etc.

Asia Climate Summit 2023 in Tokyo

Japan WG – regional market

Japanese carbon market as Hub of Asian markets
- compliance market (GX ETS; J-Credits and JCM are core credits
- Supply source of JCM; 29 partner countries
- Both compliance and voluntary credits but priority on compliance market
- Connecting with Asia and Pacific markets
- Invite gust speakers from various countries

24 Oct. 2023 In-person meeting in Tokyo
Most of meetings are online

Agenda of Japan WG (track record)

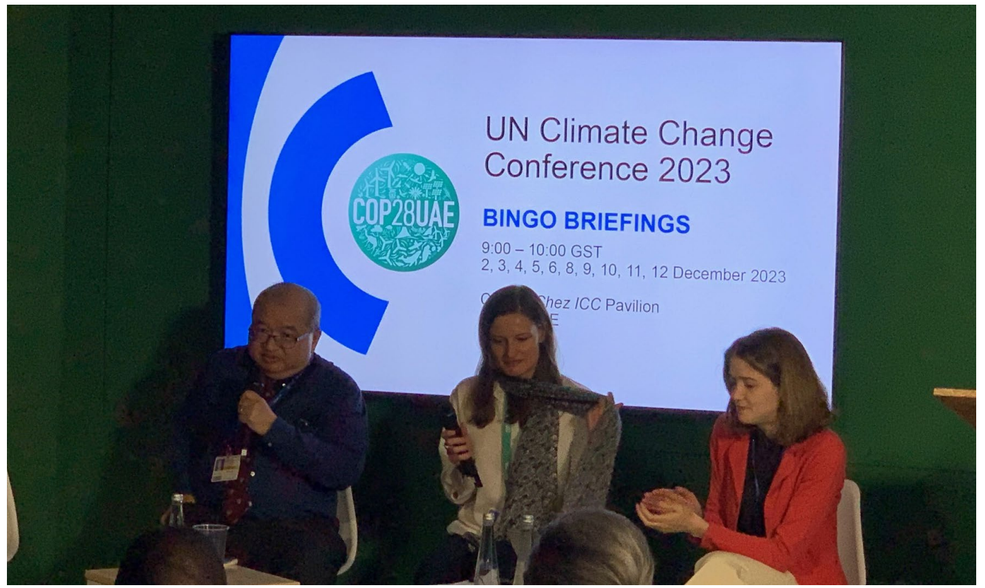
- Overviews of GX ETS and demand for credits
- Procedure of private sector JCM
- Trading platform (Tokyo Stock Exchange)
- COP decision and progress of Article 6
- Feedback of various events by IETA
- Overviews an prospects of national markets e.g. Indonesia
- Code of Best practice of voluntary market
- Collaboration of other reginal WG, ANZO WG

Series of business conferences and events in COP

European Climate Sumit 2024

Latin America Climate Sumit 2024

North America Climate Sumit 2024



COP28, Bingo

5. CARBON ACCREDITATION FOR CCS PROJECTS

Mitsubishi Research Institute, Inc (MRI)

Tetsuya Nomoto, Senior Researcher

Positioning Carbon Capture Storage (CCS) in Carbon Pricing to Decarbonise in ASEAN

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ASEAN CENTRE FOR ENERGY • ACE •

Asia Natural Gas & Energy Association

Positioning Carbon Capture Storage (CCS) in Carbon Pricing to Decarbonize in ASEAN

South East Asia CCS Accelerator (SEACA) Workshop
Part III: Creating a Transnational Asian CCS Value Chain

28 August 2024

Mitsubishi Research Institute

Center for Policy and the Economy / Energy & Sustainability Division

Tetsuya NOMOTO

Strength of MRI

Mitsubishi Research Institute (MRI) is “aleading Think Tank” in Japan.

Our Strength ～Supporting Policy-Making for Social Challenges～

Policy

- MRI has been **deeply involved for decades in the policy formulation and operation** of Japanese public sector, which forms the foundation for the country.
- MRI has established **strong relationships with key ministries**.

METI Ministry of Economy, Trade and Industry

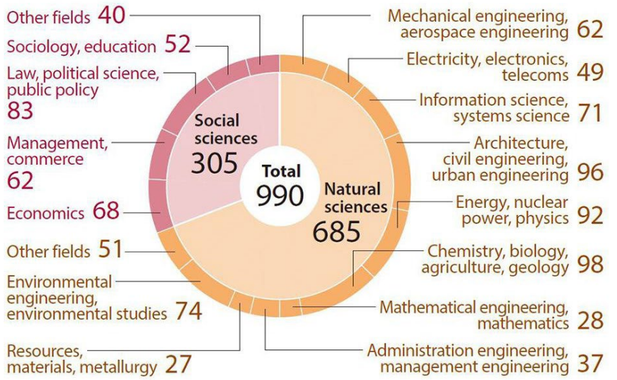
Prime Minister of Japan and His Cabinet

Ministry of the Environment Government of Japan 環境省

Technology

- Around **70% of the about 1,100 researchers and consultants** have degrees in science and technology.
- **Knowledge of the cutting-edge technologies** in various fields, MRI curries out its business.

Researchers' academic specialties (as of September 30, 2023)



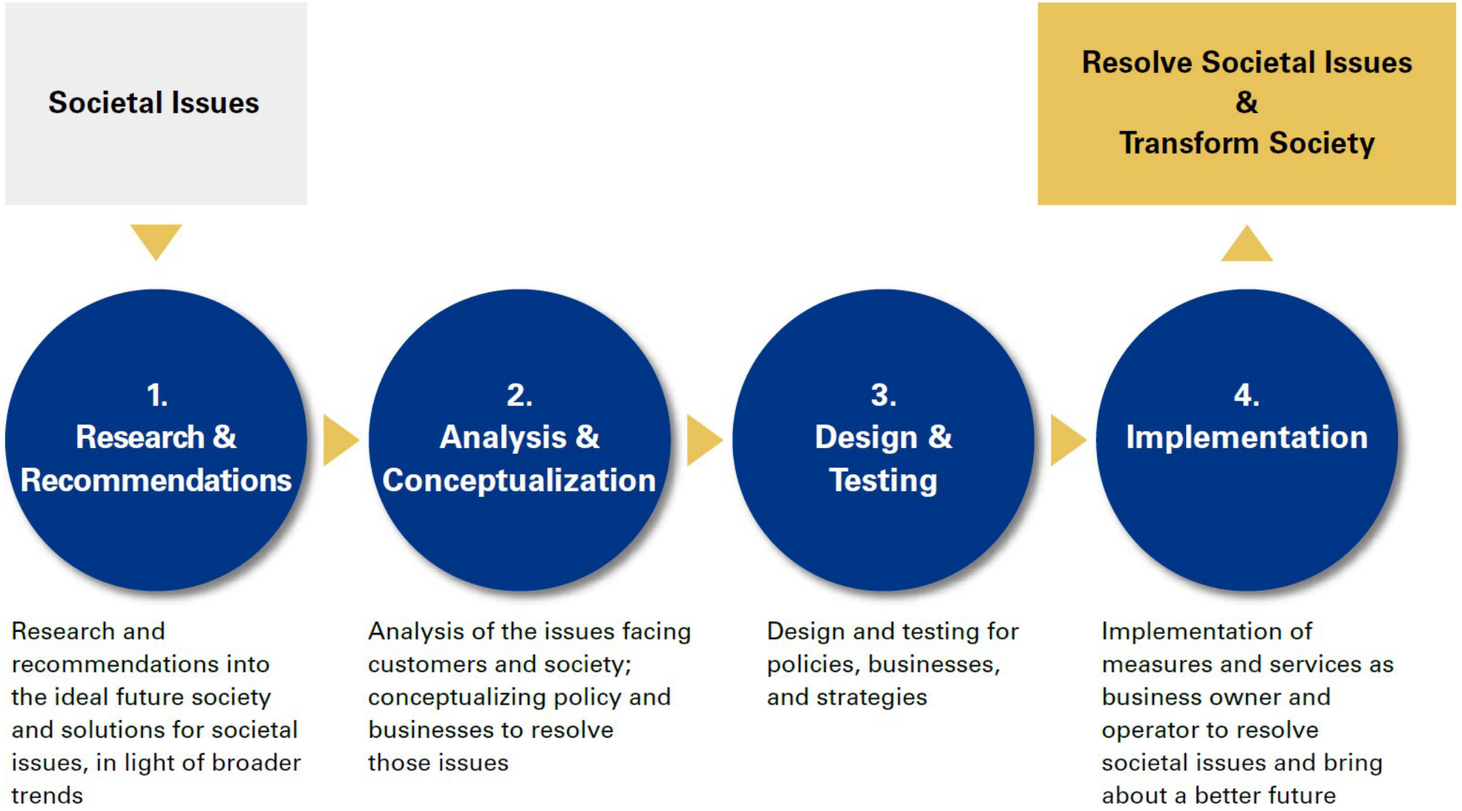
Multi Sector Hub

- **Collaboration with companies and academic institutions** in the process of policy formulation with government agencies.
- MRI serves as a **hub connecting industry, government, and academia** in Japan.

Mission and Value Creation Process

Corporate Mission: Resolve societal issues and co-create a sustainable, abundant future

Corporate Vision : Envisioning the future, leading change



Wide range of experiences in the CCUS field

Conducting research on the business environment for the promotion of CCUS in other countries, as well as developing domestic and international discussions and lobbying on future business models, on behalf of the Ministry of Economy, Trade and Industry, JOGMEC and ERIA.

Survey of the CCUS business environment

- Status of legal systems in major CCS countries (US, Canada, Europe, Australia, Indonesia, etc.)
- Identification of business risks.
- Status of application of carbon credits.

CCS potential mapping

- Identification of major emission sources and sinks in major South-East Asian countries.

Support for formulation of CCUS

- Support for conducting feasibility studies for JCM implementation (JCM methodology study)
- Cooperation with partner governments

Consideration of ways to promote CCUS in Asia

- Dispatch of Information/knowledge sharing (e.g. holding workshops)
- Holding of WS on crediting CCS
- Support for the development of GHG calculation guidelines, etc.
- Study on whole concept of CO2 transboundary transport.

CCUS technology-owning companies survey

- Creation of technical lists.

CCS economic feasibility study

Organised the world's first comprehensive workshop on cross-border CO2 transport (8 Feb 2024).

Discussions included :

- Current state of regulatory framework in Asia and Europe and international standards
- Opportunities and challenges in ongoing projects

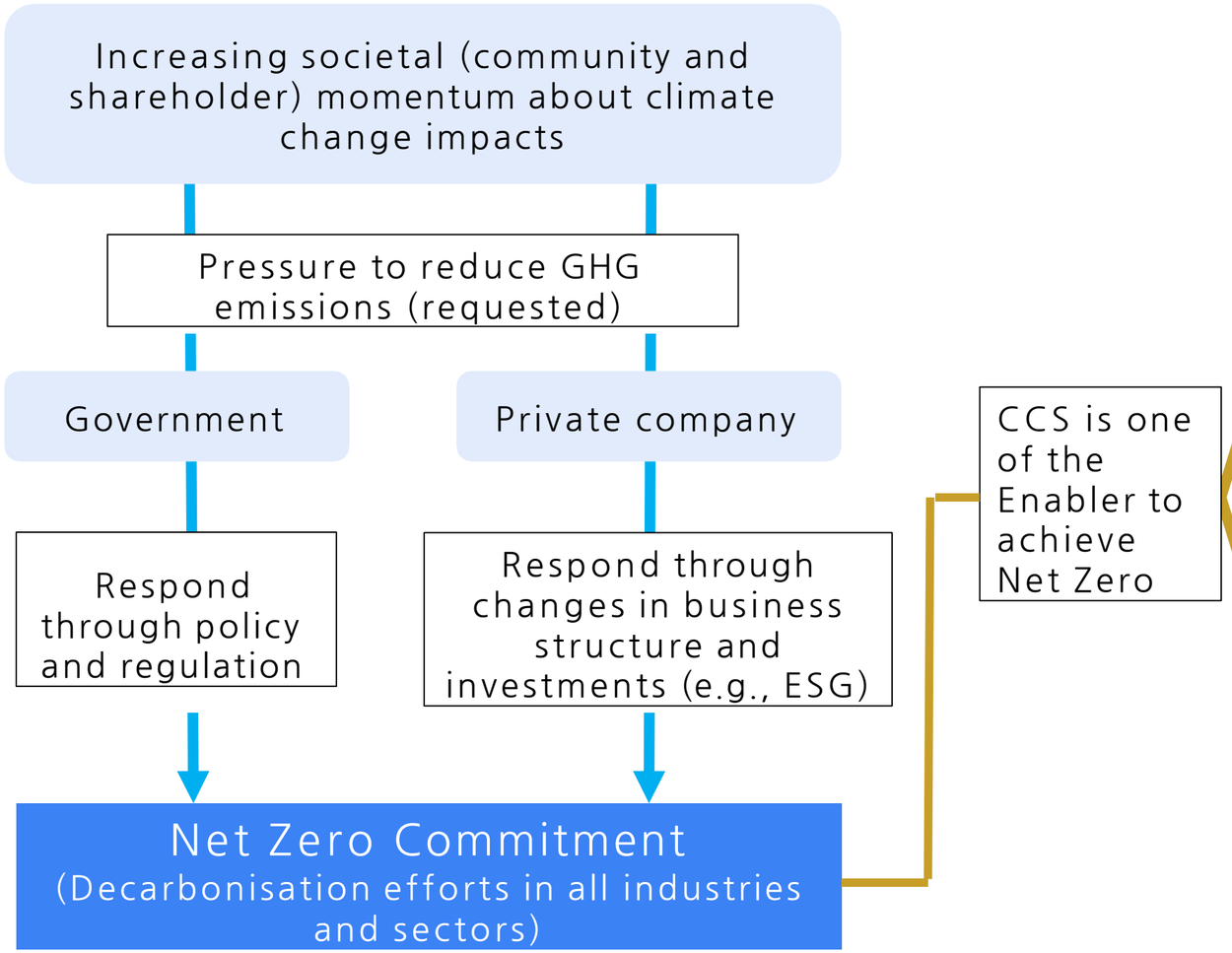
Presented a topic on the position of CCS in the ASEAN workshop on carbon pricing.

Discussions included :

- Carbon pricing was acknowledged as a catalyst tool that can promote RE penetration and support the implementation of clean technologies such as CCS technology.

Background

Growing Momentum Toward Carbon Neutrality: Expectation and Concerns for CCS



＜Expectations for CCS＞

- Realization of decarbonization in Hard-to-Abate sectors
- Realization of large-scale production of low-emission fuels (blue hydrogen and ammonia)
- Realization of low-emission power sources (*countermeasures at load-following thermal power plants to stabilize electricity supply)
- Realization of negative emissions

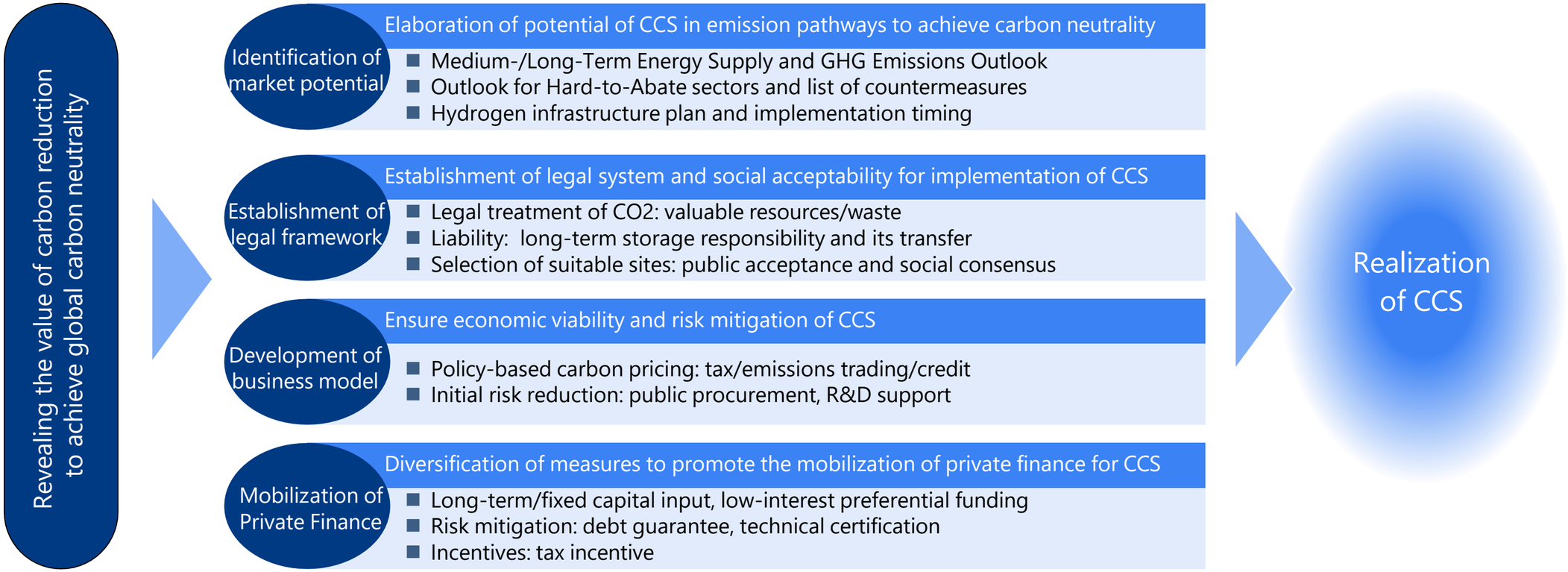
＜Concerns about CCS＞

- Lock-in technology for fossil fuel
- Negative impact on community and environment around storage sites
- Stagnation of other countermeasure initiatives and funding
- Delay in countermeasures due to characteristics of large-scale infrastructure (high cost, long lead time)

Source) Created by MRI

Business Environment Development is Essential to Realize CCS

- The development of a business environment through cooperation between the public and private sectors and among neighboring nations are essential.
- Accelerate development of the business environment through harmonizing between R&D and grand design planning led by the private sector, supported by public funding and policy approaches.



Source) Created by MRI

CCS Requires Combined in Different Incentive Scheme

- Since pure-CCS does not generate revenue on its own, incentives scheme for business development are essential.
- Most CCS projects currently in operation benefit from some form of public support.

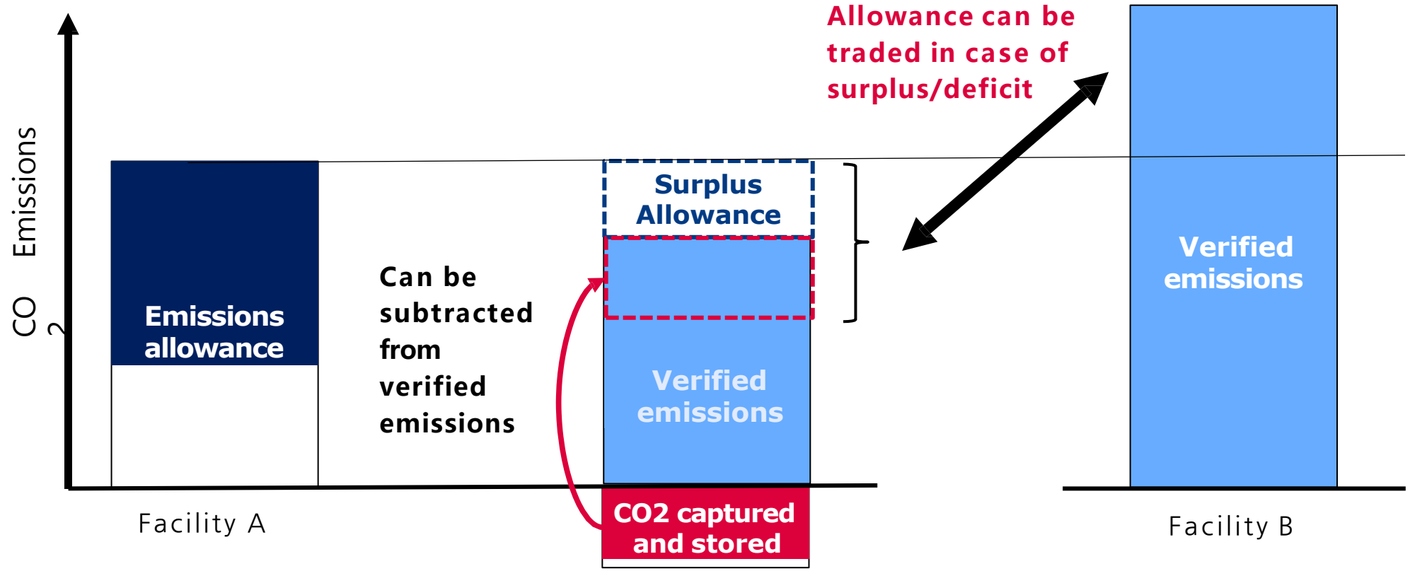
Main Incentive Scheme for CCS Development

Target	Approach	Examples
Capital Expenditure (CAPEX)	Direct Subsidy	Norway, Alberta, Australia, etc.
	Investment Tax Credit	Canada
	Contract for Difference (CfD)	UK (Under consideration)
Operating Expenditure (OPEX)	Direct Subsidy	Norway (Free transportation and storage charges), Alberta
	Tax Credit	USA (45Q)
	Carbon Pricing (ETS, Carbon Taxes, Carbon Credit)	Norway (Carbon Tax, EU-ETS) Alberta (TIER & AEOS), Australia (Safeguard Mechanism & ERF)
	Carbon Storage Unit/ Carbon Storage Obligation	-
Financing	Public equity investments, Concession Loan, Loan guarantee, etc.	-

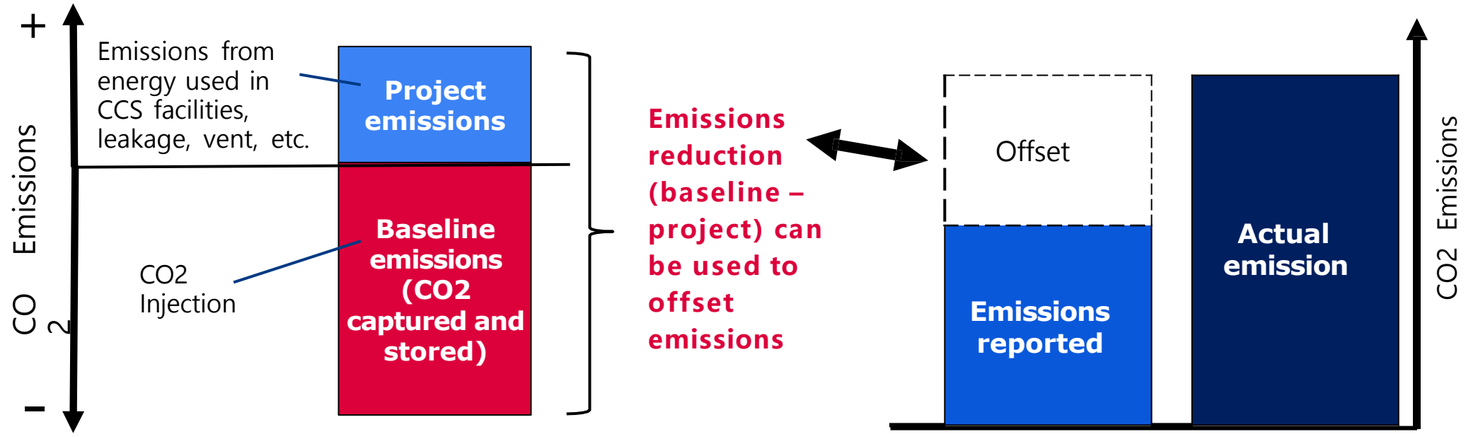
Positioning Carbon Capture Storage (CCS) in Carbon Pricing

Carbon Market in CCS is roughly Characterized by Cap and Trade (C&T) and Baseline & Credit (B&C)

1) Cap and Trade (facility based)



2) Baseline and Credit (project based)



Source) Created by MRI

Combination of Upstream and Downstream Regulations Varies by Country/Region

How fuel prices and regulations on fuel suppliers are combined:

- **Upstream Regulations**: Fuel suppliers be subject to ETS or to separate fuel standard
- **External Carbon Credit:** Use of carbon credits for CCS and EOR

Examples of Regulatory Frameworks Involving CCS

Region /Country	Fuel Supplier e.g. fuel distributers/importers [Upstream Regulation]	Fuel Consumer e.g. Generation, Industry [Downstream Regulation]	Use of External Carbon Credit
Germany	• National ETS for fuel supply for building and road transport sectors (Fuel supplier to ETS facilities are exempt from the national price)	• EU-ETS	• EU-ETS regulates the use of international credit
Australia (*1)	-	• Safeguard Mechanism (reformed in 2023)	• ERF credit for Safeguard Mechanism (CCS is eligible)
Alberta, Canada (*2)	• Federal Clean Fuel Standard (FCFS)	• Federal Fuel Charge • Provincial OBPS (TIER)	• CCS is eligible for FCFS • AEOS credit for TIER (CCS/EOR are eligible)
California, US (*3)	• Low Carbon Fuel Standard (LCFS)	• California ETS	• CCS is eligible for LCFS • ACR (CCS/EOR are eligible)

*1) ERF: Emission Reduction Fund,
*2) OBPS: Output-based Pricing System, TIER : Technology Innovation and Emission Reduction, AEOS: Alberta Emission Offset System
*3) LCFS: Low Carbon Fuel Standard

Source) Created by MRI based on various literature

Carbon Crediting by CCS Has Already Started

Common Issue to Consider CCS Carbon Credit:

- **Type of eligible CCS activities**: Eligibility of CCS-EOR in transition to CN
- **Long-term monitoring:** Credit buffer and site closure, etc.
- **Avoidance of double counting**: Capturer or injector
- **Consideration of multiple CO2 sources added in various phases using common infrastructure:** repercussions on monitoring regimes and CO2 ownership

Example Carbon Credit Scheme for CCS

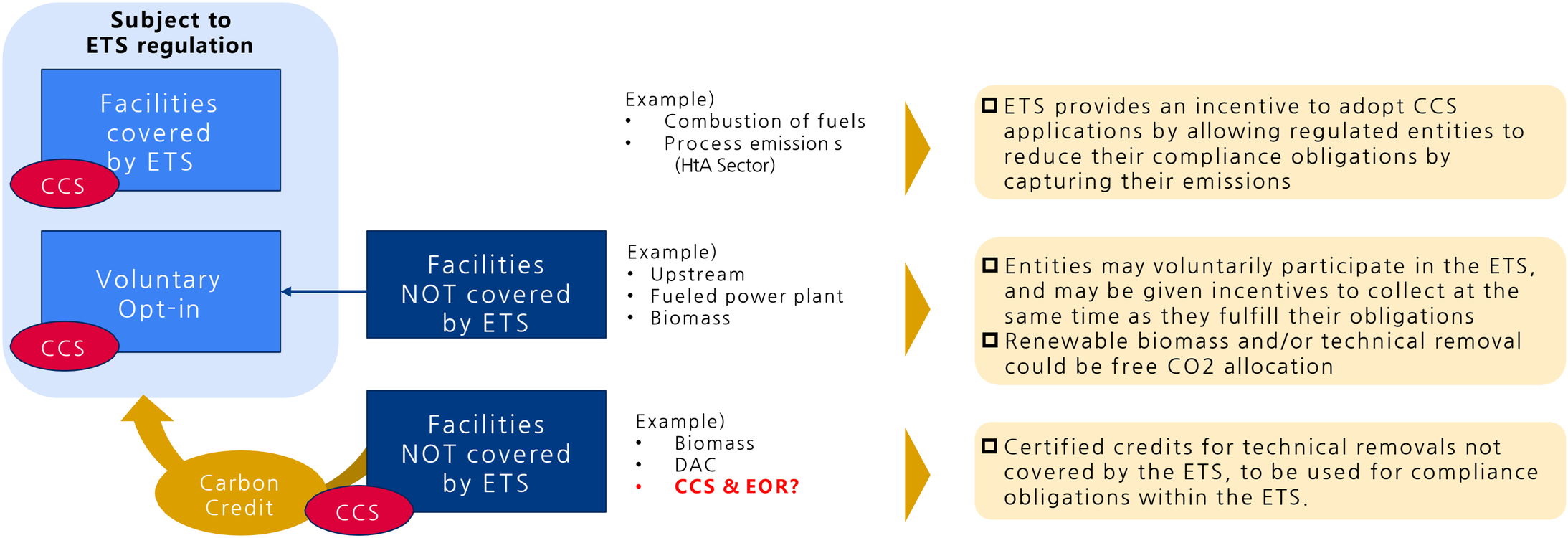
Region /Country	ACR (USA)	AEOS (Alberta, Canada)	ERF (Australia)	Puro.earth (International)	VCS (International)
Purpose	Compliance (California compliance offset program) and voluntary	Compliance offset for TIER	Compliance offset for safeguard mechanism, Voluntary	Voluntary	Voluntary (eligible for compliance offset in some area)
Legal Framework	US federal/state	Canada federal/province	Australia commonwealth/ province	US EPA (Class I , II, IV) and EU CCS Directive equivalent	-
Applicability	CCS and CO2-EOR	CCS and CO2-EOR	CCS	DACCS and BECCS with EOR+	CCS
Project	5 projects	1 CCS (Quest), 1 CO2-EOR (ME global)	Moomba	Aspira DAC project, BECCS Norway	-

Source) Kikuko Shinchi, “CCS credit schemes around the world - METI-JOGMEC-IETA Joint Workshop “Global Carbon Market and CCS -Towards Decarbonization of ASEAN-” https://www.jogmec.go.jp/content/300382140.pdf

The Position of CCS in Contributing to Achieving CN May Gradually Tightened

CCS application for Carbon Pricing:

- Fossil energy and industrial point-source capture with storage
- Bioenergy with CCS (BECCS) and WtE (Waste to Energy) with CCS
- DACCS (Direct air carbon capture and storage)

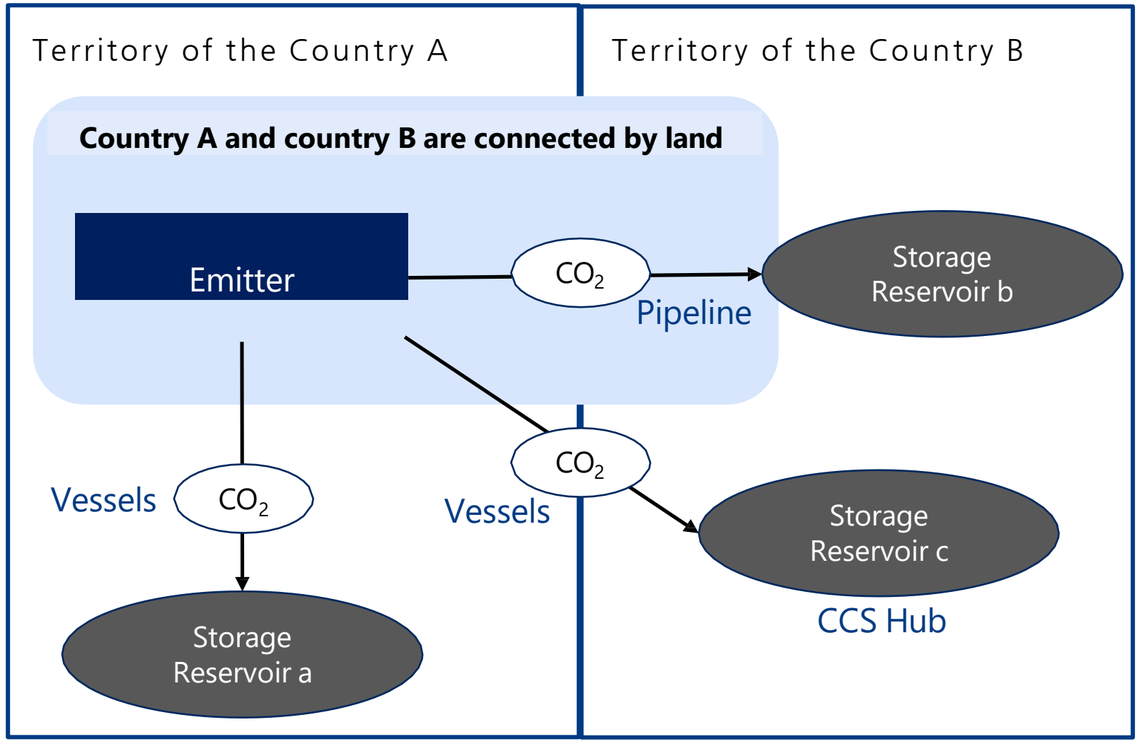


Source) Create MRI based on AA, "S. La Hoz Theuer and A. Olarte. (2023). Emissions Trading Systems and Carbon Capture and Storage: Mapping possible interactions, technical considerations, and existing provisions. Berlin: International Carbon Action Partnership "

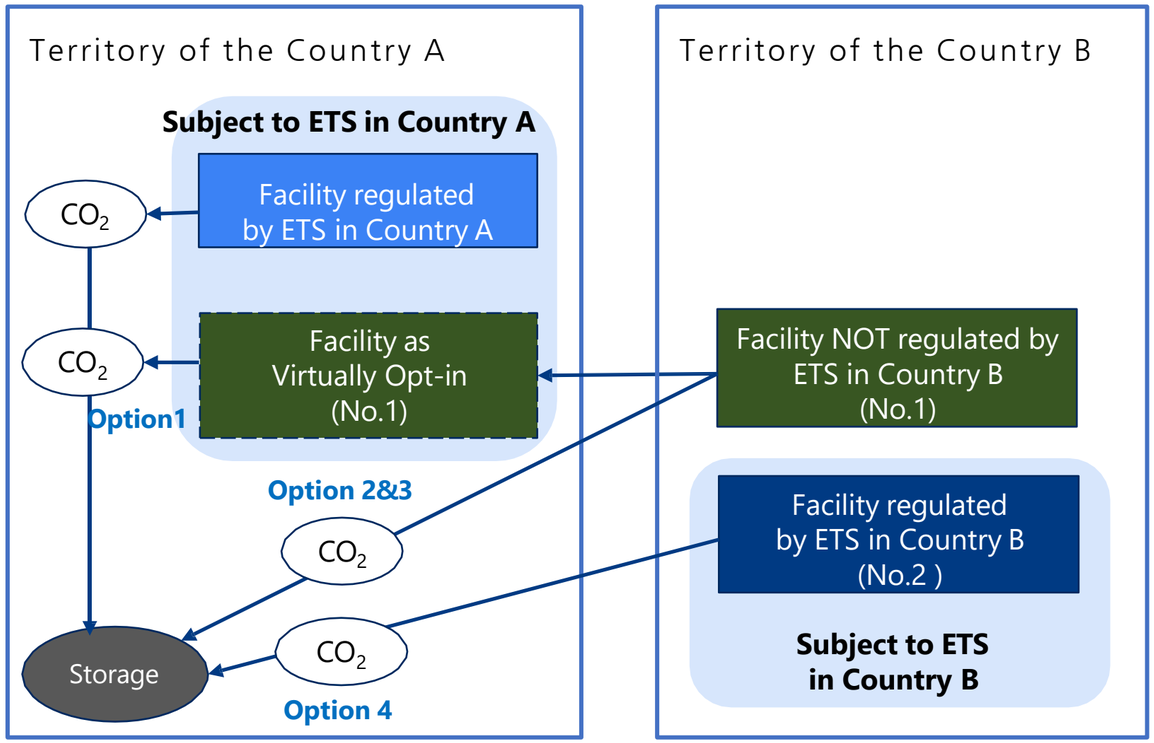
Issue of treatment of CO2 capture value in case of cross-border transportation

- When selecting CO2 storage sites, emitters give preference to routes that minimize T&S costs.
- If it is a reservoir in other country, a mechanism is needed to obtain appropriate incentives for carbon pricing.

A case in which it is more cost-optimal for an emitter to transport CO_2 to a storage reservoir in Country B than Country A



Examples of options for different CO2 storage claims depending on the ETS-regulated facilities



Source) Created by ACE and MRI collaboration

Reflection of CO2 Capture Value in Low-Carbon Fuels (e.g. Hydrogen and Ammonia, CCU and Recycled Carbon Fuels)

- Low-emission fuels play an important role in decarbonising parts of the energy system where other options, like electrification, are more difficult or expensive.
- Reducing LCCO2 (and/or carbon intensity) reflected in product value: Captures and storage CO2 emitted into the atmosphere during the product lifecycle.

Issues to consider in regulatory framework to reflect CO2 capture in product value

- Attribution of emission reductions/removals: product manufacturers or users
- Guarantee of Origin: Book & clime or mass balance
- Issuance of carbon credits in the product life cycle: CO2 capture is included in product emissions

Hydrogen and Ammonia

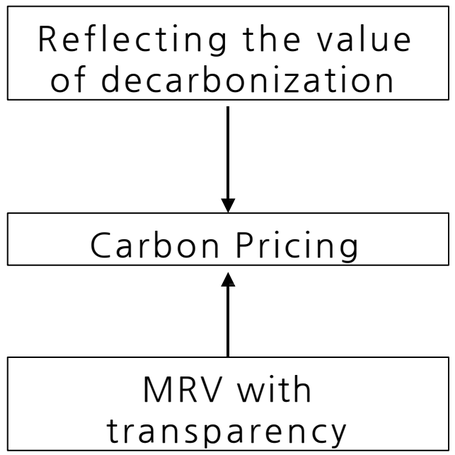
- Evaluation Approach: Based on the absolute value of carbon Intensity or product certification based on the reduction rate from the reference value.
- Production method: Electrolysis (renewable/non-renewable energy), Fossil Fuel (SMR), waste biomass
- Range: Well to Gate, Well to Wheel, etc.

CCU and Recycled Carbon Fuels

- Reduction mechanism: Substitution of conventional fossil fuel-derived raw materials and fuels, low carbonisation of hydrogen used for synthesis
- CO2 capture sources: Fossil fuel point-of sources or atmospheric CO2 capture (biomass and DAC)
- Utilization of existing transportation infrastructure

Policy Recommendation: Collaboration activities on how to reflect decarbonization values in carbon pricing

- ASEAN countries have already started to consider measures for CP (carbon tax and ETS) and carbon market formation in each own country.
- Collaboration within the ASEAN Member States is needed on how to handle (1) CO2 capture, (2) use of decarbonized fuels, (3) use of carbon credits/renewable energy certificates, and (4) regional cooperation (incl. CO2 cross-border transportation).



① Treatment of CO2 capture:
- Carbon sequestration: CCS
- Carbon recycling: CCU

② Treatment of CN-fuels:
- E-fuel, e-methane: value of RE-hydrogen
- Hydrogen, Ammonia: value of Carbon Intensity

③ Treatment of carbon credits:
- Domestic/regionals, compliant/voluntary schemes

④ Treatment in regional cooperation:
- Storage value in CO2 cross-border transportation

- Early establishment of incentives (price signals) to realize decarbonization projects in ASEAN
- Promotion of efficient abatement measures through regional collaboration (* technologies with low marginal abatement costs in region)
- Reduction and acceleration of procedural costs through common formatting of rules in the region

Profile

Tetsuya NOMOTO

Senior Researcher, Center for Policy and the Economy / Energy & Sustainability Division

Education | Master of Environment, Graduate School of Frontier Science. The University of Tokyo

Work | [April 2010-] Mitsubishi Research Institute, Inc

[April 2023-] Secondment, ASEAN Centre for Energy (ACE)

Experience:

- Over 14 years of professional experience in research on policy trends and market environment for energy transition, and decarbonization in particularly ASEAN region
- Highly specialized in supporting business development in RE, EE&C, and CCS/CCU

Main Experience of Project Leader

- Research and promotion for CCS, Hydrogen, and Ammonia projects [Government Agency]
- Study on technology trend and economic feasibility of NETs [Private Company]
- Research and support for building partnerships to promote heat pump technologies in SEA [Industry Group]
- Support project development of renewable microgrid in Indonesia [Private Company]

Envisioning the future, leading change

Mitsubishi Research Institute

5. CARBON ACCREDITATION FOR CCS PROJECTS

ExxonMobil Corporation

Casey Delhotal, Senior Director, International Government Relations, Asia Pacific

Pathways to Credits for Cross Border CCS

KEMENTERIAN EKONOMI

ASEAN CENTRE FOR ENERGY ACE

Asia Natural Gas & Energy Association

Pathways to Credits for Cross Border CCS

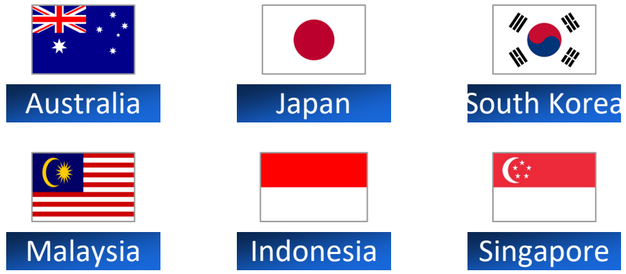
SEACA
27 Aug 2024

Asia Natural Gas & Energy Association

Cross-border CCS study answers key questions to facilitate cross-border CCS agreements

Opportunity

- CCS is critical for decarbonization efforts in Asia Pacific.
- The region is pioneering cross-border CCS opportunities to advance towards its climate targets.
- The study focuses on initial 6 countries in the region.



Challenges

- Cross-border CCS is complicated by an array of international guidelines and the differing regulatory frameworks across countries in the APAC region
- For cross-border CCS projects to be commercially viable, G2G agreements are important in providing clarity and flexibility for commercial agreements to proceed on key issues including:
  - What types of certifications can be used?
  - How to ensure no double counting?
  - Clarify long-term liabilities in the event of leakages

Objectives of ANGEA's Study

- Examine existing international guidelines, domestic regulations, and carbon accreditation mechanisms for certifying emission reductions from cross border CCS
- Review potential business models, based on the intended uses of reduction units, to identify gaps and challenges that need to be addressed in the G2G agreements.
- Provide recommendations on what should be considered in the G2G agreements (vs. what to be included in the commercial agreements).

Emission reductions from cross-border CCS can be used for NDC accounting/corporate claims or generating credits/certificates for trading

The emission reductions from the project can be intended for ….

1 Claims (No credit generation)

Likely primary use case in near-term

OR

2 Trading (Credit generation)

Opportunity for use in longer-term

	Claims (No credit generation)	Trading (Credit generation)	
Capture Country	Claim emission reductions towards its NDC (Following IPCC Guidelines)	Generating ITMOs (Article 6.2 Standard)	Contributions to NDC
	Happens concurrently		
Project Proponent	Claim emission reductions towards its own obligations (towards carbon tax or ETS)	Generate allowances/credits to trade with other companies under applicable compliance scheme	Compliance Mechanisms
	Claim emission reductions towards internal voluntary carbon targets (e.g SBTi targets etc.)	Generate credits to trade with other companies on international or domestic voluntary markets	Voluntary Mechanisms

5. CARBON ACCREDITATION FOR CCS PROJECTS

ExxonMobil Corporation

Casey Delhotal, Senior Director, International Government Relations, Asia Pacific

Pathways to Credits for Cross Border CCS

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ASEAN CENTRE FOR ENERGY ACE

Asia Natural Gas & Energy Association

5. CARBON ACCREDITATION FOR CCS PROJECTS

Panel Moderator

Hanh Le, Advisor

ANGEA

SEE YOU AFTER THE BREAK

- Prayer room is on the ground floor, Inspire Rooms 3 & 4
- Meetings, breaks, and “Quiet Zone” in Boardroom 1

6. TECHNICAL, OPERATIONAL & INFRASTRUCTURE REQUIREMENTS	The transport and subsequent storage of CO_2 requires significant infrastructure that must be designed and operated to ensure safety and efficiency. Further, the CO_2 itself will need to meet certain requirements. This session will explore these requirements including how common standards could be applied to support an Asian CCS Value Chain.		
	11:00 - 11:15	15	**BP Asia Pacific** Zulfikri Agus, Performance Manager Tangguh CCUS: An Indonesian National Strategic Project
	11:15 - 11:30	15	**Kawasaki Kisen Kaisha, Ltd. (K-LINE)** Jun Sasaki, General Manager, Carbon Solution Business Group “K”LINE’s Initiatives on LCO_2 Transportation for CCS
	11:30 - 11:45	15	**Shell** Afiq Rahmat, Energy Transition Manager Malaysia Towards an Inter-Operable CCS Value Chain in Asia
	11:45 - 12:00	15	**Mitsubishi Heavy Industries (MHI)** Taichi Tanaka, Engineering Manager MHI's Efforts to Develop Effective and Economic CO_2-Value Chain
	12:00 - 12:15	15	**Chevron** David Fallon, General Manager CO_2 Specification for CCS Storage
	12:15 - 12:30	15	**Petronas** Christopher K Singham, Head of Carbon Capture Technologies Advancing Malaysia’s Decarbonisation: Integrating Carbon Capture Technology, Utilisation & Storage
	12:30 - 12:45	30	**Panel Discussion** *Moderated by Alex Zapantis, General Manager, External Affairs, Global CCS Institute*

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ASEAN CENTRE FOR ENERGY • ACE •

Asia Natural Gas & Energy Association

SOUTH EAST ASIA CCS ACCELERATOR WORKSHOP (SEACA)

Part III: Creating a Transnational Asian CCS Value Chain

6. TECHNICAL, OPERATIONAL & INFRASTRUCTURE REQUIREMENTS

GLOBAL CCS INSTITUTE

6. TECHNICAL, OPERATIONAL & INFRASTRUCTURE REQUIREMENTS

BP Asia Pacific

Zulfikri Agus, Performance Manager

Tangguh CCUS: An Indonesian National Strategic Project

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Asia Natural Gas & Energy Association

Tangguh CCUS
An Indonesian National Strategic Project

Kuala Lumpur, August 27-28, 2024

Tangguh LNG

2009

Started operating as a two-train business

2023

Train 3 began operating and was inaugurated by the President of Indonesia as one of the country's National Strategic Projects

2.1 bcfd
Average Production

one-third of national gas production, through 3 Train LNG plants with total capacity of **11.4 mtpa**

>1700
LNG Cargoes

has been delivered to Indonesia and Asian buyers

UCC
Project

Ubadari, Vorwata **C**CUS and onshore **C**ompression is an integrated project as part of the next phase of Tangguh development to keep the 3 trains full. The UCC Project is also one of the National Strategic Projects in the country

Tangguh CCUS

National Strategic Project

The most *advanced* CCUS project in country

- **Decarbonizing Tangguh**

  Store 30+ mtCO2 at initial stage

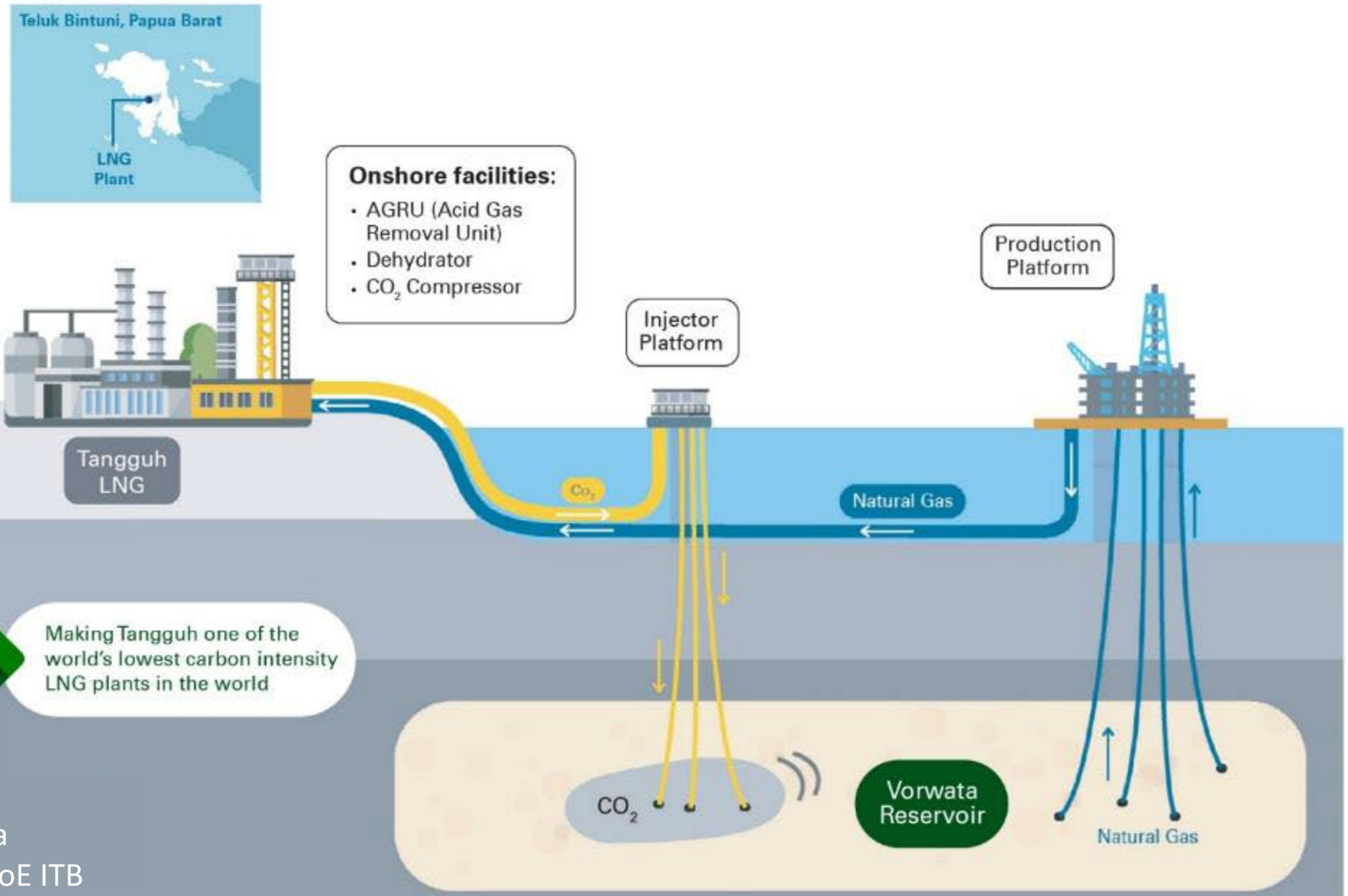
- **Increasing production**

  Enhanced gas recovery c. 400bcf

- **Decarbonizing beyond Tangguh**

  CCS hub opportunity c.1.8GtCO2 storage capacity

  Enabling lower carbon energy (blue ammonia)



Helping Indonesia's energy transition

Creating social and economic impact

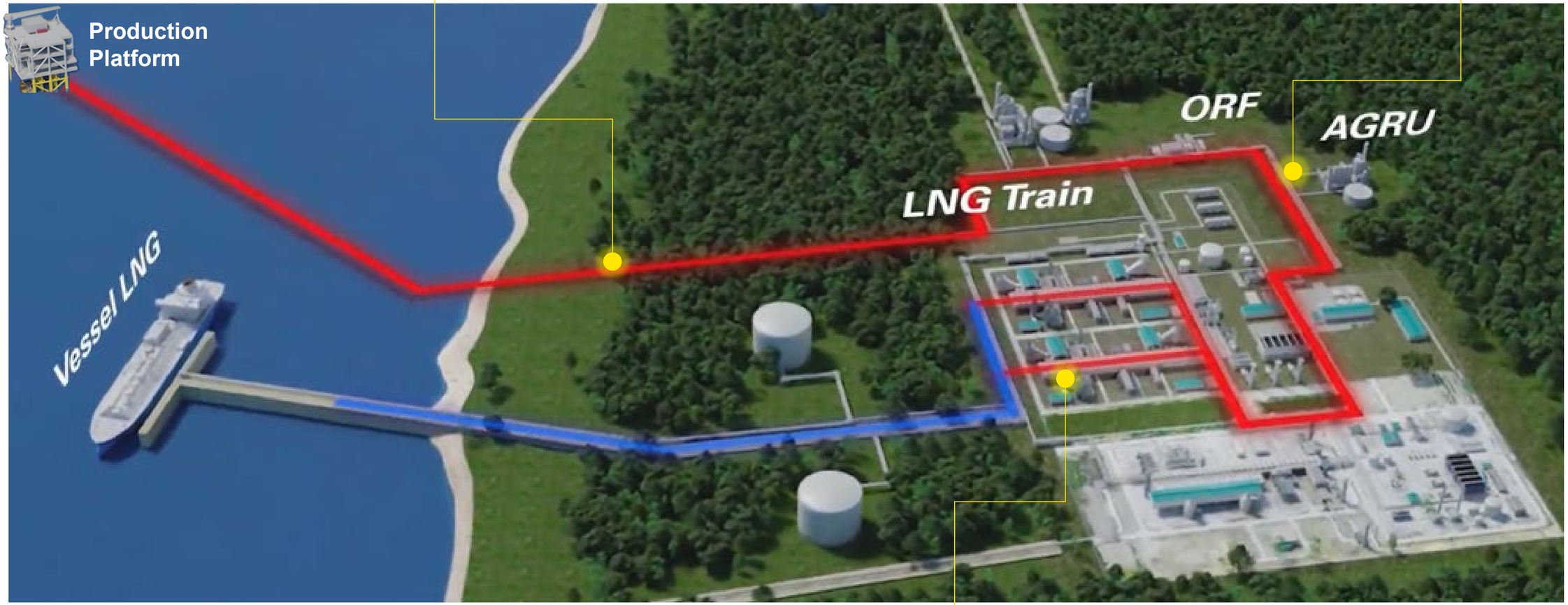
Making Tangguh one of the world's lowest carbon intensity LNG plants in the world

- MoU with Chubu in Sept 2023
- MoUs with domestic emitters including blue ammonia (Pertamina) and electricity (PLN, Jawa 1 Power) and CoE ITB

Tangguh LNG Project

1 Natural gas containing CO_2 from reservoir is sent to Onshore Receiving Facility (ORF)

2 The CO_2 is separated from natural gas in the Acid Gas Removal Unit (AGRU)



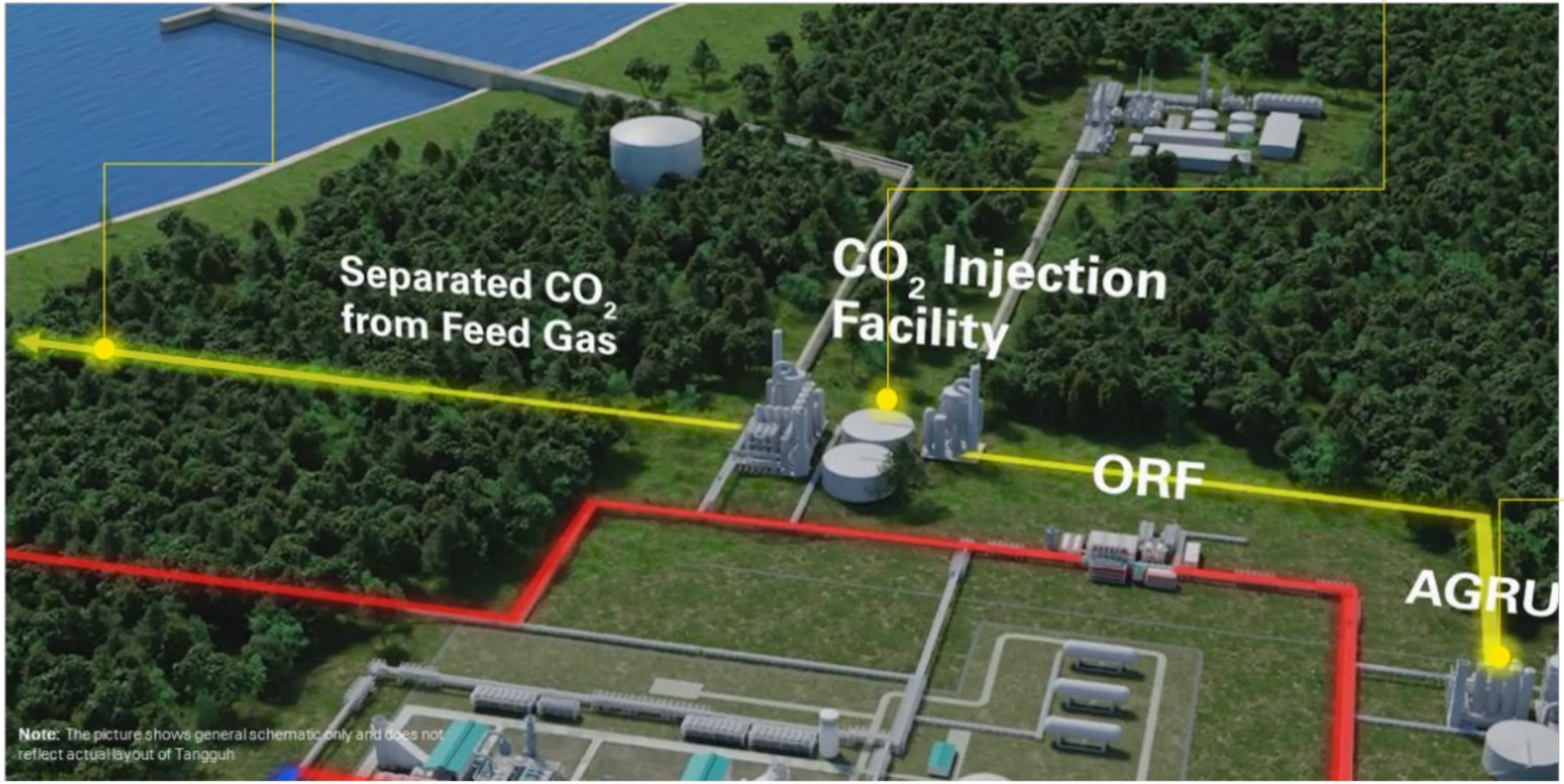
Note:
The picture shows general schematic only and does not reflect actual layout of Tangguh

3 The CO_2-free natural gas (sweet gas) is then further processed into LNG

Tangguh CCUS Project – Onshore

3 The CO_2 will be transported via pipeline to Offshore Injection Facility in dense phase

2 The CO_2 injection facility will consist of:
- CO_2 compressors
- Dehydration system
- Supporting utilities & vent systems

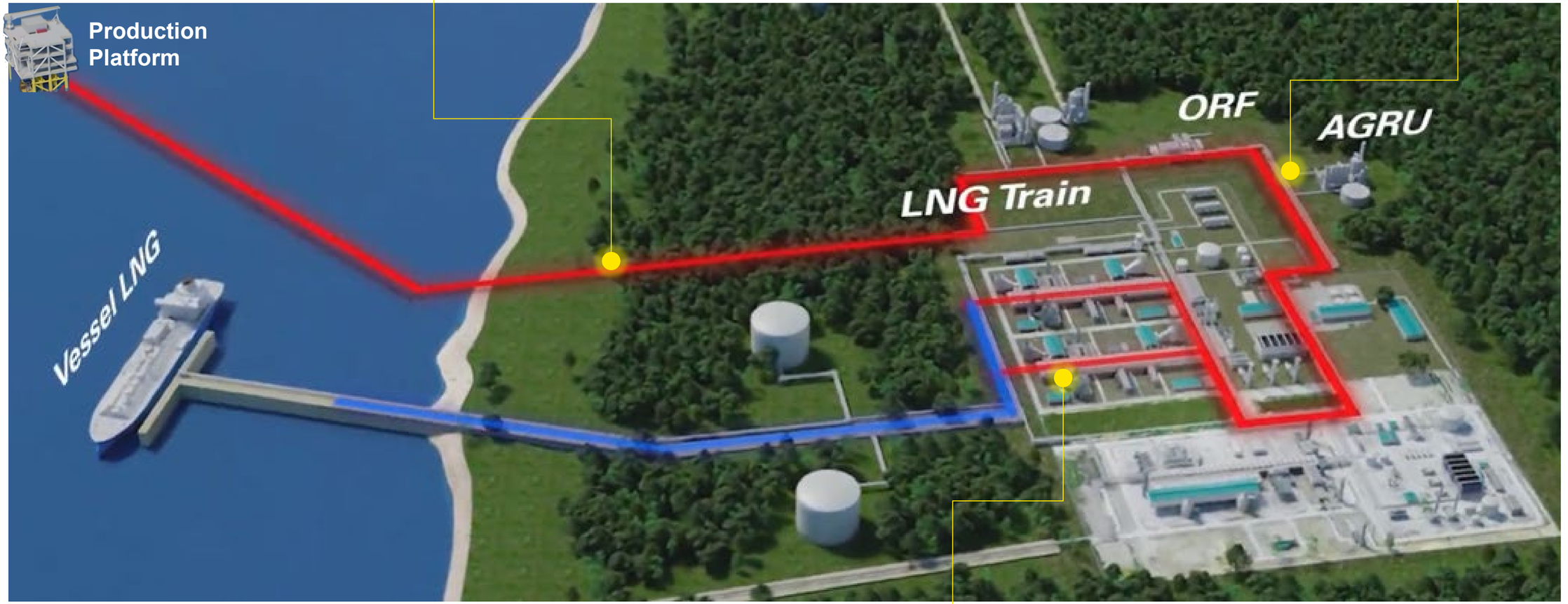


1 Instead of vented to atmosphere, the separated CO_2 will be sent to CO_2 injection facility

Tangguh CCUS Project – Offshore

1 Natural gas containing CO_2 from reservoir is sent to Onshore Receiving Facility (ORF)

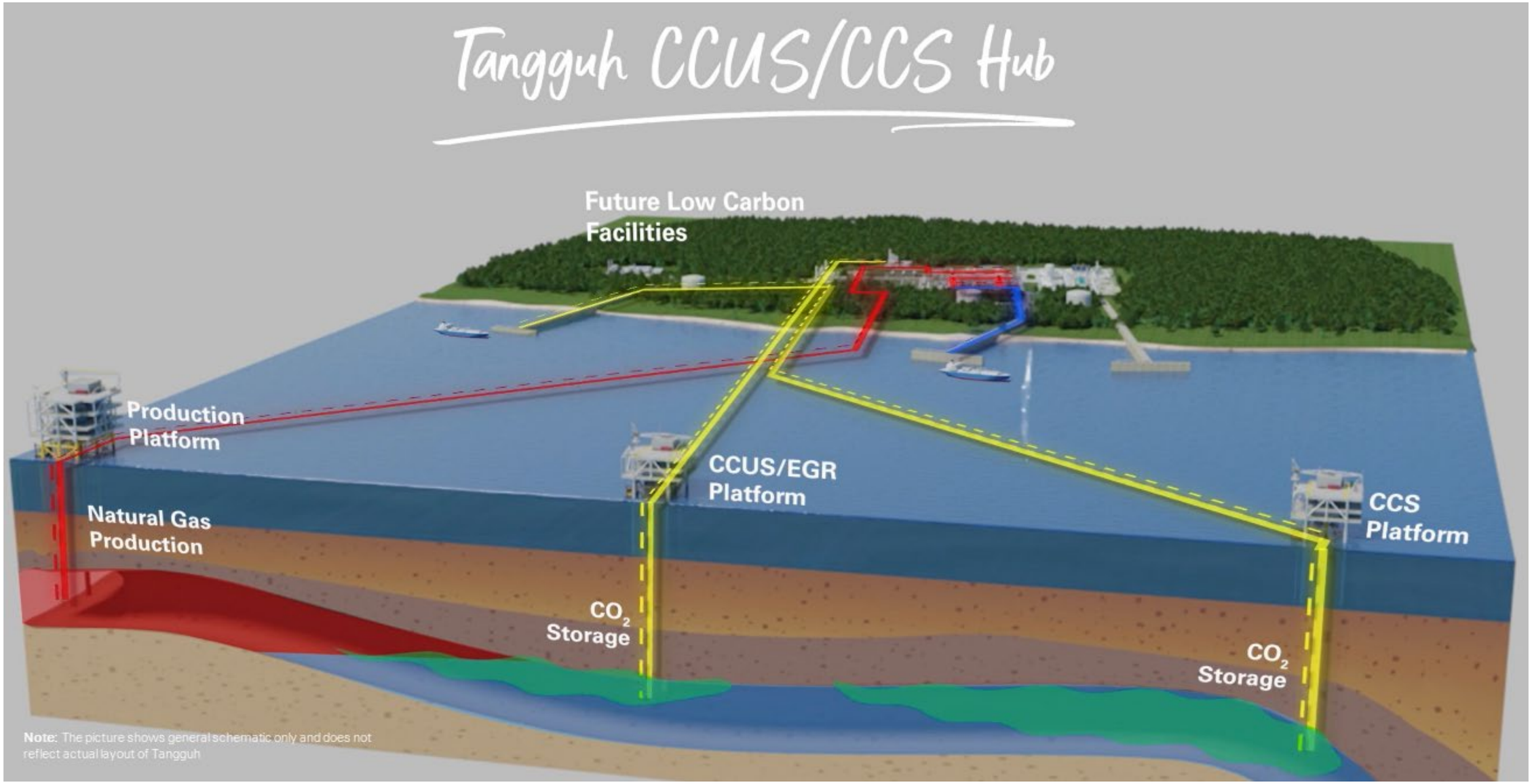
2 The CO_2 is separated from natural gas in the Acid Gas Removal Unit (AGRU)



3 The CO_2-free natural gas (sweet gas) is then further processed into LNG

Note:
The picture shows general schematic only and does not reflect actual layout of Tangguh

Tangguh CCUS / CCS Hub



Tangguh CCUS/CSS Video

6. TECHNICAL, OPERATIONAL & INFRASTRUCTURE REQUIREMENTS

Kawasaki Kisen Kaisha, Ltd. (K-LINE)

Jun Sasaki, General Manager, Carbon Solution Business Group

"K"LINE's Initiatives on LCO_2 Transportation for CCS

“K” LINE’s Initiative on LCO2 transportation for CCS

28th August 2024

Kawasaki Kisen Kaisha, Ltd.

“K” Line’s Profile

Corporate Profile

Name	Kawasaki Kisen Kaisha, Ltd. (**“K” Line**)
Established	April 5, 1919
Employees	5,570 (consolidated)
Business Lines	Marine, Land and Air Transportation
Head Office	Tokyo, Japan
Affiliates	280 (including affiliated companies)

“K” Line’s Group Fleet Composition

Total Number of Vessels in Operation : **445**

Energy

87 vessels

46 LNG Carriers

25 Thermal Coal Carriers

13 Tanker & LPG Vessels

Other:
FPSO, Drill Ship, LNG Bunkering vessel

Others

358 vessels

91 Car Carriers

185 Dry Bulk Carriers

Other: Coastal Vessels, etc.

ONE
OCEAN NETWORK EXPRESS

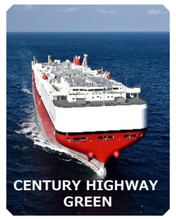
41 Container ships

(As of end of June 2024)

“K” Line Group Environmental Vision 2050

Take on the challenge of net-zero GHG emissions

Fuel Conversion



- LNG
- LPG
- Ammonia
- Hydrogen

Kite System

- “Seawing”- Automated Kite System
- Expected 20% CO2 reduction

DX Solution

- “K-IMS”- Integrated ship performance analysis

CC-Ocean

- Carbon Capture plant on vessel
- R&D and supply-chain development

“K” LINE Decarbonization	Support the decarbonization of society	Minimize “K” LINE’s impact on the sea and air	Support the environment activities of society
The challenge of achieving net-zero GHG emissions from our vessels	Be a transporter and supplier of new energy	Zero oil spills Aim for zero environmental impact	Support environmental activities Be the industry leader in ecosystem protection

Help enrich the lives of people by also promoting the support of decarbonization of society

Liquified CO2 Transport

Provided by Northern Lights

- R&D for LCO2 marine transportation
- Northern Lights starting from 2024
- Pioneer of LCO2 transportation for CCS

Offshore Wind

- Establish “K” Line Wind Service
- Be a supplier of support vessels in Offshore Wind
- Participate R&D program for floating offshore wind

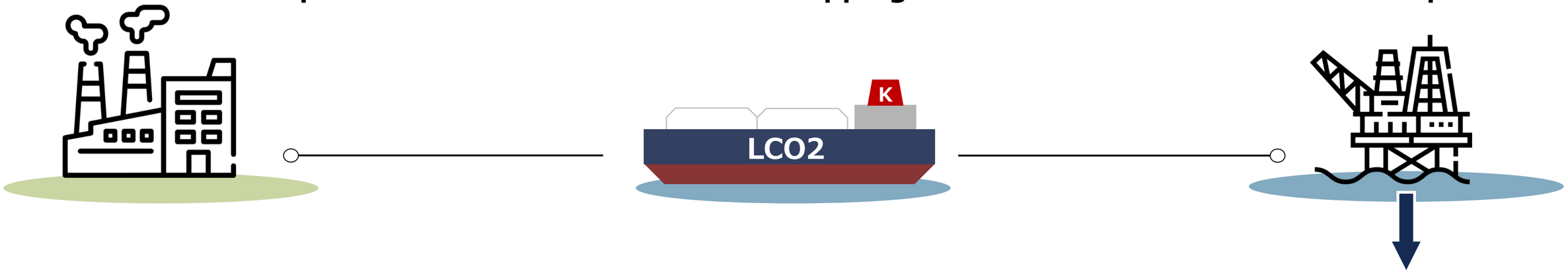
Transport New Energy

Photograph provided by Kawasaki Heavy Industries, Ltd.

- Be a supplier for new energy transportation
- Contribute new supply-chain establishment
- Participate Co2-free Hydrogen Energy Supply-chain “HySTRA”

Potential for Development of Liquefied CO2 Transport

Transportation over 200㎞ for CCS ⇒ Shipping is more economical rather than Pipeline



Significance of CCS as “Realistic Solution”

CCS is a faster and more reliable way to reduce CO2 emission.

LNG and CCS is “***two sides of the same coin***” for the balance of Energy Security and Decarbonization

Realistic Solution for achieving Net Zero

Requirement of CCS (2030’s)

15% in total reduction by CO2 emission → **1 billion ton** per annum for storage requirement

Requirement of Ship Transportation (2030’s)

10-20% in total CO2 shipping requirement → approx. **200 vessels**

Conditions for Liquefied CO2 transport

MTMP

- Proven technology
- Optimal for short or middle-distance transport

Profile of MTMP

Temperature	-30 to -20℃
Pressure	15-20barg
Density	1.08-1.03t/m3

Source: ZEP report

Northern Lights Project

Our Initiatives

- ✓ Ship Management
- ✓ Establishment of Operation Manuals
- ✓ Ship-Shore Interface Coordination

- Northern Lights' fleets is designed with MTMP (Middle Temperature/Pressure)

LTLP

- Under development
- Realizing large-scale and long-distance transport

Profile of LTLP

Temperature	-55 to -40℃
Pressure	5-10barg
Density	1.17-1.12t/m3

Source: ZEP report

NEDO's Demonstration

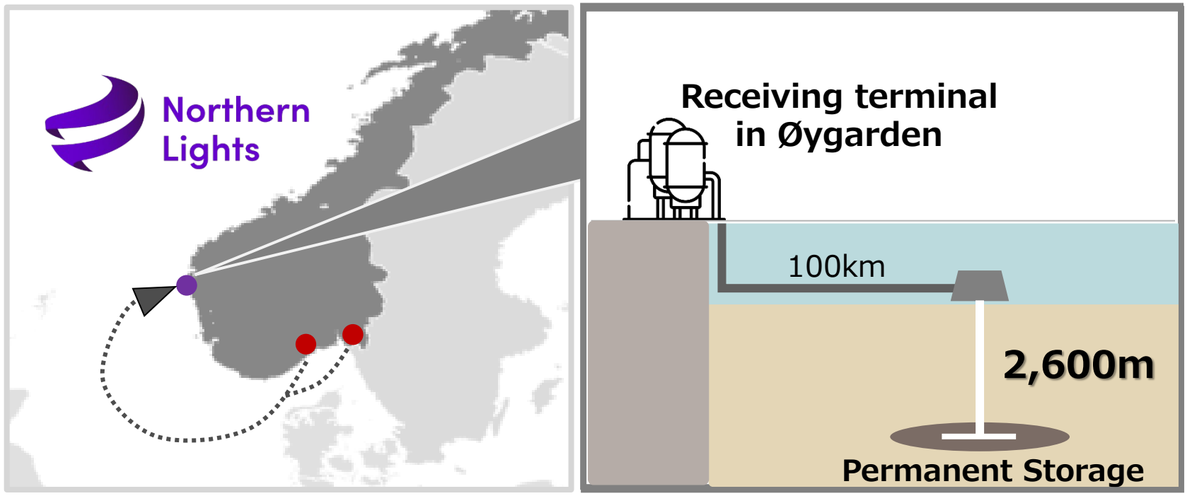
Our Initiatives

- ✓ Risk Assessment (HAZOP)
- ✓ Establishment of LTLP's Operation
- ✓ Feedback to Industrial Society

- NEDO's demonstration vessel "ExCool" is on LTLP (Low Temperature/Pressure)

Northern Lights Project

Northern Lights Phase 1



- “Northern Lights JV DA” is co-parent company by Equinor, Shell, and Total Energies (1/3 each)
- Transport CO2 to intermediate receiving terminal in Øygarden Norway and inject to the aquifer 2,600m below the seabed.

  Phase 1: 1.5 million ton per annum/CO2, First injection in 2024

  Phase 2: 5.0 million ton per annum/CO2, First injection in 2026

Roll of “K” Line

- **“K” Line and Northern Lights JV DA signed contracts for 3 x 7,500m^3 LCO2 carriers.**
- Ship management by "K" Line LNG Shipping (UK)
- Support for Fleet Operation by Charterer

Class	DNV	Length	130 m
Capacity	7,500 m3	Width	21.2 m
Condition	MTMP	Draught	7.5 m

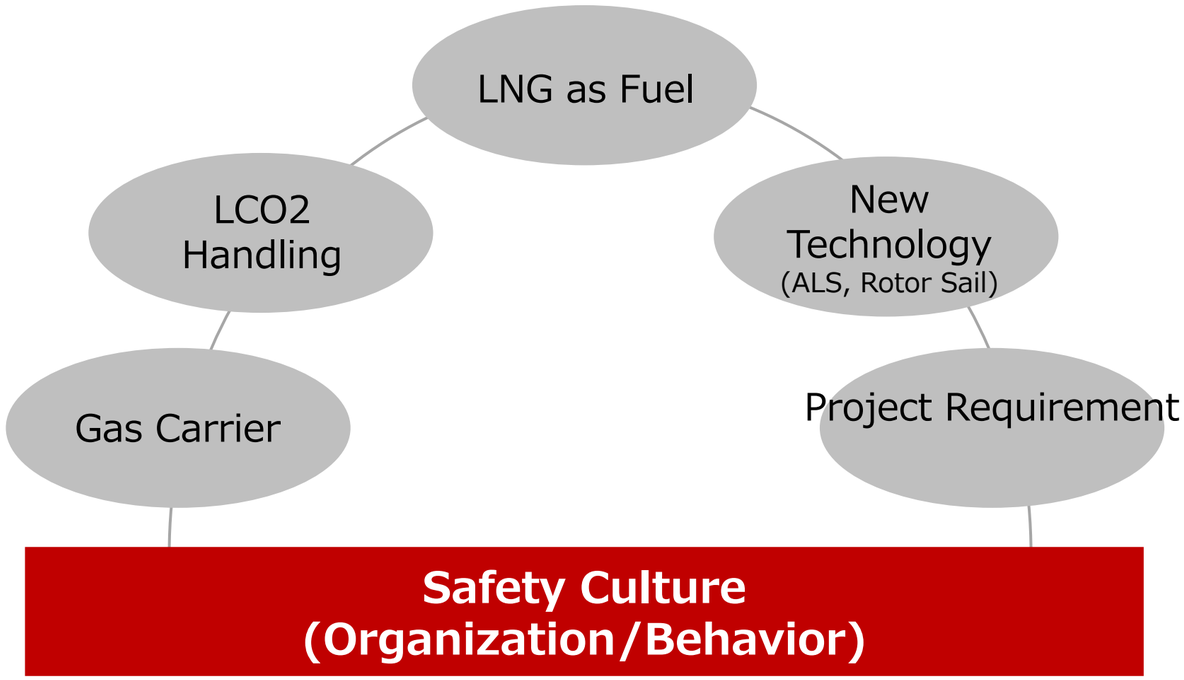
Team up for Northern Lights

- We corporate key persons across industries in Norway to challenge this new field

Crew Training

Education Program for New Project

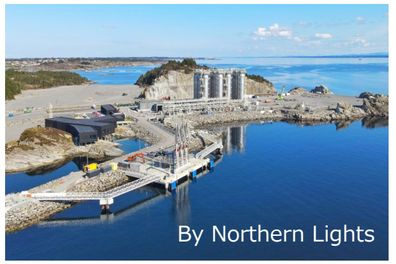
- "People" to be key to the successful delivery of any project



Preparation for Ship/Shore Interface

Objectives

- Terminal call procedures
- Ship/Shore Communication Plans
- Commissioning Procedures
- Operation Procedures
- Emergency Response, etc.



Cross Industry Innovation

- Collaborative effort with project stakeholders
  - Shipyard
  - Terminal developers/ plant manufactures
  - Terminal operators
  - Emitters/ Storage providers
  - Authorities
  - **Vessel operator** etc.

Developing technology for Low-pressure LCO2 shipping

Project Overview

- 2021~2023 R&D, Desktop Study, Ship Building
- 2024~2026 Actual Vessel Operation in LTLP

"Excool" was delivered in November 2023.

Why Low Pressure ?

- Long distance transportation in future
- Larger Ship Requirement
- Thinner tank requirement to enlarge vessel
- Low-pressure condition for thinner tank

Role of "K" Line

- Safety Assessments
- Formulation of technical guideline for the social implementation of LCO2 shipping.
- Feedback findings from demonstration results to international institutional design movement.

Contribution to…

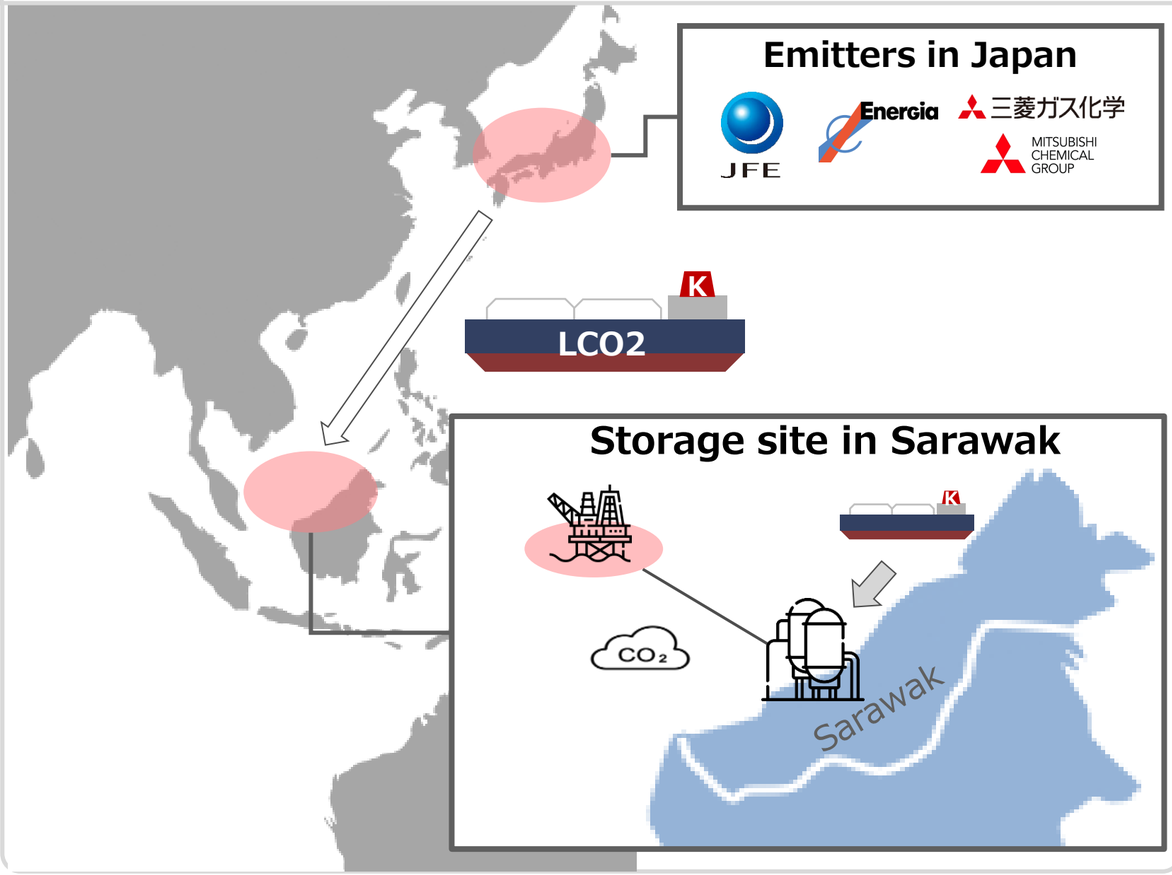
- **Technical establishment of LCO2 marine transport operation**
- **Implementation of CCUS projects globally**

Malaysia Sarawak CCS project

Malaysia Sarawak CCS Project

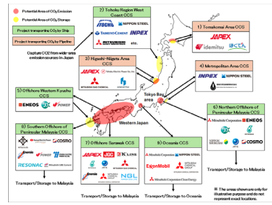
Participants

PETRONAS　JAPEX Japan Petroleum Exploration Co., Ltd.　JGC　K LINE 川崎汽船株式会社



Project Overview

- Storage CO2 offshore Sarawak
- Selected as **Advanced CCS Project,** Japanese government's subsidy project

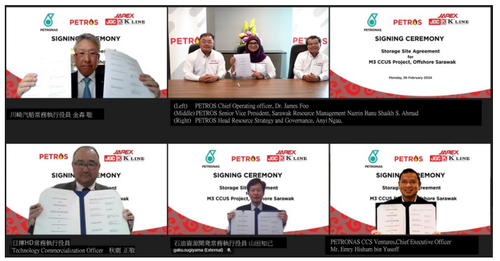


Storage Site Agreement (SSA)

Participants

PETROS　PETRONAS　JGC　JAPEX Japan Petroleum Exploration Co., Ltd.　K LINE 川崎汽船株式会社

- Executed in February 2024
- Enables Feasibility Study of storage sites starting with M3 depleted field (M3 CCS Project)
- Accelerating Malaysia's potential as a prominent regional hub for CCS



Challenges for Cross-Border Transportation

Dry ice formation

- Higher risk of dry ice formation due to cargo handling close to Triple Point for LTLP

Liquefied gas handling

- Most of hard-to-abate emitters are not familiar with liquefied gas handling

Regulatory flamework

- Bilateral Agreement must be concluded
- Domestic CCS Framework/Regulation must be established

What we do

- ✓ To establish safe operation procedure through NEDO demonstration project
- ✓ To leverage our operation know-how and High-quality LNG/LPG track record
- ✓ To support for establishment of safe/stable operation procedures for emitters
- ✓ To share our advanced knowledges to government and industries

Key Takeaways :

- **Transport of Liquified CO2 by sea** : one of important parts of **realistic solution for CCS**
- LNG and CCS : ***"the two sides of same coin"*** for Energy Security and Decarbonization in APAC
- Major Transportation Methods : "**MTMP**" and "**LTLP**". "**LTLP**" for **leading role in APAC**
- **Northern Lights**, the world's 1st commercial transport for CCS **by "K" Line** coming soon
- NEDO's R&D of **"LTLP"** : In demonstration phase by "**ExCool**", the world's 1st LTLP ship
- **Malaysia Sarawak CCS** : **Advanced CCS Project** supported by Japanese Government
- **"K" Line as pioneer of LCO2 transportation for CCS in Europe/Japan** with MTMP (Northern Lights) and LTLP (NEDO's ExCool)

6. TECHNICAL, OPERATIONAL & INFRASTRUCTURE REQUIREMENTS

Shell

Afiq Rahmat, Energy Transition Manager, Malaysia

Towards an Inter-Operable CCS Value Chain in Asia

#PoweringProgress

SHELL CCS

Towards an Inter-operable CCS value chain in Asia

Afiq Rahmat, Energy Transition Manager
August 2024

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Shell's net carbon intensity

Also, in this **presentation** we may refer to Shell's "Net Carbon Intensity", which includes Shell's carbon emissions from the production of our energy products, our suppliers' carbon emissions in supplying energy for that production and our customers' carbon emissions associated with their use of the energy products we sell. Shell only controls its own emissions. The use of the term Shell's "Net Carbon Intensity" is for convenience only and not intended to suggest these emissions are those of Shell plc or its subsidiaries.

Shell's net-Zero Emissions Target

Shell's operating plan, outlook and budgets are forecasted for a ten-year period and are updated every year. They reflect the current economic environment and what we can reasonably expect to see over the next ten years. Accordingly, they reflect our Scope 1, Scope 2 and Net Carbon Intensity (NCI) targets over the next ten years. However, Shell's operating plans cannot reflect our 2050 net-zero emissions target and 2035 NCI target, as these targets are currently outside our planning period. In the future, as society moves towards net-zero emissions, we expect Shell's operating plans to reflect this movement. However, if society is not net zero in 2050, as of today, there would be significant risk that Shell may not meet this target.

Forward Looking Non-GAAP measures

This **presentation** may contain certain forward-looking non-GAAP measures such as **cash capital expenditure** and **divestments**. We are unable to provide a reconciliation of these forward-looking Non-GAAP measures to the most comparable GAAP financial measures because certain information needed to reconcile those Non-GAAP measures to the most comparable GAAP financial measures is dependent on future events some of which are outside the control of Shell, such as oil and gas prices, interest rates and exchange rates. Moreover, estimating such GAAP measures with the required precision necessary to provide a meaningful reconciliation is extremely difficult and could not be accomplished without unreasonable effort. Non-GAAP measures in respect of future periods which cannot be reconciled to the most comparable GAAP financial measure are calculated in a manner which is consistent with the accounting policies applied in Shell plc's consolidated financial statements.

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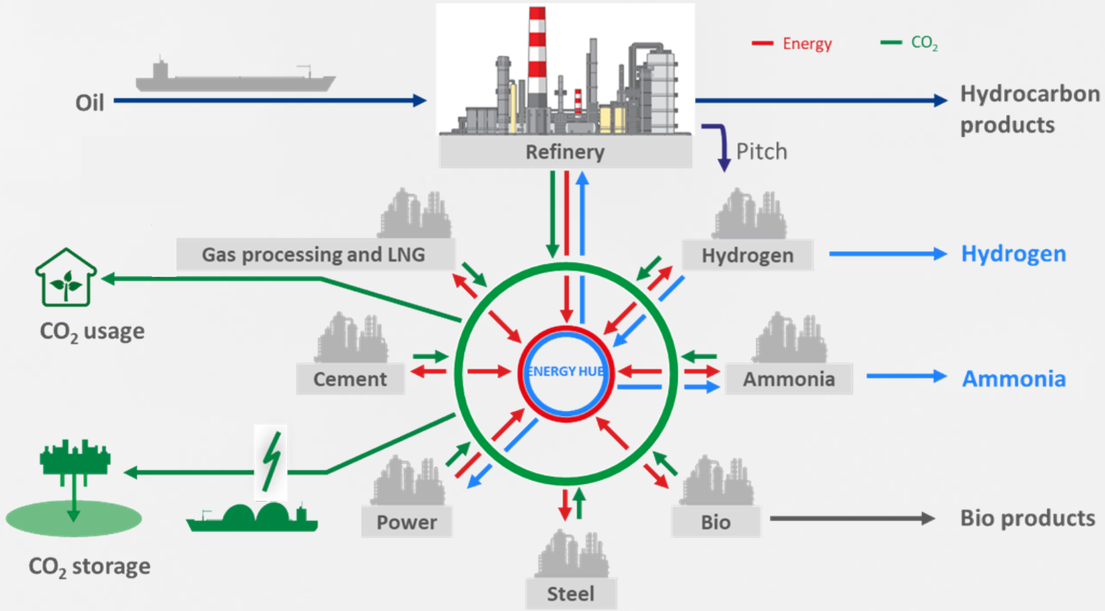
CCUS IN SHELL: STRATEGY

DEVELOPING CCUS TO ACCELERATE DECARBONISATION

SHELL CCUS strategy

- Develop **commercial CCUS hubs** that **enable decarbonisation of multiple (industrial) customers** and support Shell's role in the energy transition
- **Work with governments** to help shape their net-zero emission pathways and **advocate for CCUS through active membership in industrial organisations**



Shell is working on CCUS opportunities that enable:

Net-zero emissions from own operations

Low-carbon gas

Low-carbon hydrogen

Bio-energy with CCUS

Decarbonising sectors

Direct air capture

- Multiple projects and opportunities in the funnel across different regions with the potential to decarbonise multiple value chains and customers
- Involved in the entire value chain including operating assets, capturing CO_2, building and operating transport and storage infrastructure
- Active research and development program advancing technology and supporting project deployment

END-TO-END PROJECT EXPERIENCE IN SHELL

CCUS technology is proven

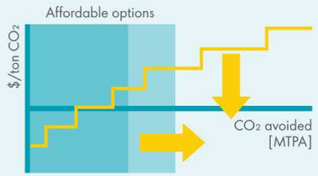
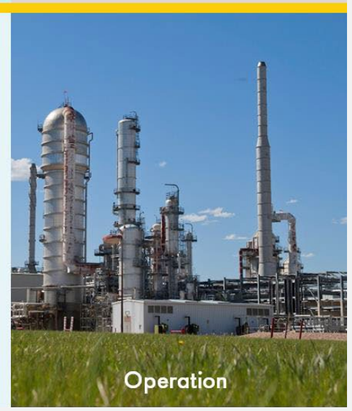
Shell is involved in all stages of CCUS development and deployment

Technology developments can deliver cost reduction

Shell collaborates to develop technologies

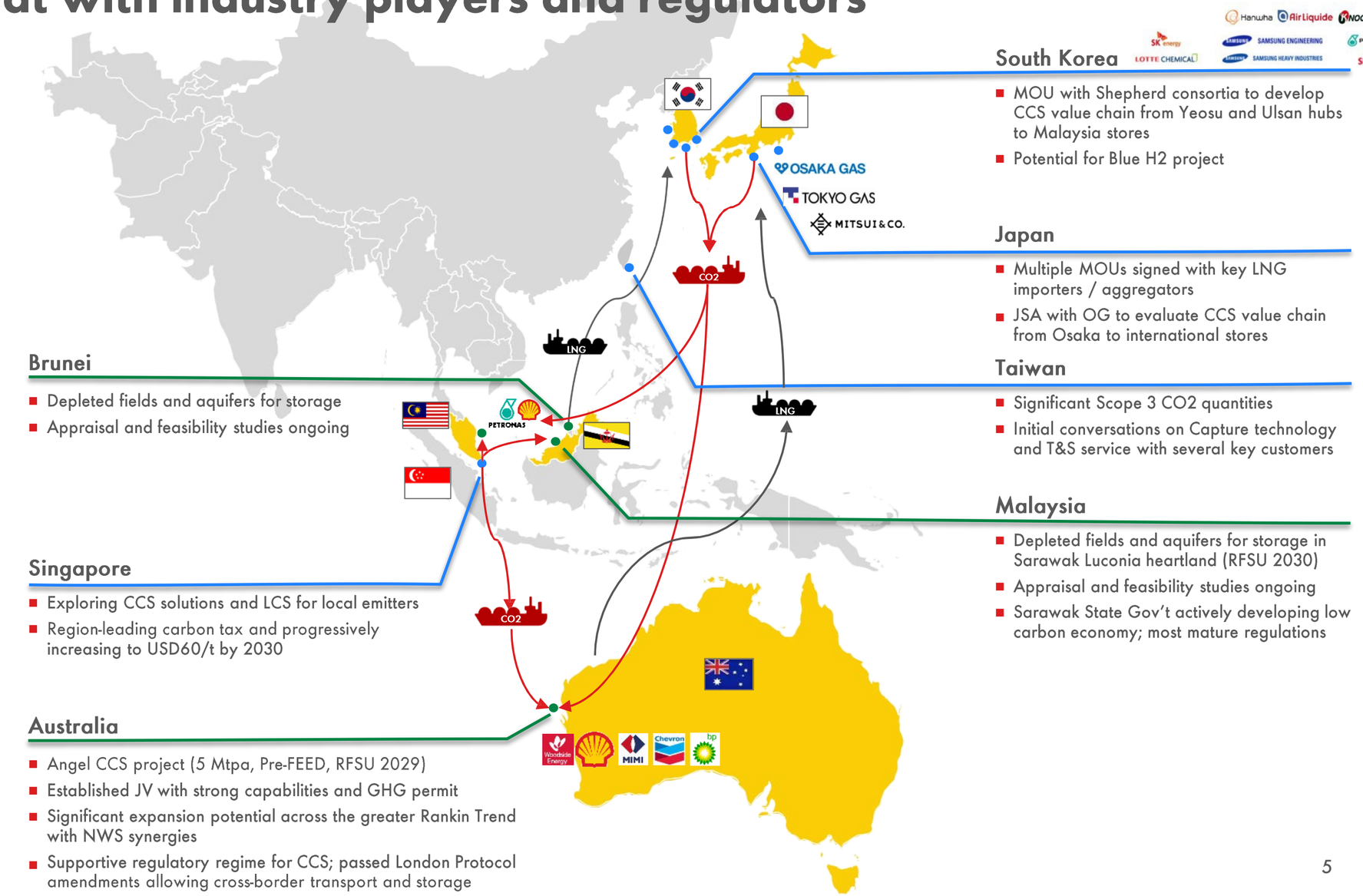
Shell has own CO_2 capture technology

CCUS costs evolution driven by innovation and replication

CO_2 Abatement platform ongoing work	Technology Development ViennaGreenCO_2	OGCI CI investments	Quest
			
Development	Pilot	Investment	Operation

Shell sees a unique opportunity for a cross-border multi-store CCS business in Asia and we can achieve that with industry players and regulators

- CCS is a key pillar of Shell's climate target to become a net-zero emissions energy business by 2050
- Investing $10-15 billion from 2023 to 2025 to support the development of low-carbon energy solutions, including hydrogen and CCS
- Shell's customers in Japan, S. Korea, Singapore and Taiwan emit >70 Mtpa of CO2
- Strong storage positions with world-class reservoir characteristics for CCS in Australia, Brunei and Malaysia
- Leading in LCO2 shipping design for long distance shipping in APAC
- Recognised industry operator in the region with world-wide CCS capabilities



South Korea

- MOU with Shepherd consortia to develop CCS value chain from Yeosu and Ulsan hubs to Malaysia stores
- Potential for Blue H2 project

Japan

- Multiple MOUs signed with key LNG importers / aggregators
- JSA with OG to evaluate CCS value chain from Osaka to international stores

Taiwan

- Significant Scope 3 CO2 quantities
- Initial conversations on Capture technology and T&S service with several key customers

Malaysia

- Depleted fields and aquifers for storage in Sarawak Luconia heartland (RFSU 2030)
- Appraisal and feasibility studies ongoing
- Sarawak State Gov't actively developing low carbon economy; most mature regulations

Brunei

- Depleted fields and aquifers for storage
- Appraisal and feasibility studies ongoing

Singapore

- Exploring CCS solutions and LCS for local emitters
- Region-leading carbon tax and progressively increasing to USD60/t by 2030

Australia

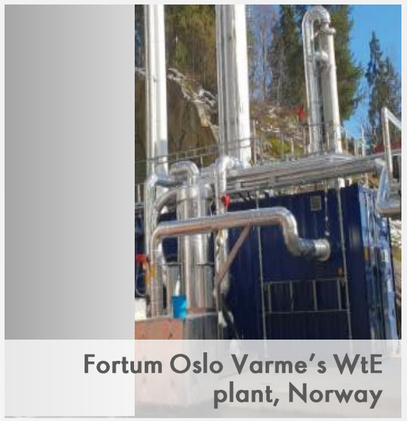
- Angel CCS project (5 Mtpa, Pre-FEED, RFSU 2029)
- Established JV with strong capabilities and GHG permit
- Significant expansion potential across the greater Rankin Trend with NWS synergies
- Supportive regulatory regime for CCS; passed London Protocol amendments allowing cross-border transport and storage

* China is led by a separate CCS portfolio team

CO_2 CAPTURE

MODULARISATION AND STANDARDISATION

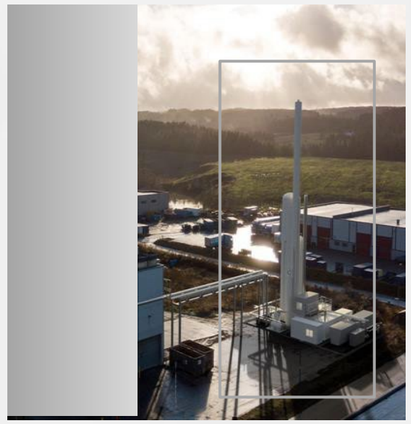
Efforts to modularise and standardise solutions enables customers to save schedule & cost.



Fortum Oslo Varme's WtE plant, Norway

PILOT UNIT
1.5 kTA

- Standard 40' container-built turnkey solution
- Objective: validate a technology for a given flue gas/application



SMALL UNIT
10 kTA

- Standard 40' container-built turnkey solution
- For small scale emitters, local CO_2 utilisation or first step CCUS implementation

MEDIUM UNIT
100 kTA

- Standard container-built turnkey solution (special built containers)
- For medium scale emitters (WtE, bio-incineration, cement, metal industry, GTs, etc)

LARGE UNIT
200 to 400 kTA

- Transportable on public roads through special convoy
- For relatively large-scale emitters and applications such as cement manufacture, CHP, WtE...

LARGER UNIT
>500 kTA

- For large scale emitters and applications such as cement manufacture, CHP, WtE...

Demonstrator

Carbon capture and CO_2 compression / treatment / liquefaction
Maximum standardisation, digitalisation and fabrication optimisation

CO_2 TRANSPORT

SHELL LCO2 SHIPPING STANDARDISATION

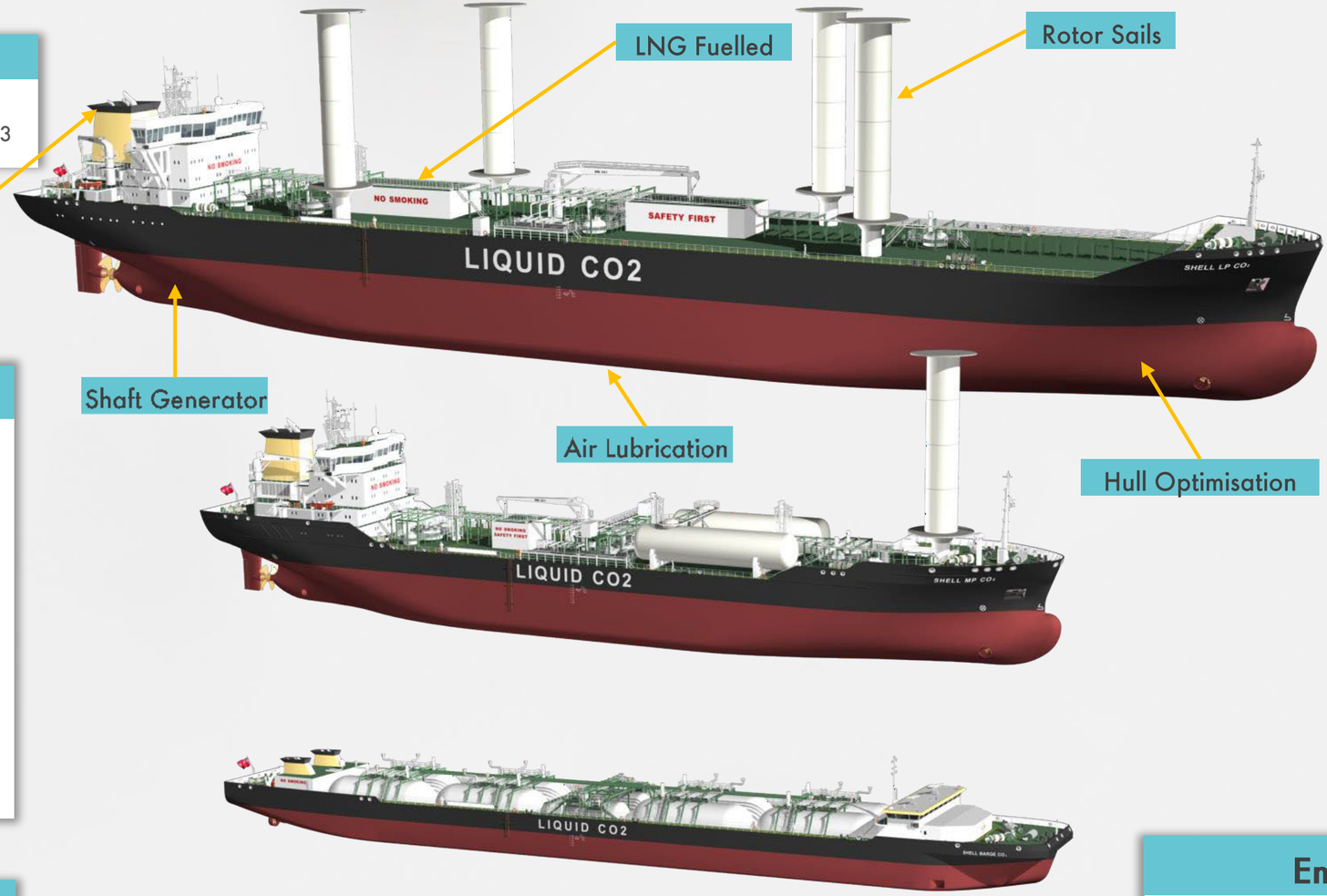
Low Pressure LCO_2

Concept designs up to 30,000m³
Capacity Range 7,500m³ to 70,000m³

Onboard CCUS & NOx Abatement

LNG Fuelled

Rotor Sails



Shaft Generator

Air Lubrication

Hull Optimisation

Medium Pressure LCO_2

- Supervision of design, engineering and construction of two 7,500m³ vessels for delivery 2024
- Preliminary design of 12,000m³ with Approval in Principle (AiP) from Classification Society
- Concept Designs up to 35,000m³
- Capacity Range 7,500m³ to 30,000m³

LCO_2 Barging

Feasibility designs from 2,000m³ to 9,000m³ for Inland Waterways

LCO_2 Standardisation

Active contribution & participation towards development of LCO_2 ship standardisation

- International Organization for standards (ISO) LCO_2 shipping technical study in progress
- Society of International Gas Tanker and Terminal Operators (SIGTTO) LCO2 in progress
- Joint Industry Project on Low Pressure CO_2

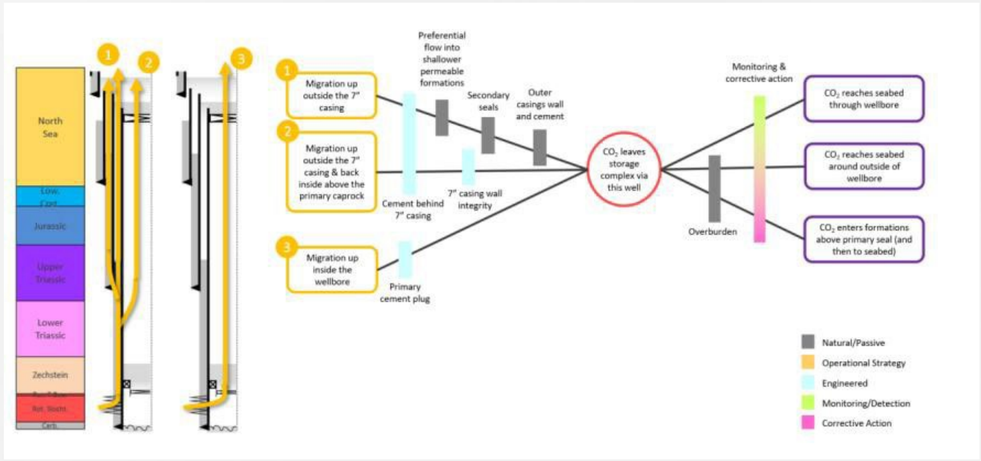
Emissions Reduction

Energy efficient and emissions reduction technologies integrated in to designs

Shell can offer flexible shipping solutions for CCUS that enable decarbonisation of hard to abate sectors with no access to local stores reachable by pipeline

CO_2 STORAGE
STANDARDISED LEGACY WELL ASSESSMENT FOR CONTAINMENT

- A structured way to assess risk of legacy wells
- Combination of:
  - Assess risk of non-present/non-sealing barriers
  - Ability to access, repair the well
- Containment diagram per well
- Quantify potential leak rate with Seepage Calculator
  - CO_2 specific physics to be included

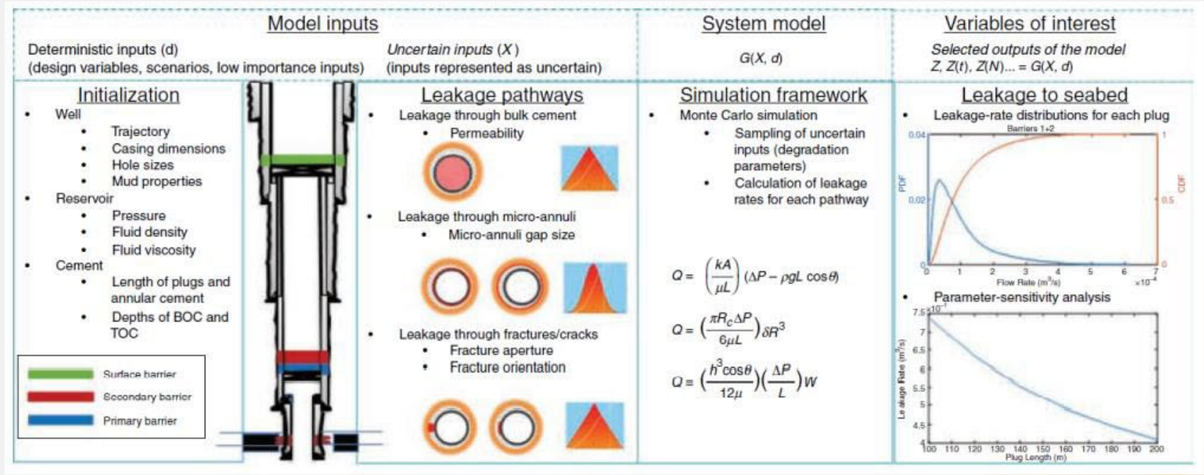


Well specific containment diagram

Standardized risk assessment legacy well

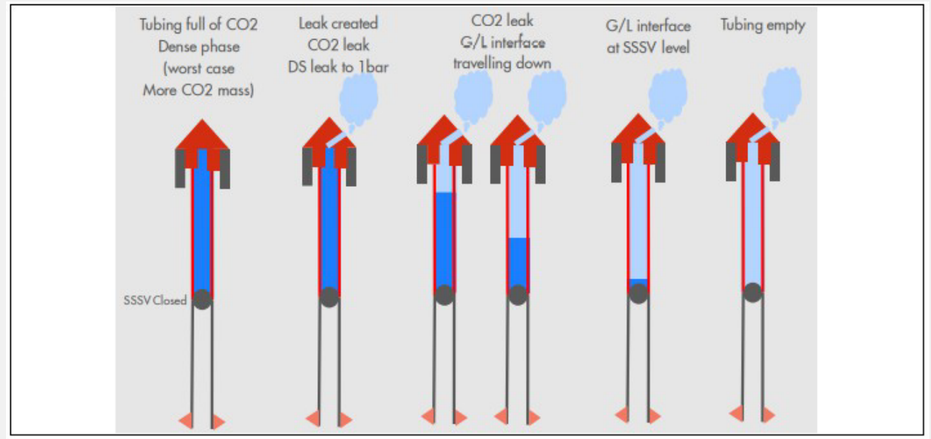
Type	Generic Description	Evaluation for the Storage Seal
Green	Containment Confirmed	The risk of flow to the environment or unwarranted crossflow during or post injection is deemed ALARP with high certainty. Rock-to-rock isolation is present in competent cap rock. Adequate length (100ft or local legislation) of cement. Cement plug verified and/or set on a competent base. The well meets both Shell and regulatory requirements as evidenced by well records. No further analysis is required. Note: Wells which are not in in the plume or would only face insignificant pressure should be classified as not applicable as they are outside the AOI
Yellow	Containment is or will be confirmed, no expectation intervention is required.	Containment risk, based on indirect evidence, deemed ALARP. Detailed analysis (e.g. salt creeping, bowtie, log analysis, cement placement modelling, corrosion prediction calculation, leak rate calculations, etc) was or is required. Long term containment monitoring may be required. This category also includes wells which meets WAM criteria, but regulatory approval to accept the well abandonment status remains valid when the license changes to CO_2 storage is pending, but expected. Example: Absence or inconclusive cement integrity logs triggers indirect verification via placement modelling, drilling records analysis etc. Lack of direct verification evidence on cement plugs but good indications from operational cement parameters.
Orange	Containment not ALARP, but the well CAN be repaired *see note below	Unwarranted crossflow or flow to the environment risks are not ALARP. Direct intervention or interception is possible. High POS for restoration of formation seal. Interception well deemed possible with conventional ranging technology (there is steel). Well meets WAM criteria, but it is expected the regulator will require an intervention. The Wells Discipline will provide a cost and time estimate. Example: No lateral coverage of cement plug in storage seal; well has unmitigated sustained casing pressure (SCP) or sustained casing ventflow (SCVF). Well, meets Shell requirements, but not regulatory requirements, e.g. on cement length or number of permanent isolations.
Red	Containment not ALARP and the well CANNOT be repaired. *see note below	As above, but with a low POS on success of the well re-entry and final abandonment. Example: Long unplugged open hole sections, no well bore access or obstruction inside well, no or low POS relief well possibility, poorly abandoned sidetrack wells.
Purple	No information – Avoid injection	The well is within the CO_2 plume or within the area of pressure response and has penetrated the storage zone(s). There are no abandonment records to verify if there is permanent isolation between the storage zone and the environment. Example: This situation is typical for land wells in North America where old legacy wells were drilled by small independent operators combined with a weak regulatory oversight. Depending on the project risk assessment and Measurement Monitoring and Verification (MMV) plan the AOI may have to be avoided.

Seepage calculation



CO_2 STORAGE
STANDARD PRACTICE FOR CCUS WELL DESIGN

- CCUS wells face unique challenges
- Especially for injection into heavily depleted gas reservoirs
- Potential for very low temperatures (-75 deg C)
  - High tensile loads, materials challenges
- As CCUS store gets filled, pressures go up
- Many other unique load cases



Process of emptying the tubing in a release to atmospheric conditions scenario, while the SSSV is closed. The process of emptying the tubing starts with a gas-liquid interface developing and travelling to the SSSV (*Acevedo & Chopra, 2017*)

Global STANDARD PRACTICE		Sponsor:	Wout Keultjes
		Owner:	Serge Roggeband
Department:	Global	Number:	EP202202203211
Subject:	Standard Practice for Casing and Tubing Design of Carbon Capture & Storage Wells	Revision:	0
		Classification:	Restricted

Standard Practice for Casing and Tubing Design of Carbon Capture & Storage Wells

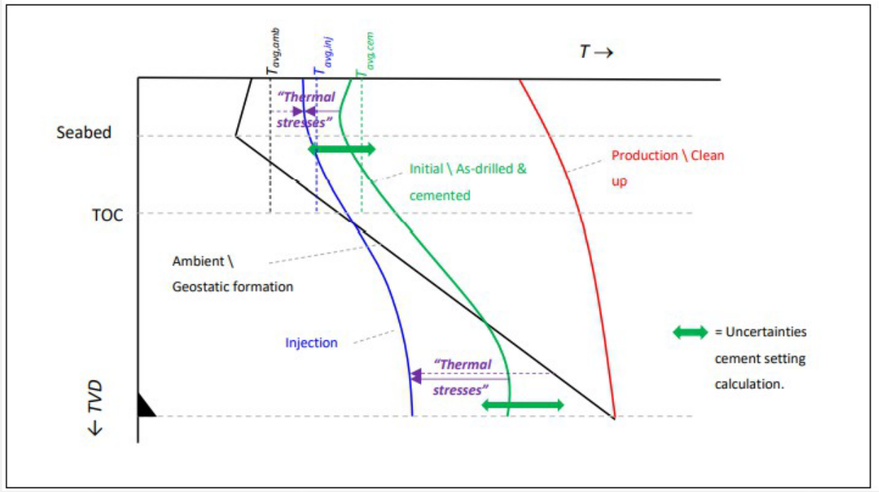
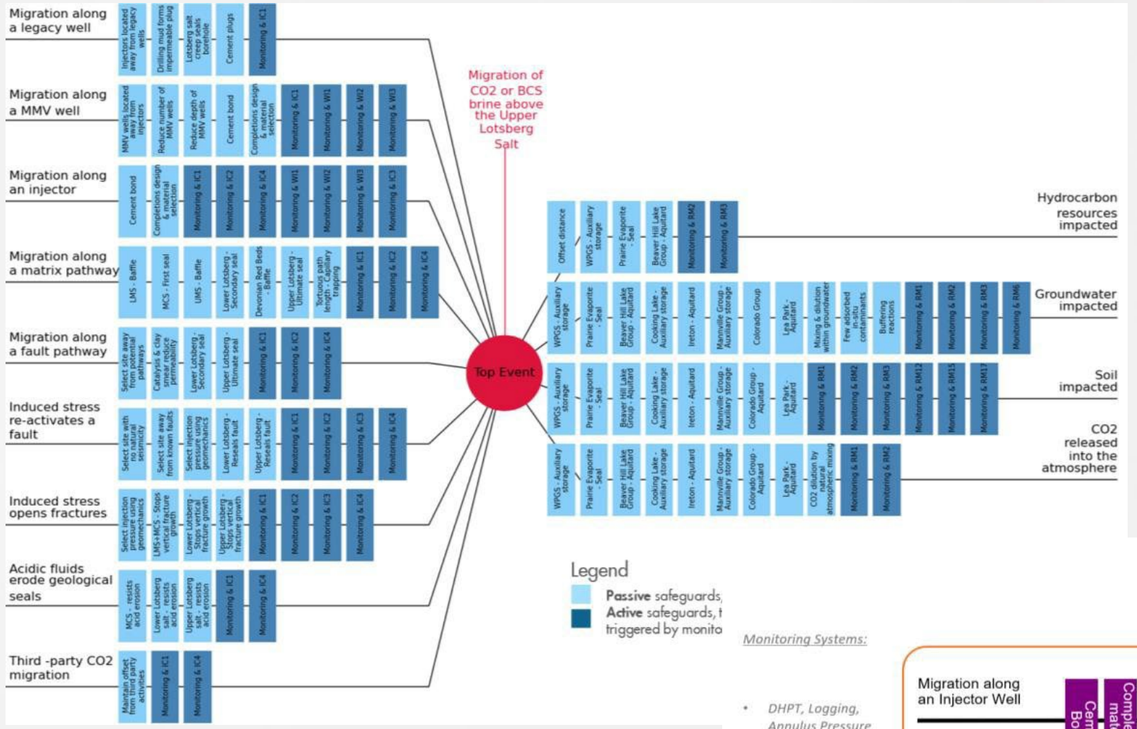


Illustration of temperature changes and associated thermal stresses for injection operations. These are different when using the initial (as cemented) temperatures vs the ambient (geostatic) formation temperatures. Above the TOC the average temperature along the uncemented pipe determine the thermal stresses, while below it, the local temperature change

CO_2 STORAGE
A RISK-BASED MMV EVOLUTION OVER TIME – THE QUEST EXAMPLE

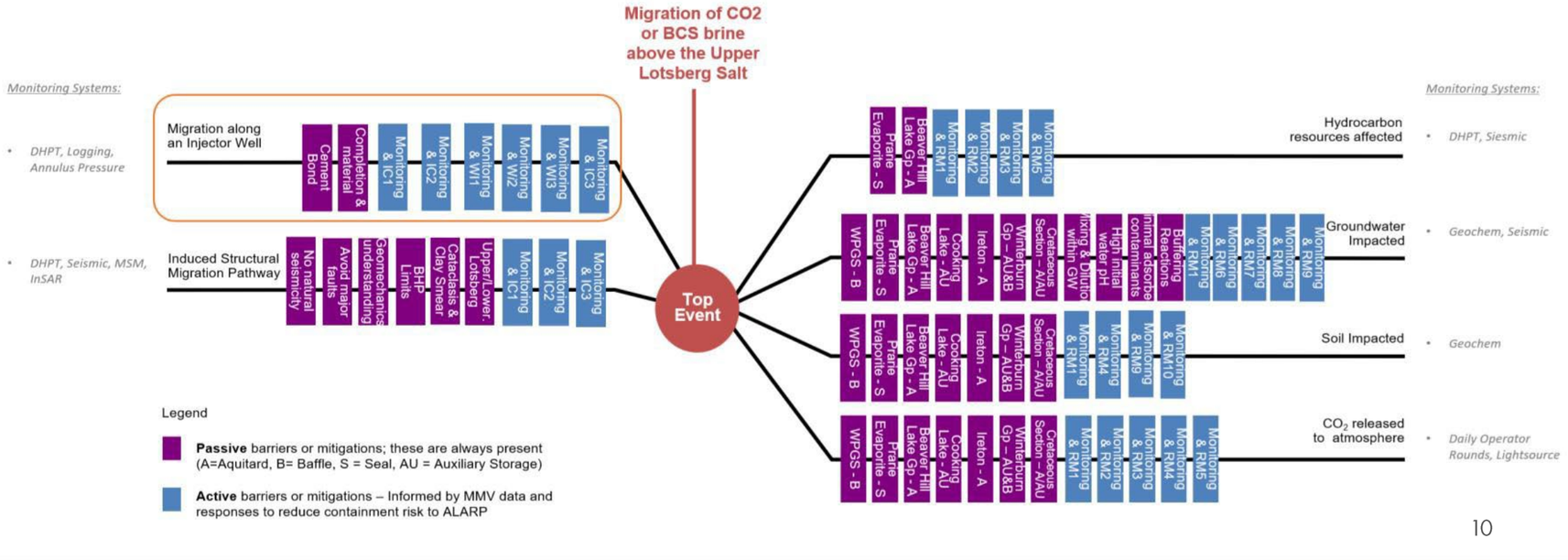


Quest original containment bowtie 2015

Early view of risks was very conservative

- Geological risks are negligible
- Well risks are managed by standard Well Integrity Management System

Updated leaner operational containment bowtie 2020



Costs and Tariffs are for illustration purposes only

BRINGING IT TOGETHER

MAXIMISING SYNERGIES INCREASES REGIONAL COMPETITIVENESS

Capture	Onshore	Shipping	Receive	Storage

Estimated tariff > 200 $/MT CO_2

Viable Business Case (~7 $ bln Capex)

High tariff required for project to be economical. 50% of tariff supports the emitter in capture and export cost. Remaining half of tariff is needed to support the transport and storage (T&S) service provider.

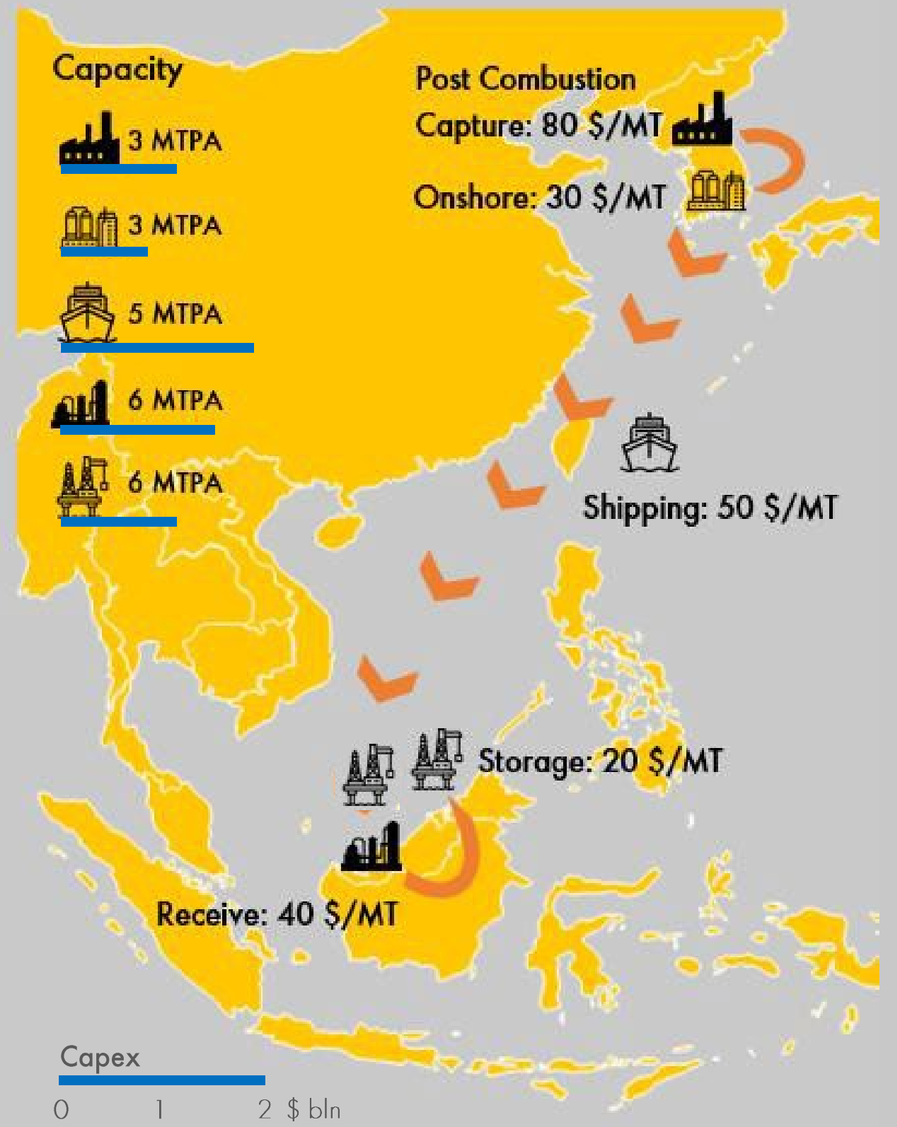
Regulation Certainty Drives Project Realization

Clear government commitments underpinned by strong carbon policy reduces the perceived risks of CCS, attracts financing and encourages investment by industry needed to mature the value chain.

Foster Public-Private Partnership (PPP)

Synergies and scale lower unit cost and enhance the affordability and viability of CCS projects. PPP can create a unified vision, a sustainable collaborative environment and a robust distribution of risks and sharing of resources.

Case Study: S.Korea-Malaysia CCS Value Chain



Summary

- There is vast potential for a CCS industry to develop in Asia, a fast-growing region with rising energy demand and GHG emissions. CCS is an essential part, particularly for hard-to-abate industry, complementing other solutions.
- Shell sees a unique opportunity to create a cross-border multi-store CCS industry in Asia-Pacific and we can draw on our experience in delivering CCS technology globally.
- Establishing the value chain in a standardized manner leveraging **global experience and maximising synergies at each location,** will encourage inter-operability and efficient build of infrastructure required to store CO2 in a safe, permanent and environmentally responsible way.

6. TECHNICAL, OPERATIONAL & INFRASTRUCTURE REQUIREMENTS

Mitsubishi Heavy Industries (MHI)

Taichi Tanaka, Engineering Manager

MHI's Efforts to Develop Effective and Economic CO_2-Value Chain

6. TECHNICAL, OPERATIONAL & INFRASTRUCTURE REQUIREMENTS

Chevron

David Fallon, General Manager

CO_2 Specification for CCS Storage

KEMENTERIAN EKONOMI

ASEAN CENTRE FOR ENERGY ACE

Asia Natural Gas & Energy Association

the human Chevron energy company™

CO_2 Specification for CCS Storage

Lessons from Gorgon CCS Operation

Photo: Gorgon gas processing facility with carbon dioxide removal and compression modules in foreground

- Moisture content was an issue at Gorgon
  - This issue delayed initial project start-up due to required engineering rework
  - Key issue was transient excursions in moisture expected during startup

- Apart from drying there is no other treatment of the Gorgon CO_2 stream
  - Key focus is to ensure that CO_2 remains supercritical
  - Again non normal transient conditions such as extended periods of no CO_2 storage are where issues arise

Observations on Emerging CO_2 Specification Trends

- Contracting parties to the *London Protocol* are required to develop an “Action List”
  - Australian Government has issued an Interim National Action List for CCS which is conservative in nature

- CCS Hubs themselves will likely also require / impose separate specifications
  - Careful attention will need to be paid to
    - Mixing of CO_2 sources from different industries
    - Integration of CO_2 delivered via different transportation methods (Shipping vs Pipeline)

- Imposing unduly stringent specifications by governments and / or Hub operators will increase the barriers to growth of the CCS industry as one of the solutions in the movement to a lower carbon economy
  - Tighter specifications will increase capture costs as additional equipment needs to be added

- Key opportunity is to continue strong collaboration between government and industry proponents to find mutually acceptable outcomes

6. TECHNICAL, OPERATIONAL & INFRASTRUCTURE REQUIREMENTS

Petronas

Christopher K Singham, Head of Carbon Capture Technologies

Advancing Malaysia’s Decarbonisation:

Integrating Carbon Capture Technology, Utilisation & Storage

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ASEAN CENTRE FOR ENERGY • ACE •

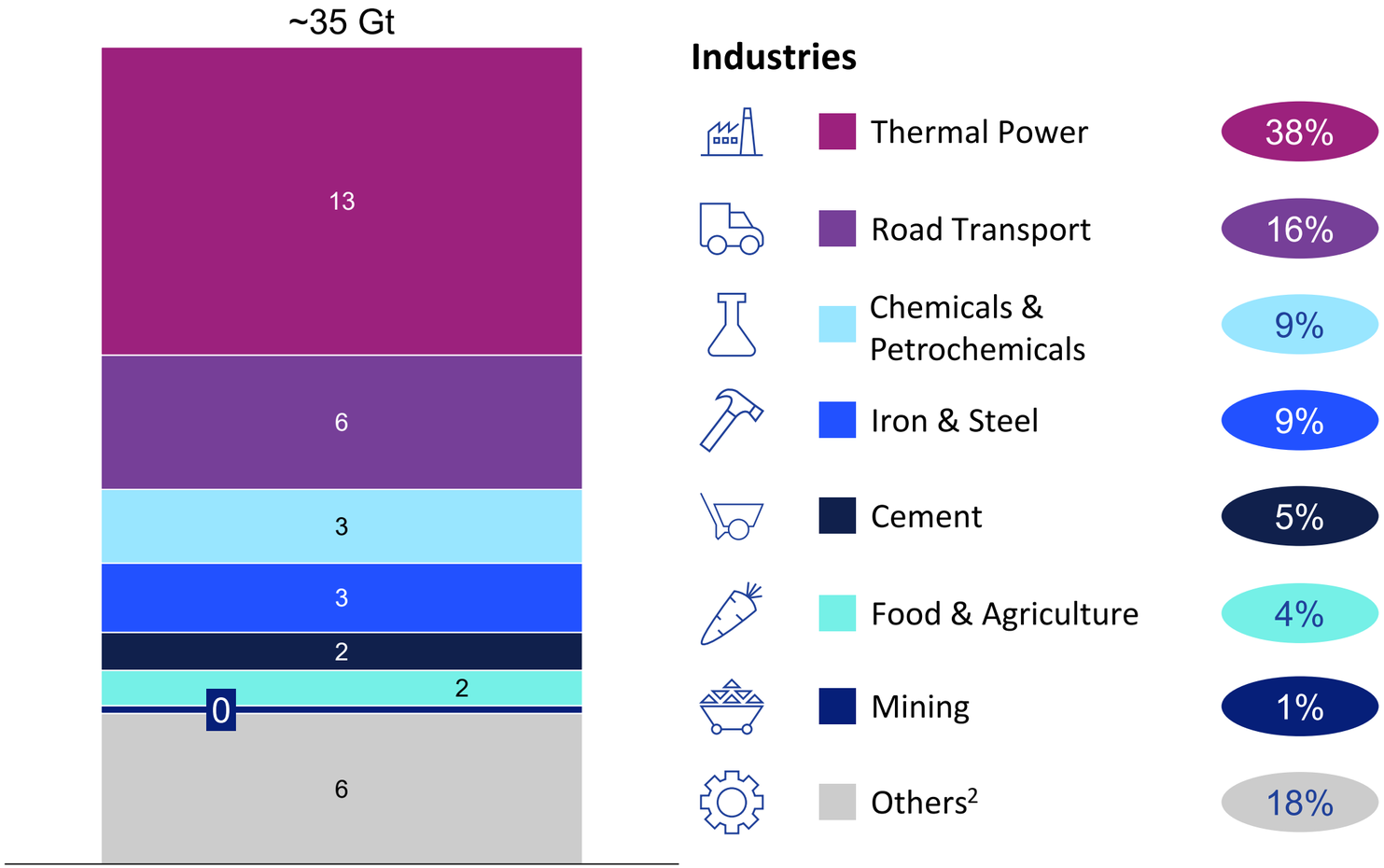
Asia Natural Gas & Energy Association

Advancing Malaysia’s Decarbonisation: Integrating Carbon Capture Technology, Utilisation & Storage

The PETRONAS Group adopts zero tolerance against all forms of bribery and corruption. We abide by the PETRONAS Code of Conduct and Business Ethics (CoBE) & Anti-Bribery and Corruption (ABC) Manual, guided by our Shared Values and Statement of Purpose.

CO_2 Emissions and Decarbonisation Regulations are Growing Globally Starting with Europe's Carbon Border Adjustment Mechanism (CBAM)

Global CO_2 emissions[1], Gt and % (2020)



1. Only CO_2 emissions counted, not including other GHG like CH4, N2O, etc.
2. Including non-metallic minerals, shipping and other industry emissions, etc.

Source: Climate Watch (latest 2020 data published in Oct 2023), IEA

Key Highlights

- Countries are gradually implementing decarbonisation regulations, **with EU leading the pack with CBAM taxation framework** that will be gradually implemented in the next 10 years
- **More cross border carbon adjustment regimes** are likely to come into play in the future. E.g. the US announced in its 2021 Trade Policy Agenda that it is considering imposing a carbon border adjustment on imports into the US
- Against this context, piloting adoption of Carbon Capture and Storage (CCS) tech could be a beneficial move for Malaysian iron and steel producers

Overview of Malaysia’s National CCUS Initiative

1. Malaysia's journey to a low-carbon future is guided by the **National Energy Transition Roadmap (NETR)** and the **New Industrial Master Plan (NIMP).** Launched in August and September 2023, respectively, NETR focuses on decarbonising the energy sector while NIMP addresses the broader industrial landscape. CCUS is a critical component of both initiatives.

2.
- PETRONAS was appointed as the champion for the **CCUS Mission-Based Project** in 2023 to deploy CCUS. Through **Project CarbonStrike**, PETRONAS has been collaborating closely with MITI to conduct pilot projects in hard-to-abate sectors, informing the development of carbon reduction policies, including potential incentives and taxes.

- The **CCUS Act** is currently being drafted for parliamentary tabling in Q4 2024.

3.

We do this as a Joint Venture of Reputable Companies across the CCUS Value Chain, with over 100 Years of combined Industry Expertise

Our Shared Commitment to the Path to Net Zero

PETRONAS

Provides capture and utilisation technology, storage services and in-market Malaysia expertise

MISC

Provides terminal and transportation services

Samsung E&A

Provides Capture Technology, Consultancy-FEL-EPC services

Honeywell UOP

Provides capture technologies

TechnipFMC

Provides expertise in offshore EPCC, as well as monitoring and measurement

What We Offer: One-Stop-Shop Solution to Help You Address the Entire Carbon Capture Value Chain

Carbon Emitter

We partner with you as a service provider…

CarbonStrike

…You get our entire suite of end-to-end carbon capture services, without having to work with multiple vendors

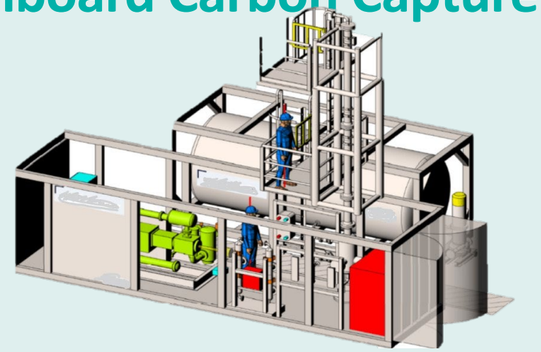
- Consultancy
- Financing
- Carbon Capture
- Liquefaction
- Temporary Storage
- Transportation
- Permanent Storage
- Utilisation
- Carbon Credits
- EPC

Hybrid Membrane-Solvent Technology Membrane Contactor (MBC)

A hybrid process combining membrane with solvent separation technologies to optimise CO_2 capture solution for onshore capture applications

CO_2 Capacity	**10-1000 TPD**
CO_2 Outlet Purity	**>95%**
UTC (USD/tonne)	**USD 30-50**
TRL	**5**

Rotating Packed Bed (RPB) Technology for Onboard Carbon Capture and Storage (OCCS)



Rotating Packed Bed (RPB) for Post-Combustion Flue Gas

A technology aimed to miniaturise distillation columns/contacting towers to be smaller and more compact

CO_2 Capacity	**10-50 TPD**
CO_2 Outlet Purity	**>95%**
UTC (USD/tonne)	**USD 40-60**
TRL	**6**

GCCSI Technology Compendium – PETRONAS Membrane Contactor (MBC)

GLOBAL CCS INSTITUTE

HUGH BARLOW
Carbon Capture Technology Lead

SHAHRZAD S M SHAHI
Carbon Capture Technology Lead

PETRONAS

MEMBRANE CONTACTOR (MBC)

khairul_rostani@petronas.com nanthini.raman@petronas.com

SUMMARY

A KEY TO ACHIEVING NET ZERO TARGETS

PETRONAS, pioneering as the first Oil and Gas company in Southeast Asia to commit to net zero emissions by 2050, introduces a groundbreaking solution in carbon capture technology: the Membrane Contactor (MBC). This fully modularised technology seamlessly integrates the strength of solvent-based absorption with the adaptability of membranes. MBC's innovative design boasts a revolutionary 50% reduction in overall volume, previously deemed unattainable in carbon capture technology. More than just its size, the MBC signifies impact, offering new avenues for industries tackling decarbonisation challenges, particularly in hard-to-abate sectors. With its compact and flexible nature, MBC empowers companies to scale their carbon capture efforts in line with their decarbonisation ambitions. Implementation is no longer synonymous with daunting infrastructure projects; MBC's swift setup and minimal operational disruption makes carbon capture not only feasible but also accessible, and remarkably cost-effective for the industries.

BENEFITS

- **Minimises Overall Carbon Footprint:** MBC's state-of-the-art multi-cartridge membrane contactor modules, achieve an impressive 50% reduction in the overall volume while maintaining high carbon capture efficiency, all within a compact design.
- **Tailored Solutions for Every Need:** MBC offers unparalleled scalability, allowing seamless adjustments to match the unique requirements of our clients. MBC adaptable nature ensures flexibility by catering to clients' evolving operational needs.
- **Competitive Cost to Capture:** Lower compression cost due to high regeneration pressure up to 5 barg, and lower solvent circulation rate up to 30%, as first of its kind modular technology. Aimed at achieving CO_2 capture for a competitive cost of US$30-50 per tonne, MBC ensures maximum value for every investment.
- **Confronting Challenges with Innovation:** By segregating the solvent and gas phases, MBC effectively mitigates foaming issues, minimising the need for anti-foam agents. By having a differential pressure control system, this not only cuts operational costs but also extends membrane lifespan, guaranteeing sustained performance over time.

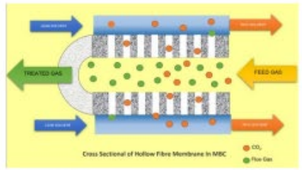


Figure 1: Cross Sectional of Hollow Fibre Membrane in MBC

KEY DATA

TRL	5	Capture Rate Range (tpd)	10 - 600	Modular (Y/N)	Yes
Source CO_2 Purity Range	3 - 30%	Energy Consumption (GJ/tCO_2)	<2.9	Capture Efficiency (%)	>95%
Number of Commercial Plants	~	Number of Pilot Plants	4	Pressure Drop	<0.2bar
Target Industries	Refineries, Hard-to-abate industries (Cement, Steel, Chemicals and Power & Gas Plants)				

TECHNOLOGY DESCRIPTION

Carbon Capture and Storage (CCS) technology plays a critical role in combating climate change. Despite its potential benefits, the widespread adoption of CCS faces several challenges. Traditional CCS systems often require significant space for installation, posing issues for industries with limited land or optimised facilities. Integrating large-scale CCS systems into existing industrial sites can be costly and disruptive, making it a less attractive option for many businesses.

PETRONAS and its groundbreaking Membrane Contactor technology is poised to revolutionise the CCS landscape. With a remarkable >20-fold increase in mass transfer area compared to conventional systems, this innovation delivers unparalleled efficiency. This enhancement results in a compact and efficient separation system boasting a remarkable 75% reduction in height, 40% reduction in weight, and impressive cuts of 25% in solvent usage. Going beyond its impressive physical characteristics, PETRONAS' modular technology offers scalability and operational simplicity, effectively addressing common challenges like flooding and foaming.

Its versatility, demonstrated by its compatibility with a diverse range of solvents, ensures adaptability to meet the unique needs of various markets. PETRONAS and Dalian Institute of Chemical Physics (DICP) has taken innovation a step further by enhancing the CO_2 separation performance, boasting superior absorption capabilities, which has a capture efficiency of more than 95%. This breakthrough results in reduced solvent usage and a 25% decrease in regeneration energy consumption, compared to conventional amine packed bed column system.

PETRONAS' proprietary technology incorporates a suite of design enhancements aimed at driving down the cost of CO_2 capture. From shorter MBC columns to streamlined solvent circulation and integrated inter-cooler heat exchanger designs, every aspect is meticulously crafted for maximum efficiency and cost-effectiveness.

In a landscape where sustainability and economic viability are non-negotiable imperatives, PETRONAS leads the change with transformative CCS solutions, setting new benchmarks for environmental responsibility and commercial excellence.

PROCESS DESCRIPTION

The process starts with a conditioning step of the flue gas from the point source emission (3-30% CO_2), whereby the flue gas is cooled down to between 40°C and 60°C via a combination of Waste Heat Recovery Unit (WHRU) and Direct Contact Cooling (DCC) if available where SOx, NOx and fine particulates are removed.

After cooling, the absorption of CO_2 from the cooled flue gas takes place in the MBC absorber where this gas stream is in contact with the semi-lean amine solvent. Gas flows into the membrane tube side counter-current with semi-lean solvent which is fed into the shell side of the MBC absorption module.

The counter current flow configuration enables the leanest solvent to come into contact with flue gas near the gas exit of the module, maintaining high CO_2 concentration gradient between the flue gas and solvent throughout the module, which is translated into better CO_2 removal efficiency.

The depleted gas is released to the atmosphere; while the CO_2 rich amine is heated and sent to the MBC regenerator. Additional heat is added in the reboiler to favour the release of the absorbed CO_2. Two streams leave the desorber: the CO_2 rich gas stream which can either be sequestered to storage or utilised to a higher value product, and the semi-lean amine. The semi-lean amine is then recycled back into the MBC absorber. The CO_2 recovered has purity more than 98%.

The flow rate of the feed gas, and the solvent can be varied independently depending on the process conditions and requirements, providing the system with higher flexibility for any changes in process inputs as compared to the conventional tall absorption columns.

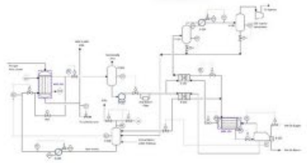


Figure 2: PETRONAS MBC Flue Gas Process Flow Diagram

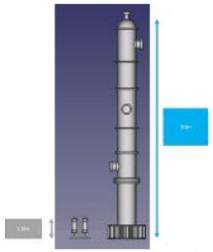


Figure 3: MBC Comparison with the Conventional Column Height

PROOF POINT: PETRONAS'S CARBON CAPTURE DEMO PROJECT.

MBC Capture technology will be deployed for Carbon Capture demonstration project at one of PETRONAS's facilities, with a capacity of 10 TPD, a significant stride towards embracing low-carbon solutions. By leveraging MBC technology, PETRONAS aims to achieve substantial cost reductions in its capture processes, with anticipated equipment savings of 27% and energy cost savings of 30%. This strategic initiative highlights PETRONAS' dedication to environmental sustainability, prioritising emission reduction at its core operations.

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Scan here to read more!

Pg 122-123

How Do We Work Together?

We are ready to start a partnership with you which will take approximately six to nine months to operationalise.

Reach out to our team:

Focal Point

Christopher Singham
christopher_ksingham@petronas.com

THANK YOU

PETRONAS


PETRONAS
50
YEARS

6. TECHNICAL, OPERATIONAL & INFRASTRUCTURE REQUIREMENTS

Panel Moderator

Alex Zapantis, General Manager, External Affairs

Global CCS Institute

SOUTH EAST ASIA CCS ACCELERATOR WORKSHOP (SEACA)

Part III: Creating a Transnational Asian CCS Value Chain

7. INTERNATIONAL SUPPORT AND INVESTMENT

International collaboration and investment in CCS in Asia will be essential to support the creation of a CCS Value Chain in the region. Speakers in this session will describe the relevant activities of their organisations for support, financing, and investment in CCS in South East Asia.

GLOBAL CCS INSTITUTE

7. INTERNATIONAL SUPPORT AND INVESTMENT

The World Bank Assistance

Dr. Harshit Agrawal, Senior Energy Specialist

The World Bank

Challenges and Enablers to Finance CCS projects

August 2024

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CARBON CAPTURE AND STORAGE (CCS) IS A NECESSARY CLIMATE SOLUTION – WB AIMS TO ACCELERATE DEPLOYMENT IN DEVELOPING COUNTRIES

Carbon Capture and Storage (CCS) is an essential solution to reach global climate targets…

- **The world will fail to meet the Paris Agreement goals without carbon capture** – to achieve net zero global emissions in 2050, the world needs to grow CCS capacity
- The **World Bank Group's Climate Change Action Plan** mentions carbon capture as a solution for fossil fuel-dependent economies to consider in the **development of NDCs and long-term strategies**, and for **transitioning to low-carbon energy**
- CCS may support developing countries to **industrialize along a lower carbon pathway**, maintain jobs for **workers in hard-to-abate sector** (e.g., cement, steel), and monetize advantageous **geology for carbon storage**

… however, developments of CCS are still in early stages and challenges exist in developing countries

- According to the Global CCS Institute, there are **392 projects that have been announced**, however currently only **41 facilities are operational**
- **Barriers to widespread deployment of CCS** in developing countries includes:
  - **High CAPEX for carbon capture systems**, both greenfield and retrofit
  - **Limited business case** for non-EOR CO_2 storage facilities
  - **Low technology transfer** and capacity building outside of oil & gas sectors
  - **Data gaps** on geological storage capacity
  - Lack of guidance for **cross-border transport and offshore storage** of CO_2 (e.g., the London Protocol provides guidance but not all countries are party to the Protocol)

The World Bank's prognosis on CCS

- **In the short term, market enabling advisory work is needed** – WB's current and past projects in Nigeria, South Africa, Vietnam, Timor-Leste, and Indonesia can be replicated in other developing countries
- Medium term presents **more risk mitigation and investment opportunities in cases where there is an enabling regulatory environment** – eventually, carbon prices can support the business case
- Geographically, there is **great interest in Asia Pacific** countries with additional challenges related to transboundary transport and storage

FOUR KEY SUCCESS FACTORS FOR CCS PROJECTS: TECHNICAL FEASIBILITY, COST EFFECTIVENESS, PROPER REGULATIONS, AND SUPPORT FROM THE LOCAL COMMUNITY

Successful CCS project

Actual emission reduction

Key success factors

Technical feasibility

- **Proper capture technology**
- **Efficient value chain**: Ensure that the CCS system is compatible with existing infrastructure
- **Suitable storage sites**: Select appropriate sites with necessary geological characteristics
- **Environmental and safety** risks mitigation

Cost effectiveness

- **Cost management**/ cost reduction strategies: CCS hubs, reuse of existing infrastructure
- **Sustainable business models**: Ensure profitability of project

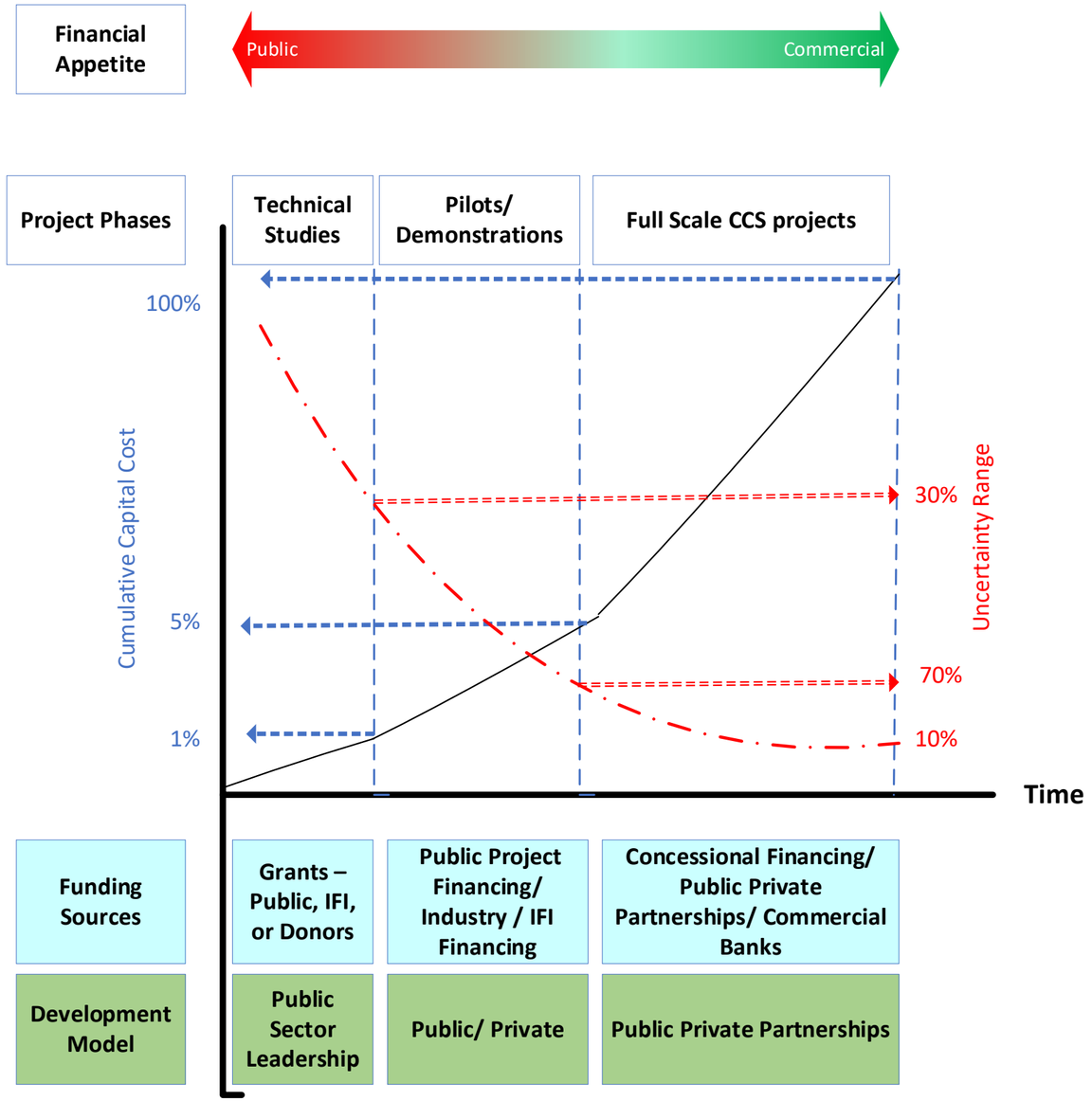
Proper regulatory and incentives environment

- **Funding and incentives**: Secure funding from govt. subsidies, grants, or private investments
- **Dedicated legal and regulation** framework
- **Strong MRV system:** Clarify liabilities of CO_2 along the value chain
- **Clear allocation of roles** & responsibilities

Support from the local community

- **Industry collaboration and knowledge sharing**: Collaborate with industry partners, research institutions, and other stakeholders
- **Social acceptance**: Establish public trust and community support for CCS initiatives

FINANCING AND DEVELOPMENT MODELS FOR CCS PROJECTS



WB AIMS TO SUPPORT THE DEVELOPMENT OF CCS ALONG THE VALUE CHAIN THROUGH ADVISORY AND INVESTMENT SERVICES

	Enablers	Carbon Capture	Transport & Storage
Objectives	Establish **effective Carbon Capture and Storage ecosystem** to accelerate investment in emission removal opportunities	• Support the **adoption of carbon capture technologies across key industrial sectors** to align with country's climate goals and international commitment	• Facilitate the **development transport and storage infrastructure close to major emitters**, making storage more economically viable
Challenges to address in the region	• Insignificant demand of verified CO2 reductions and removals due to **absence of sufficient incentives and regulations** • **Limited financing instruments** and domestic Financial Institutions participations in financing CCS projects	• **Most industrial carbon capture projects are not economically** viable due to a lack of supportive market conditions and risks associated with the technology • **No clear incentives** to encourage carbon capture demand in industries	• **Lack of a viable business model** between emitters and CO_2 transport & storage providers • **Regulatory gaps on CO_2 transport and storage** (e.g., guidance on cross-border transport, provisions to operationalize procedures for obtaining storage permits)
Potential WB involvement	• **Market enabling reforms advisory** to support the development of robust CCS ecosystem • **Support the provision of financial instruments** by domestic FIs to finance carbon removal projects	• **Provide techno-economic advisory work** to direct emitters (e.g., cement, steel) as well as hubs • **Provide investment and concessional financing** in carbon capture technologies to direct emitters as well as hubs	• **Develop a robust business model** to support developing countries in becoming a low- cost provider of storage solutions • **Provide investment and concessional financing** in potential storage operations

Cross-cutting: **Capacity and knowledge building to increase awareness and understanding of CCS** amongst national stakeholders, including its role in meeting mitigation targets, technology, economics, legal and regulatory

THANK YOU

Asian Development Bank Program

Atsumasa Sakai, Senior Energy Specialist

Asian Development Bank (ADB)

ADB’s Support to Hard-to-Abate Sectors

Microsoft Teams

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7. INTERNATIONAL SUPPORT AND INVESTMENT

Japanese Initiative

Kazuki Kobayashi, Researcher, Planning Division, CCS Project Department, Japan Organization for Metals and Energy Security (JOGMEG)

Transborder CCS and Joint Crediting Mechanism (JCM)

Transborder CCS and JCM(Joint Crediting Mechanism)

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August 2024

About JOGMEC

- **Japan Organization for Metals and Energy Security (JOGMEC)**
- Aim to secure the stable supply of energy and natural resources for Japan and to realize carbon neutrality through CCS, supply of low/zero carbon fuels including hydrogen, ammonia, geothermal energy and wind power.

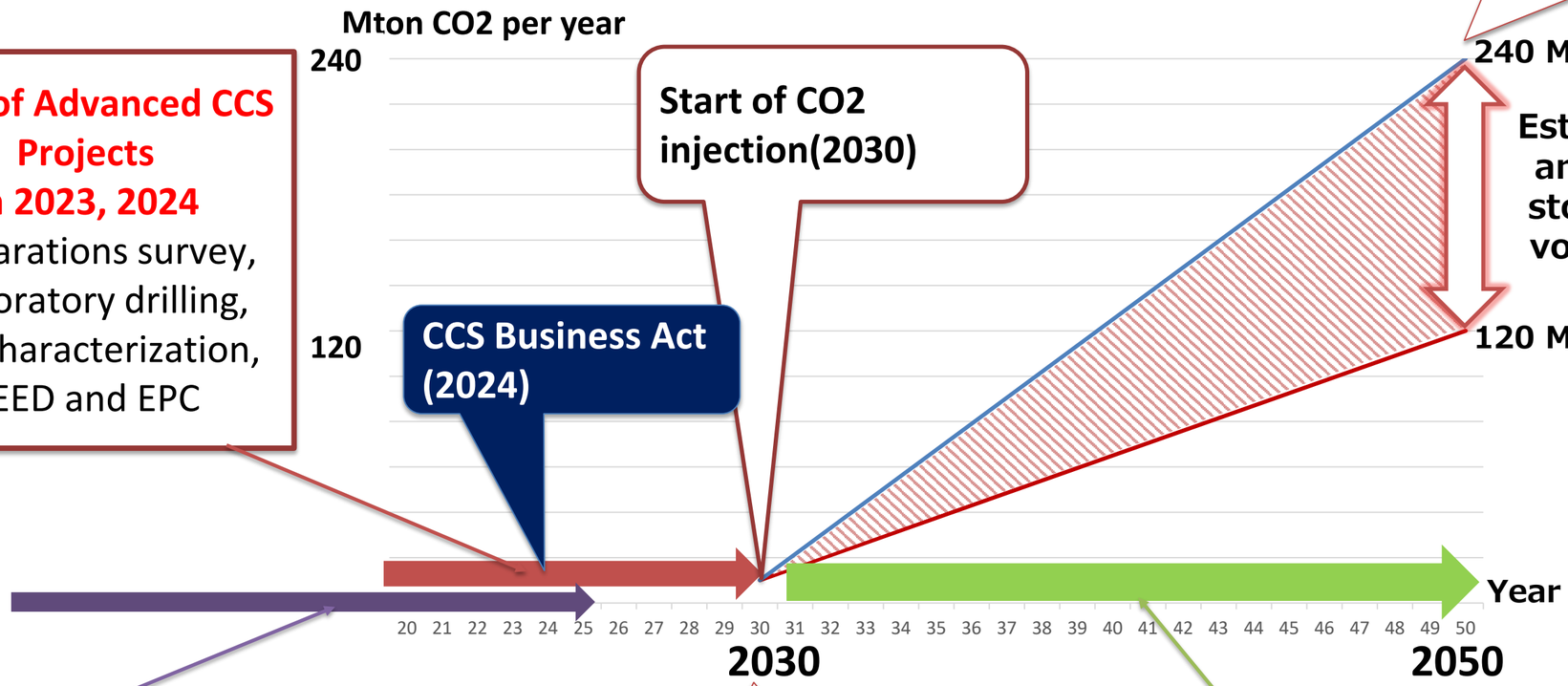
New Mission (2022~)

- **CCS**
- **Hydrogen, Ammonia**
- **Wind Power**

- Financial support: Support risk money with taking equity capital and liability guarantee.
- Technical support: Joint FS and technical study for challenging issue at the operation field/site.

Japanese Carbon Neutral Strategy and CCS Implementation Target

Achievement of carbon neutrality (2050)



Start of Advanced CCS Projects in 2023, 2024
Preparations survey, exploratory drilling, site characterization, FEED and EPC

Basic studies and demonstration projects. (Iwanohara,Tomakomai, Minami-aga, Hirai, etc.)

46%* reduction of GHG emission (2030)
* Compared with 2013

- Technical /financial follow-up
- Second-mover support

JOGMEC's role:
- Geological/geophysical surveys
- Execution of Advanced CCS Projects and other pilot projects in Japan and oversea
- Post-site closure monitoring
- Future financial support to commercial operations

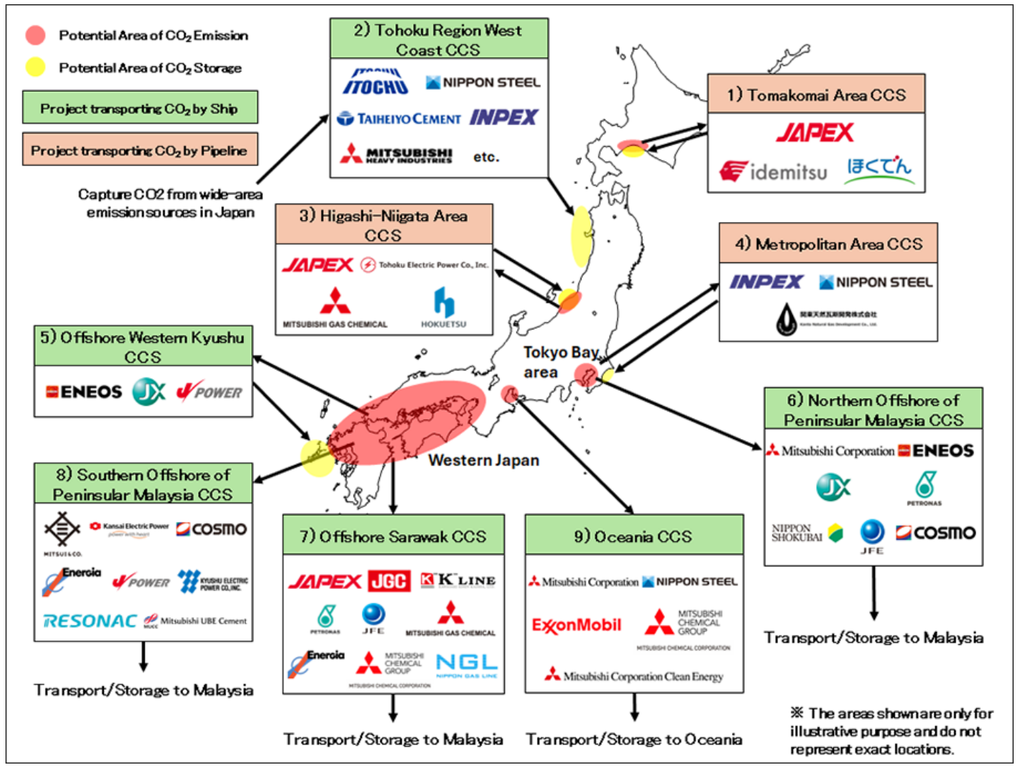
Based on METI (Ministry of Economy, Trade and Industry): May 27, 2022 20220527_2.pdf (meti.go.jp)

Advanced CCS Projects

Leading and piloting commercial scale CCS operations

- **Target**:
  - Injecting total 6-12 Mtpa of CO2 at year 2030
  - Geophysical surveys and exploratory well drillings, and examination of technical/institutional feasibilities
- **Structure:**
  - Government funding until FID
  - **Total value chain** of emitter/transportation/storage
- **9 role model project candidates**: Variety of features
  - Combination of multiple CO2 sources
  - Domestic storage (5) vs. Overseas (4)
  - Pipeline (3) vs. Shipment (6)
  - Expandability required

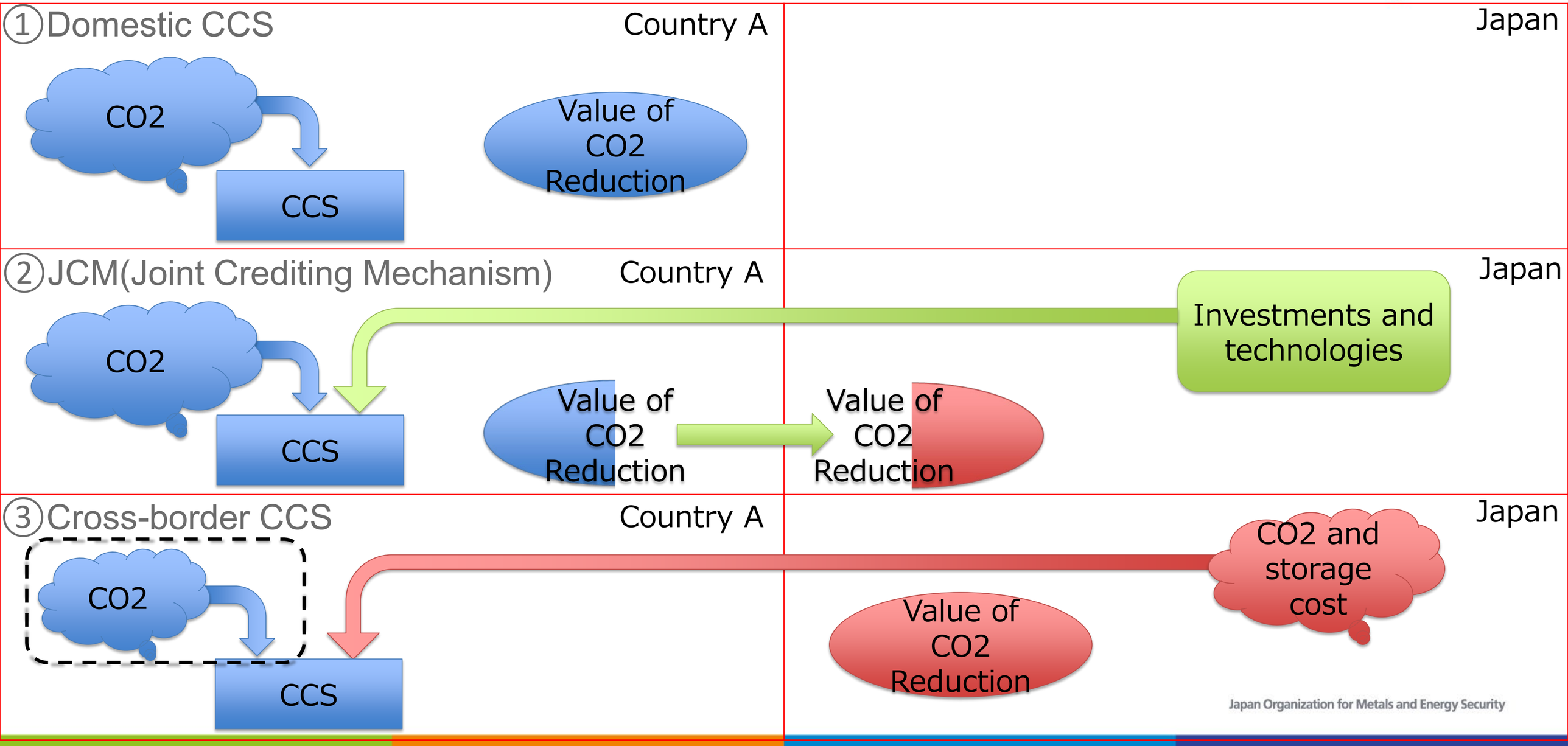
Projects will be examined at the stage gates



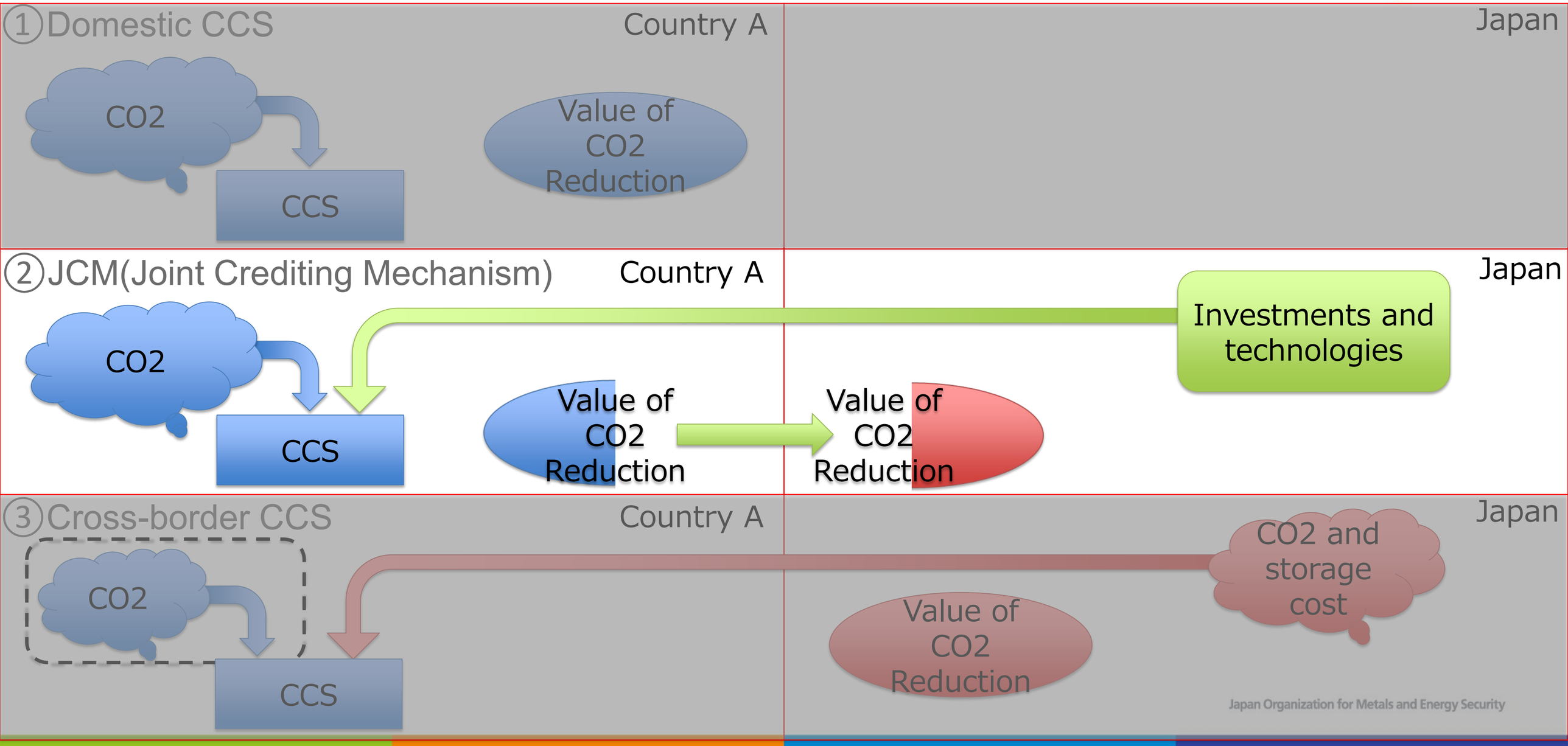
Location of 9 Japanese Advanced CCS Projects and companies.
The 9 projects plan to store approximately **20 million** tons of CO2 per year.

Source)[Advanced Efforts for Commercialization of CCS- JOGMEC selects Nine projects as Japanese Advanced CCS Projects - : News Releases | Japan Organization for Metals and Energy Security (JOGMEC)]

Variations of CCS

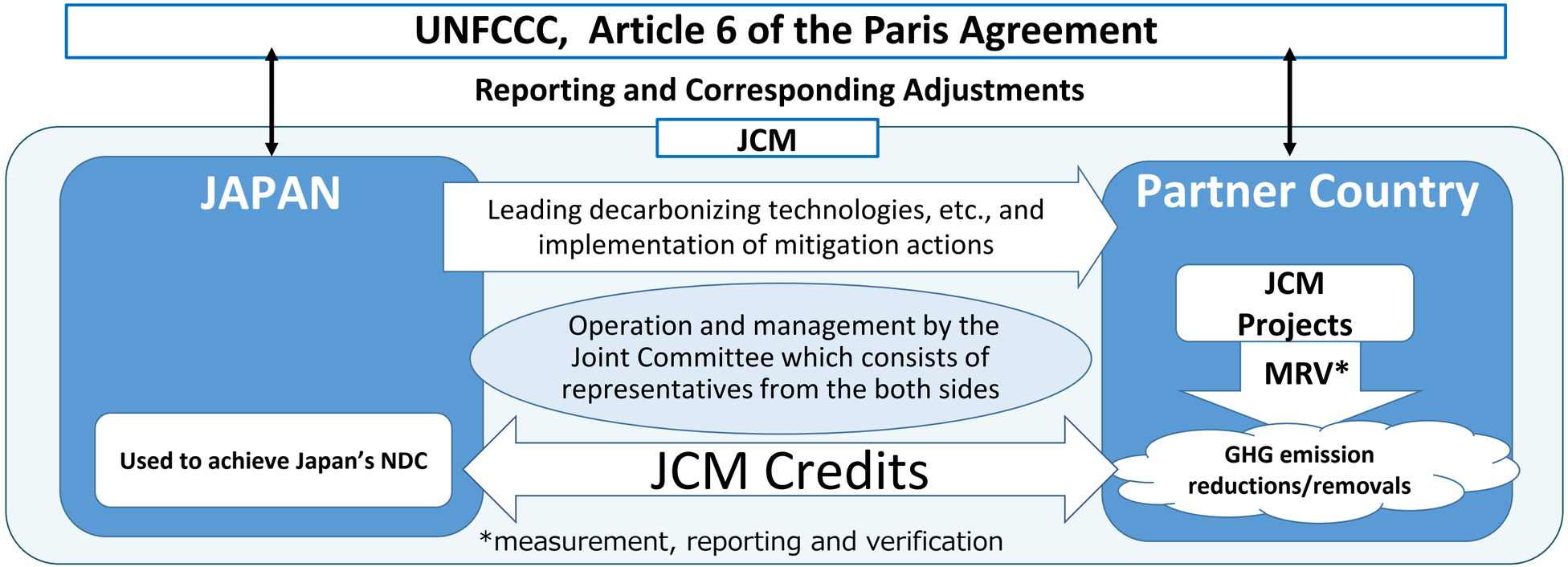


JCM(Joint Crediting Mechanism)



Basic Concept of the Joint Crediting Mechanism (JCM)

- Facilitating diffusion of leading decarbonization technologies, products, systems, services, and infrastructure as well as implementation of mitigation actions, and contributing to sustainable development of partner countries.
- Contributing to the ultimate objective of the UNFCCC by facilitating global actions for GHG emission reductions or removals.



Japan Organization for Metals and Energy Security

Adapted from a presentation given at JOGMEC's International Workshop "Global Carbon Markets and CCS: Towards Decarbonization in ASEAN" held on 25-26 January 2023.

Revision of JCM Rules & Guidelines

The JCM Rules & Guidelines are being rewritten in relation to Article 6 of the Paris Agreement. JCM-CCUS Guidelines were drafted by METI and MOE (Ministry of the Environment) through the expert meetings.

Additional items added to the draft of CCS Rules & Guidelins

- Participation conditions
- Sectoral Scope
- Eligible project
- Net emission reduction for CCS Projects
- Project stage within scope
- GHG sources
- Closure period monitoring
- Credit Reserve

Current Sectoral Scopes for the JCM

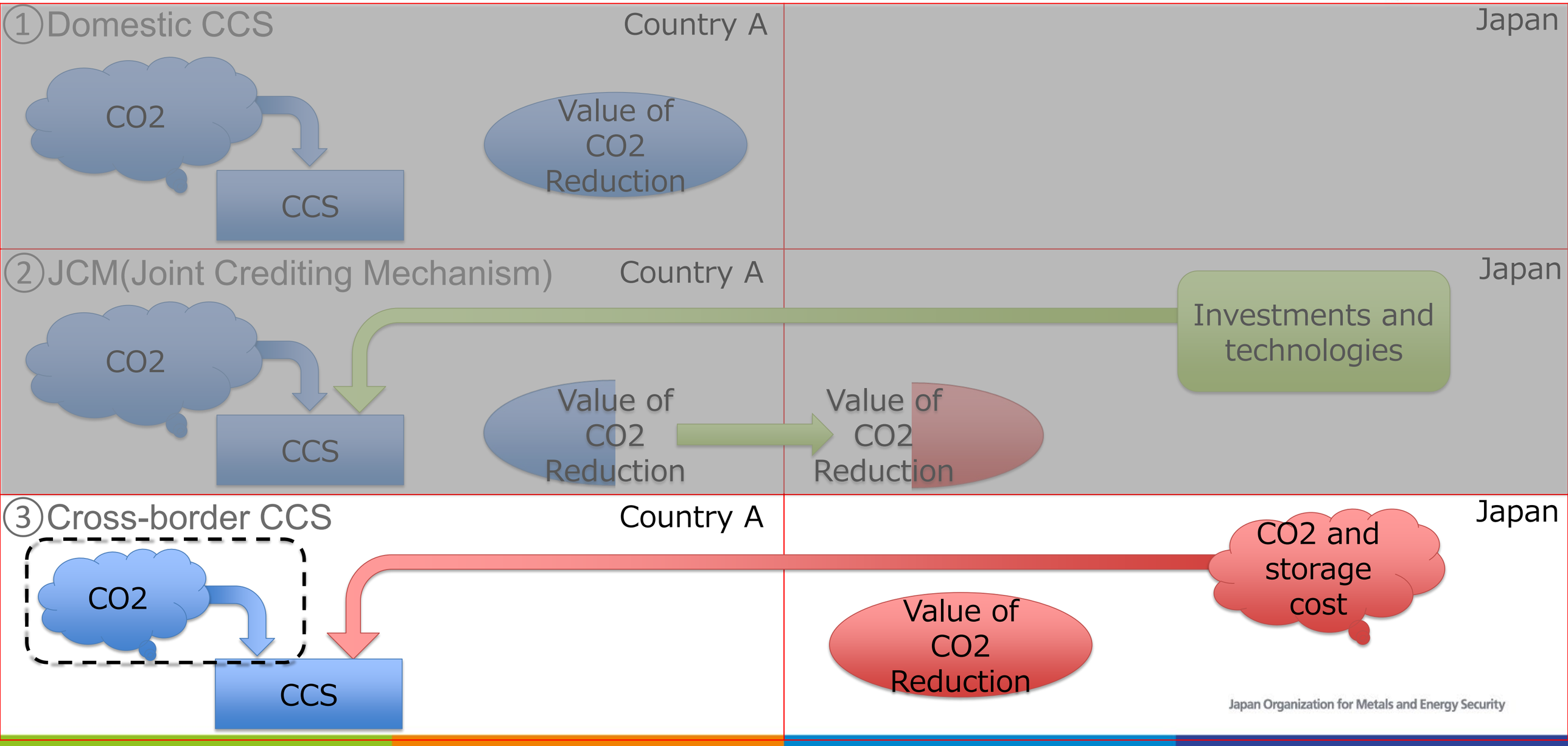
1.	Energy industries (renewable - / non-renewable sources)	9.	Metal production
2.	Energy distribution	10.	Fugitive emissions from fuels (solid, oil and gas)
3.	Energy demand	11.	Fugitive emissions from production and consumption of halocarbons and sulphur hexafluoride
4.	Manufacturing industries	12.	Solvents use
5.	Chemical industry	13.	Waste handling and disposal
6.	Construction	14.	Afforestation and reforestation
7.	Transport	15.	Agriculture
8.	Mining/Mineral production		

Agreement between the JCM Secretariats of both countries is required

CCS project is not yet included in the scope of JCM.

Adapted from a presentation given at JOGMEC's International Workshop "Global Carbon Markets and CCS: Towards Decarbonization in ASEAN" held on 25-26 January 2023.

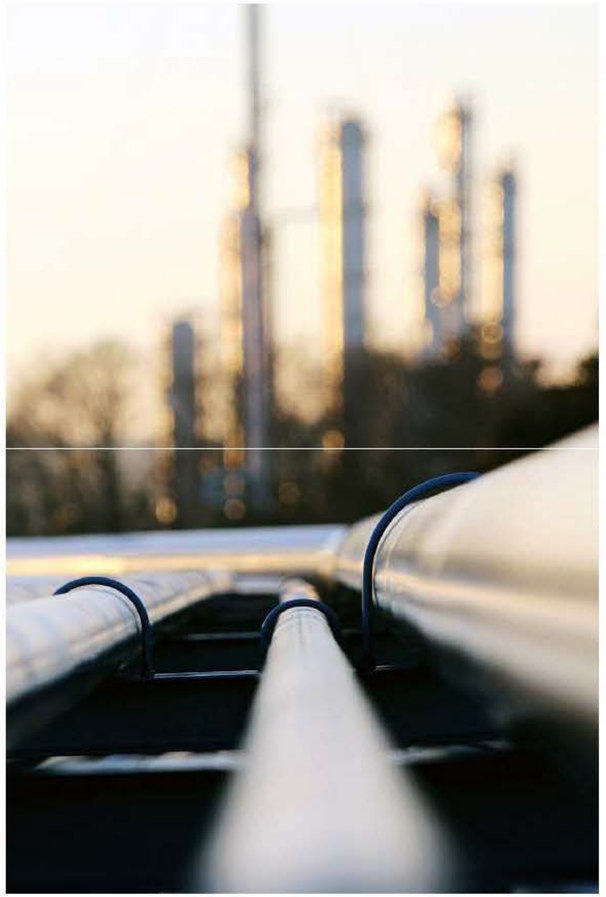
Cross-border CCS



London Protocol 1996

1(b). London Protocol 1996 (Dumping at sea)

- supersedes 1972 Convention where party has signed up to it
- transboundary movement of CO2 for dumping at sea (offshore sequestration rather than onshore sequestration) prohibited by Article 6
- 2009 Amendment – allows transboundary movement of CO2 for dumping pursuant to agreement/arrangement with countries concerned, including regime for permitting controls / responsibilities (yet to come into force)
- Provisional Application mechanism allows participating States to apply the 2009 Amendment prior to it coming into force



Adapted from Ashurst, Counsel, Guy Dwyer at JOGMEC's Workshop on Cross-border CO2 Transportation in Asia-Pacific held on 8 February 2024.

Collaboration with ASEAN Center for Energy (ACE) on CO2 Cross-border Transportation

Download at ACE's website!!

https://aseanenergy.org/publications/opportunities-and-challenges-for-co2-transportation-in-asean/

JOGMEC's Workshop on Cross-border CO2 Transportation in Asia-Pacific (Feb. 8 online)

- **Legal frameworks and issues related to CCS business promotion and cross-border CO2 transport**
- **Current status of CCS projects with cross-border CO2 transport and its challenges**

Workshop on CO2 cross-border transport and storage (CCS) in Asia and the Pacific

HOSTS: JOGMEC, METI, ASIA CCUS NETWORK
SECRETARIAT: Mitsubishi Research Institute

CCS (Carbon Capture and Storage) is being considered worldwide as an essential technology for achieving net-zero emissions and decarbonizing industrial sectors. However, one of the issue is the uneven distribution of suitable storage sites. The Asia-Pacific region is expected to have sufficient storage potential, and like in Europe, cross-border CO2 transport may become an important business model in Asia in the future. This workshop aims to contribute to the social implementation of CCS, including cross-border transport of CO2, in the Asia-Pacific region through lectures by experts and discussions among stakeholders.

Date: Thursday, February 8, 2024
Morning Session 10:00-12:50 | Afternoon Session 14:00-16:35 (JST)

TOPICS

Morning Session | Legal frameworks and issues related to CCS business promotion and cross-border CO2 transport
- Current status of international conventions/standards, regional/national legislation, public acceptance and other relating materials regarding cross-border CO2 transport
- Framework for the promotion of cross-border CO2 transport
- Regional challenges and lessons learnt from international cooperation

Afternoon Session | Current situation of CCS projects with cross-border CO2 transport and its challenges
- CO2 cross-border transport projects from the perspective of emission (Capture), transport and storage operators
- Prospects for projects
- Challenges in business Model (Public-private partnerships, institutional expectations, international cooperations, etc.)

Speaker candidates

Morning Session	Afternoon Session
Dr. Koji Yamamoto, JOGMEC	Nor A'in Md Salleh, PETRONAS
Norihiko Saeki, METI	Akihiko Takao, Mitsubishi Corporation
Ian Havercroft, Global CCS Institute	(TBC), Northern Lights JV
Beni Suryadi, ASEAN Centre for Energy	Masatoshi Numano, Mitsui O.S.K. Lines, Ltd.
Guy Dwyer, Ashurst	Taisuke Horimi, Nippon Steel Corporation
Hiroyasu Konno, Nishimura & Asahi	Keisuke Miyoshi, JOGMEC
Ingvild Ombudstvedt, IOM Law advokatfirma	MC: Masumi Takanashi, JOGMEC

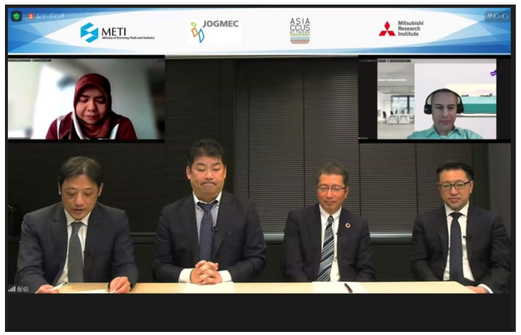
REGISTRATION LINK
https://www.mri.co.jp/en/news/20240208.html

Multi-national Speakers and participants (1100 attendees)

Speakers: METI, Global CCS Institute, ASEAN Centre for Energy, PETORONAS, Mitsubishi Corporation, Northern Lights JV, Mitsui O.S.K. Lines, Ltd., Nippon Steel Corporation, and law firms

Participants: Governments and government agencies, international financial institutions, national & major international oil companies, electric power, steel and cement manufactures, universities and research institutes, media, NGOs, etc.
from 15 countries (Malaysia, Indonesia, Vietnam, Thailand, Australia, the US, Denmark, Germany, Switzerland, Finland, and several other Asian and African countries)

Workshop Handbook will be available within 2024 !



MOC on the Cross-border CCS

METI, JOGMEC and PETRONAS signed MOC at the Asia CCUS Network Forum held in September 2023 to promote discussion on bilateral CO2 cross-border transportation and storage.

Source) METI, JOGMEC and PETRONAS Have Concluded MoC on Cross-Border Transportation of CO2 for CCS Businesses

METI and MTI signed MOC at the Asia Zero Emissions Community held in August 2024 to facilitate knowledge exchange on best practices for cross-border CCS and the sharing of insights on CCS technologies.

Source) https://www.meti.go.jp/press/2024/08/20240821001/20240821001.html

JOGMEC's activities for realizing CCS value chain

We will continue our initiatives to realize the CCS value chain in Japan and overseas.

We have unique features!

1.Policy implementation body
2.Technical assistance function
3.Financial assistance function

We look forward to working with governments, financial organizations and industries in Asia-Pacific!

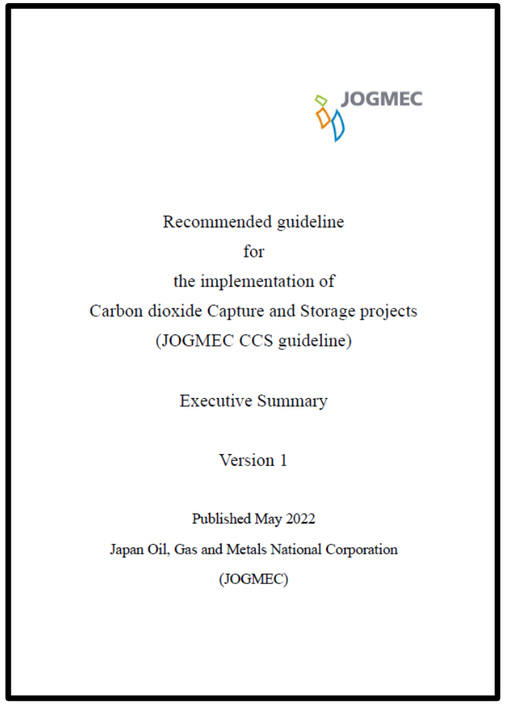
ACN: Asia CCUS Network
AZEC: Asia Zero Emission Community

Characteristics of JCM and cross-border CCS

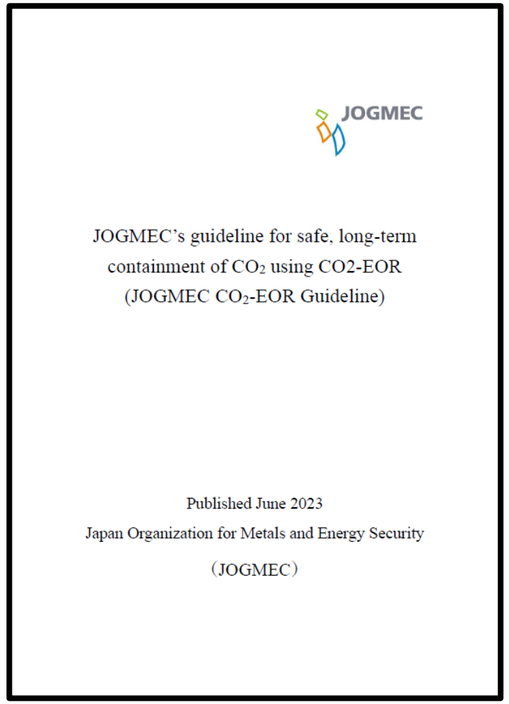
	JCM	Cross-border CCS
Intergovernmental agreement or arrangement	Necessary (bilateral)	Necessary (bilateral first)
Country implementing CCS	JCM Partner Countries	Any country (The London Protocol must be followed)
Infrastructure investment	Shared by the partner country and Japan	Storage company (country)
Cost recovery measures	JCM Credits (Compliance)	Storage fee
Contributions to NDC	Shared by the partner country and Japan	Exporting country (Japan)
Scalability of captured CO2	Depending on the situation in the partner country	Highly scalable (Combination of cross-border CCS and domestic CCS)
Risk Mitigation	Shared by the partner country and Japan	Securing CO2 from both domestic and overseas sources would contribute to reduce financial risk

- CCS's certainty can be improved by securing multiple revenue streams. Selecting the appropriate revenue streams is important for every project situation.
- To promote CCS, it is necessary to have G-to-G discussions, public-private partnerships, collaboration among various stakeholders, and strong government support and commitment.

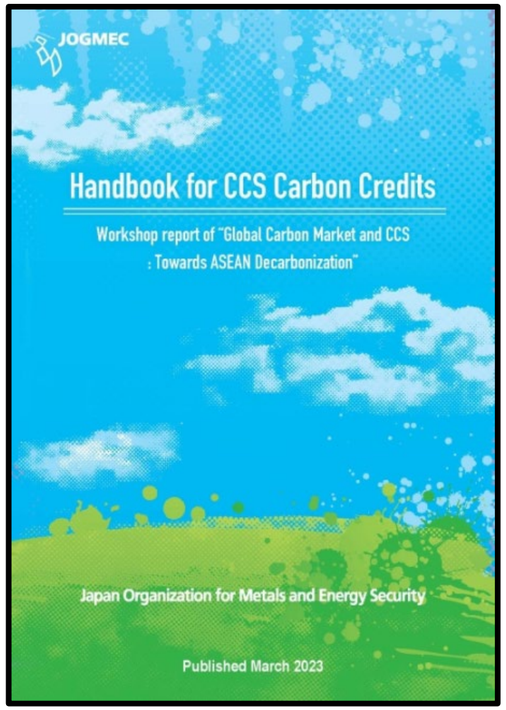
JOGMEC's Publications



https://www.jogmec.go.jp/english/news/release/news_10_00004.html



https://www.jogmec.go.jp/english/news/release/news_10_00038.html



https://www.jogmec.go.jp/english/news/release/news_10_00026.html

Workshop on CO2 cross-border transport and storage (CCS) in Asia and the Pacific (Feb 2024)

Contents and Materials of the Workshop

Thank you very much for your attention.

7. INTERNATIONAL SUPPORT AND INVESTMENT

Panel Moderator

Matt Steyn, Public Affairs Manager APAC

Global CCS Institute

KEMENTERIAN EKONOMI

ASEAN CENTRE FOR ENERGY • ACE •

Asia Natural Gas & Energy Association

SOUTH EAST ASIA CCS ACCELERATOR WORKSHOP (SEACA)

Part III: Creating a Transnational Asian CCS Value Chain

GLOBAL CCS INSTITUTE

Alex Zapantis, General Manager, External Affairs - Global CCS Institute

THANK YOU

GLOBAL CCS INSTITUTE