CCUS and Low Carbon Fuels

11 – 12 March 2025 | Tokyo, Japan

Methane emission management for reduction of carbon intensity of natural gas / LNG

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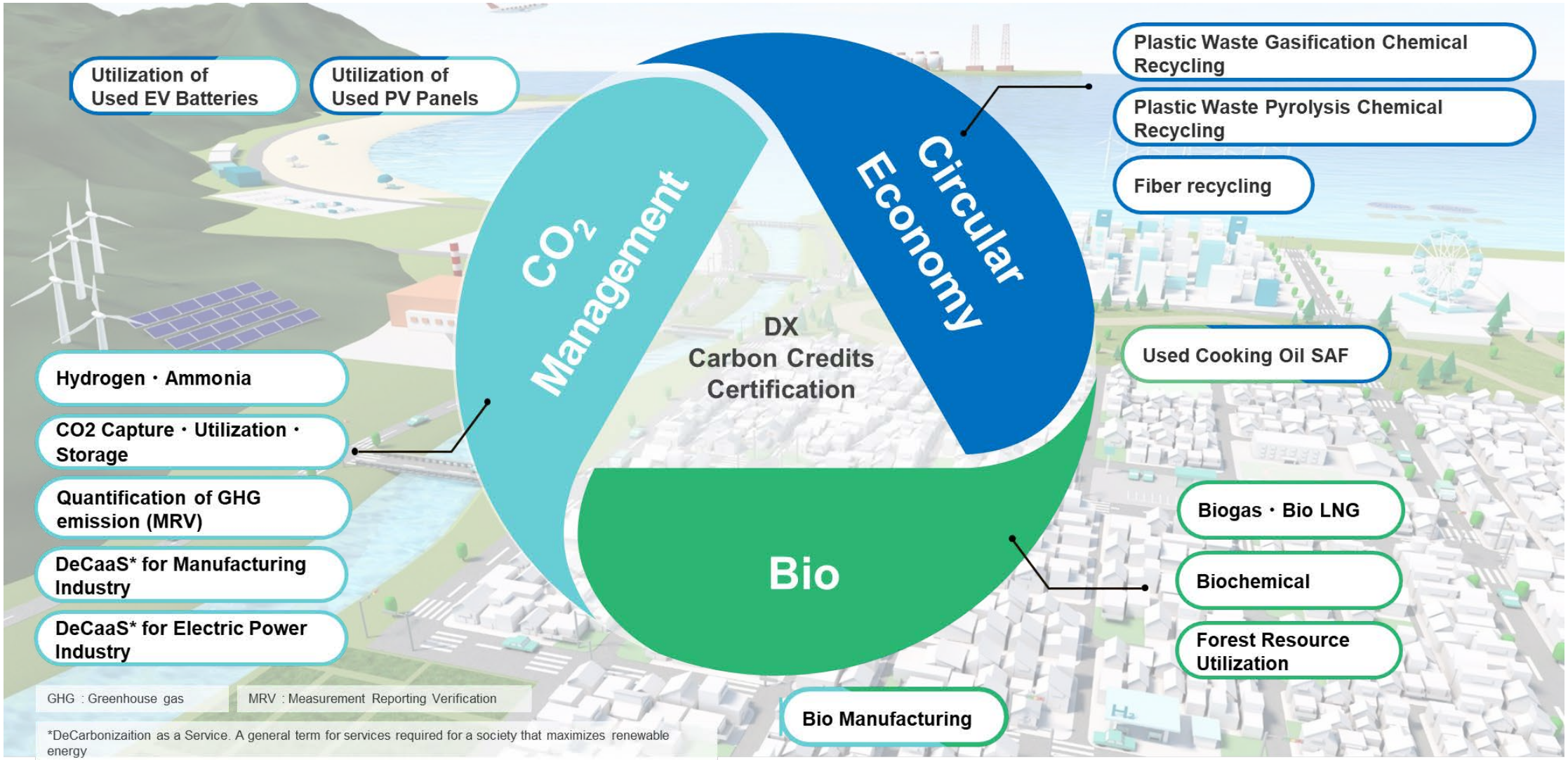
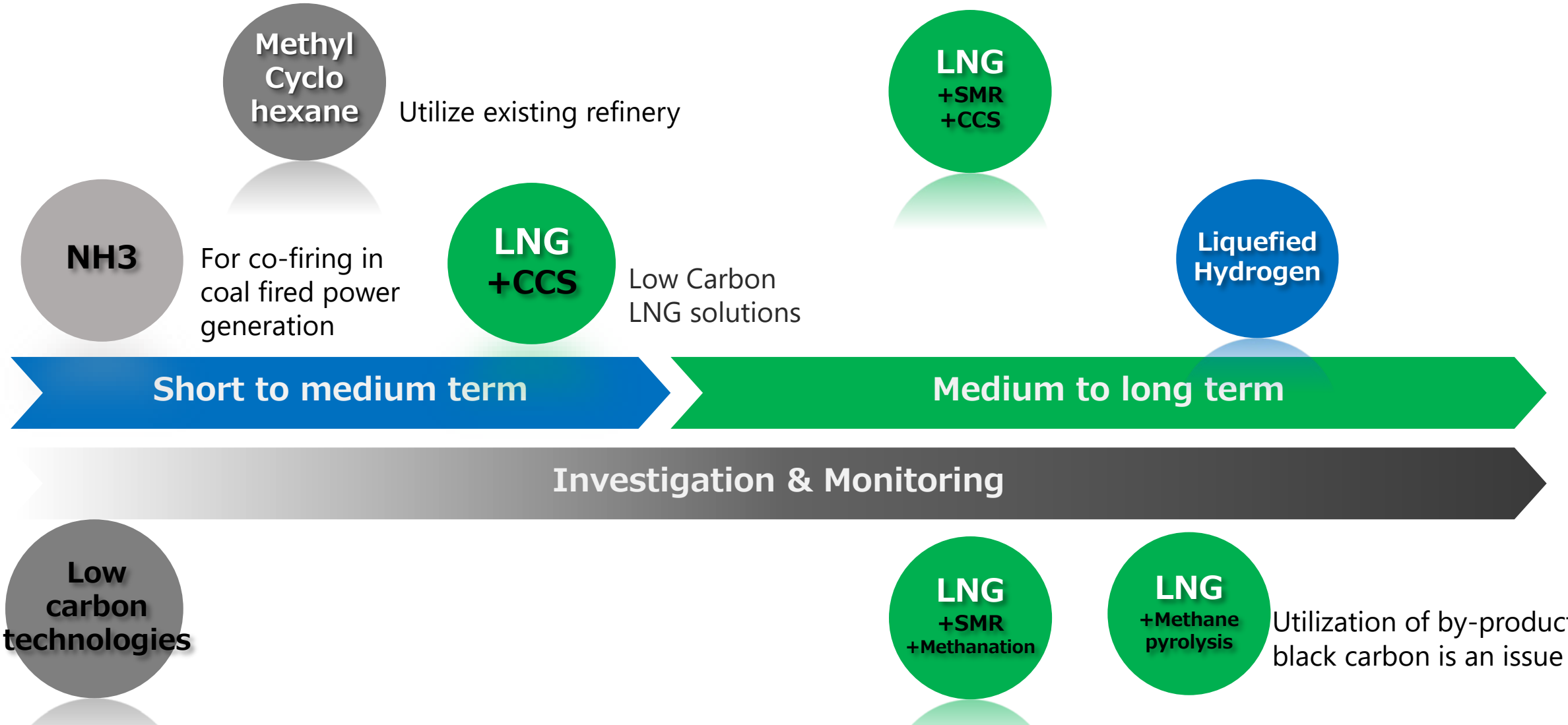
JGC Corporation

JGC's business in Energy Transition

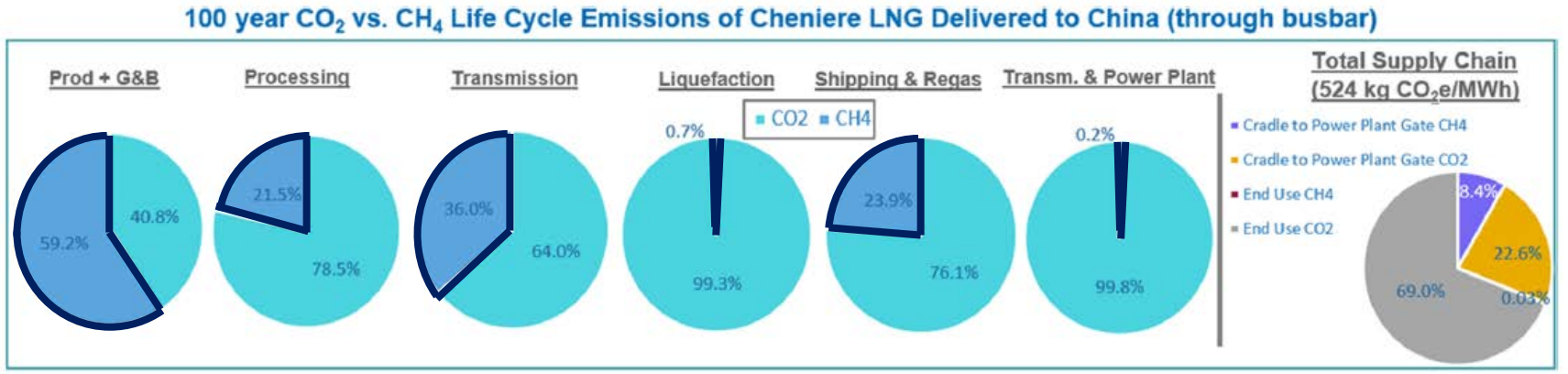


Transition Fuel



Emissions from LNG Supply chain

- The LNG/Natural gas supply chain is characterized by a variety of emissions.
- Methane is the main issue upstream, while CO2 is the key concern during liquefaction and downstream phases.
- Each type of emission requires specific and effective measures, as there is no one-size-fits-all solution.



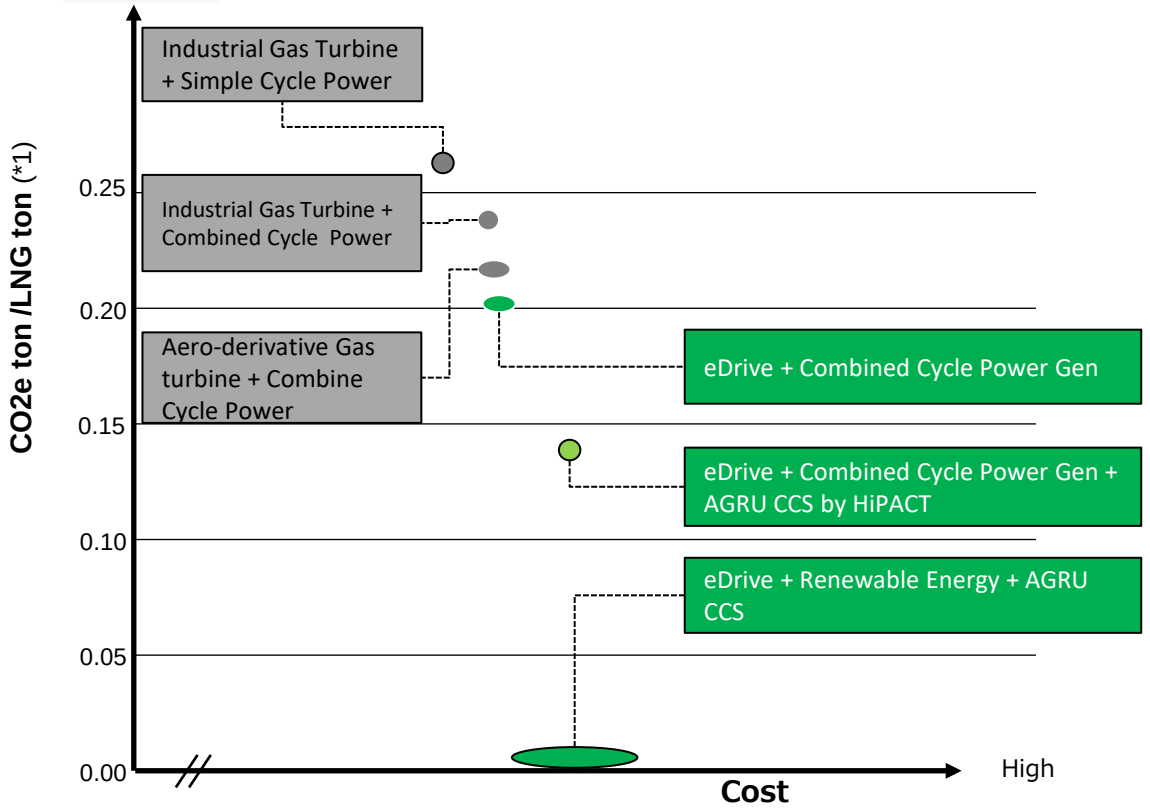
Selina A. Roman-White, James A. Littlefield, Kaitlyn G. Fleury, David T. Allen, Paul Balcombe, Katherine E. Konschnik, Jackson Ewing, Gregory B. Ross, and Fiji George
ACS Sustainable Chemistry & Engineering **2021** *9* (32), 10857-10867
LNG Supply Chains: A Supplier-Specific Life-Cycle Assessment for Improved Emission Accounting

How to reduce GHG emissions from LNG Liquefaction ?

In order to promote further decarbonization of LNG plants, JGC Group propose reduction in GHG emissions by combining various technologies.

1. eDrive for the refrigeration compressor and driving it with electric power generated by combined cycle is 1st step.
2. 2nd step is sequestration of CO2 from AGRU by HiPACT.
3. Ultimately, by supplying electricity from renewable energy, CO2 emissions from LNG plants will be close to zero.

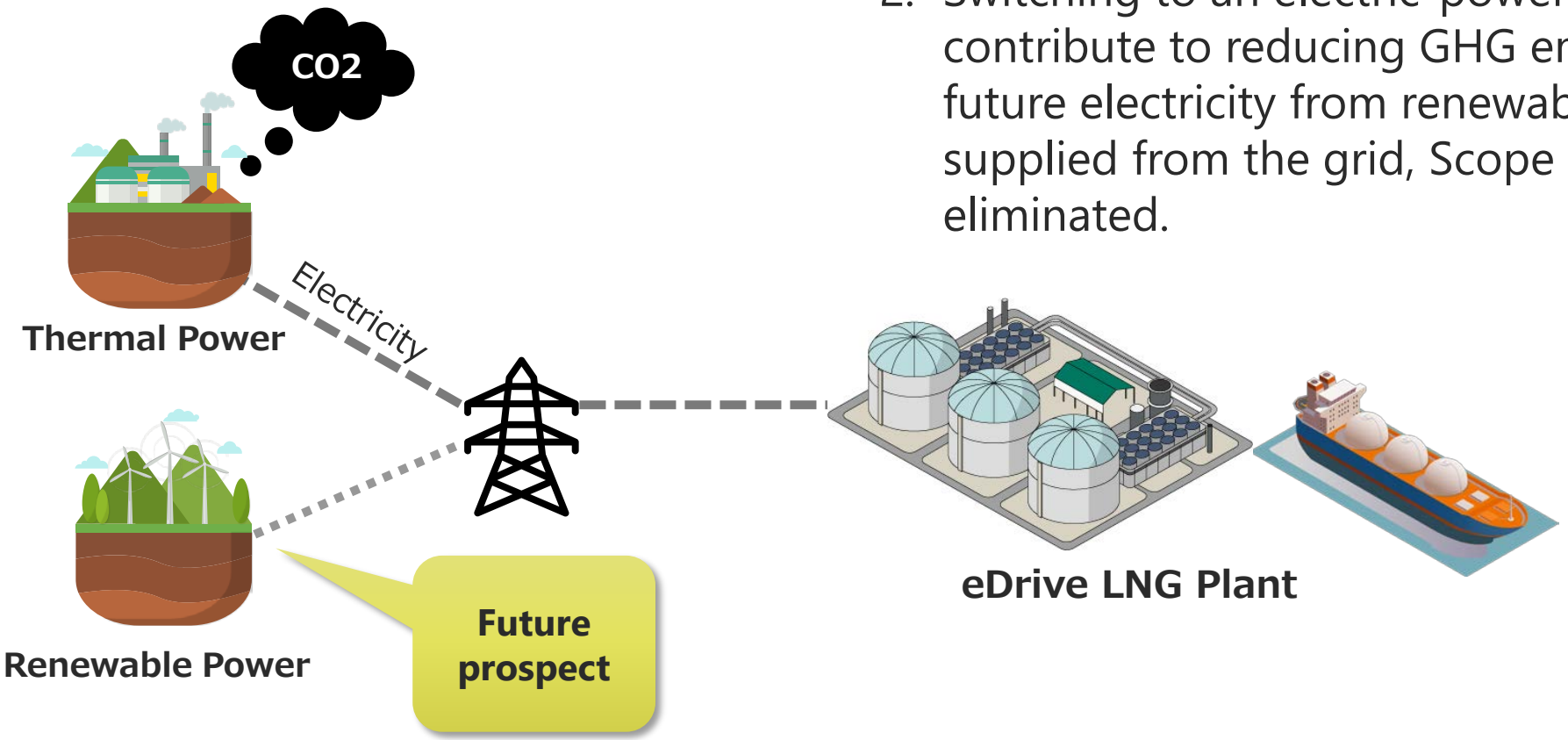
Example of CO2 intensity in LNG Plant



(*1) Very Rough Calculation with 5.0MTPA base with 2% CO2 in feed gas
(*2) H2 has a lower energy density than C1, therefore if co-firing with the same volume fuel flow rate, the driver power will be smaller and the LNG production will drop. In order to increase production, it is necessary to modify the fuel system.

eDrive LNG

1. While the refrigerant compressor in LNG liquefaction facility is operated by Gas Turbine, recently electrical motor driven type is also emerging.
2. Switching to an electric-powered LNG plant does not contribute to reducing GHG emissions, but if in the future electricity from renewable energy sources is supplied from the grid, Scope 1/2 emissions will be eliminated.



CCS – JGC's experiences

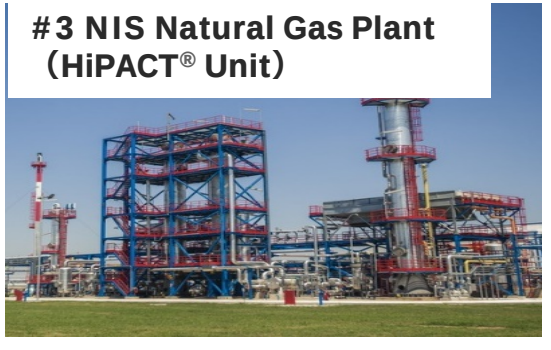
Since completing the first CCS facility in Algeria in 2004, JGC has constructed one of the world's largest CCS facilities in Australia, and JGC has also built the first large-scale CCS demonstration test facility in Tomakomai, Hokkaido in Japan, establishing our position as a leading contractor in the CCS field.

No	Operator	Country	Emitter	Captured CO_2 (MTPA)	Scope of JGC	Completion	Features
1	BP Exploration (In Salah)Ltd./SONATRACH	Algeria	Natural gas Processing	1.2	EPC, FEED	2004 (EPC)	The world's second CCS facility for natural gas processing
2	Gorgon JV	Australia	LNG Liquefaction	3.4 to 4.1	EPC, FEED	Not disclosed	One of the world's largest CCS project
3	Naftna Industrija Srbije (NIS)	Serbia	Natural Gas Processing	-	Licensing	2015	A commercial plant that uses HiPACT®, a joint development technology by our company and BASF
4	Japan CCS Co.,Ltd.	Japan	Refinery (Hydrogen Production Unit)	0.3 (cumulative)	EPC, Test run	2016	Japan's first large-scale CCS demonstration test
5	BP Berau, Ltd.	Indonesia	EGR/CCUS for LNG Plant	Approx 5.2 (270MMSCF)	EPCI	On-going	Contract Amount: 2.4 Billion USD.

#1 In Salah Gas Plant

#2 Gorgon LNG Plant

#3 NIS Natural Gas Plant (HiPACT® Unit)



#4 Tomakomai CCS

CCS – Ongoing project -

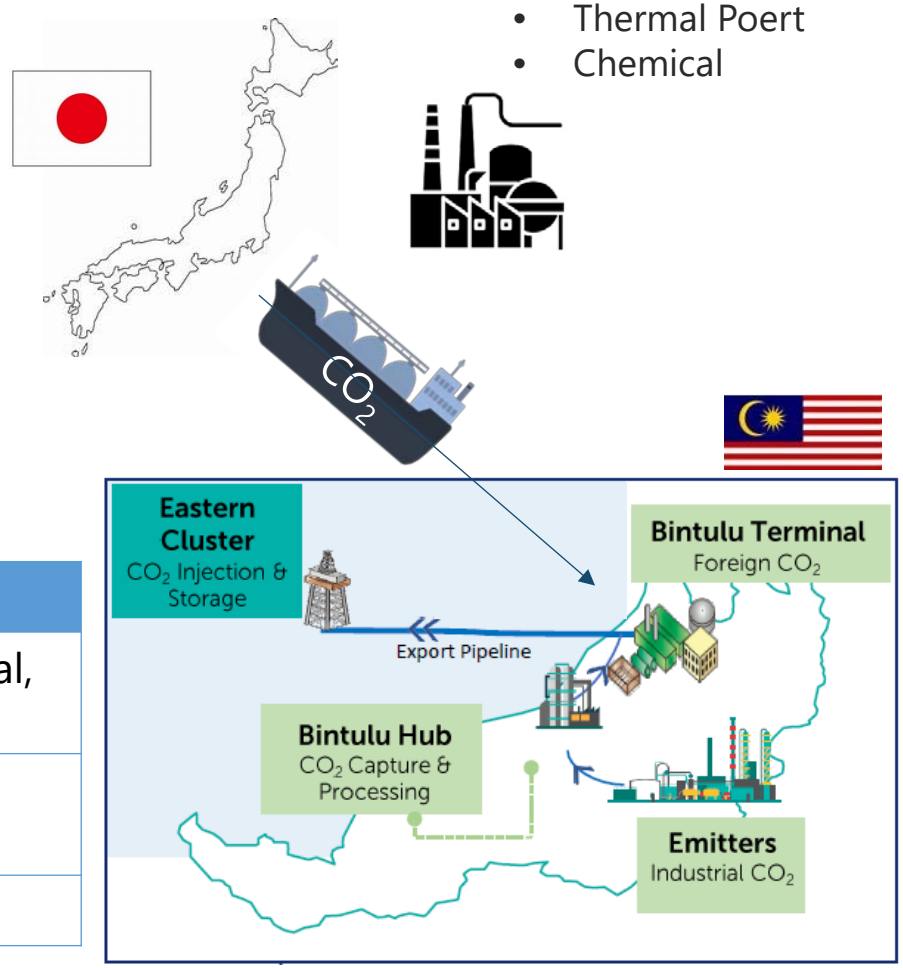
- CO2 from Malaysia and “Hard-to-abate industries” in Japan will be captured, transported and sequestered in the large gas field in Sarawak offshore
- The capacity is scheduled to be expanded in stages from 5 million tons/year to 10 million tons/year.
- **Selected for JOGMEC's Advanced CCS Project in FY2024**
- Commenced Basic Design （FEED） for CO2 Receiving facility

Large-scale storage： Utilizing large-scale depleted gas fields (storage capacity confirmed)

Asia’s first： Aiming to establish Asia’s first international open source hub

International collaboration：

Hard to abate industries
- Steel
- Thermal Poert
- Chemical



Consortium members	
Emitter	JFE Steel, Chugoku Electric Power, Mitsubishi Chemical, Mitsubishi Gas Chemical
Transportation, Sequestration	JAPEX、**JGC Holdings**、Petronas CCS Ventures, K－Line
Transportation in Japan	Nippon Gas Line

First Step for Decarbonization – Methane -

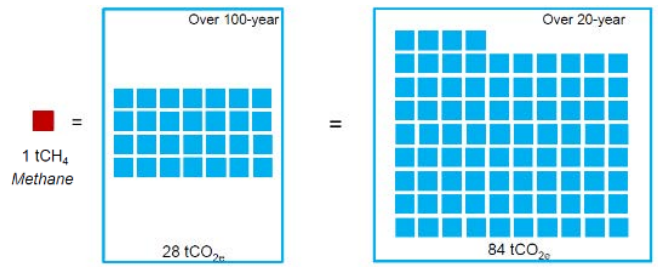
- CCS and eLNG application has have significant reduction, but it need huge amount of investment.

- These cost will produce a low carbon LNG, while leading to LNG pricing up.

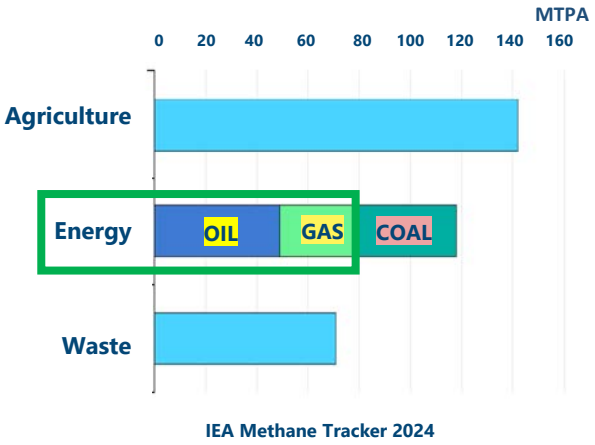
- **<u>Methane abatement project as easier solution for low carbon LNG realization.</u>**

Why is methane highlighted in Oil and Gas industry?

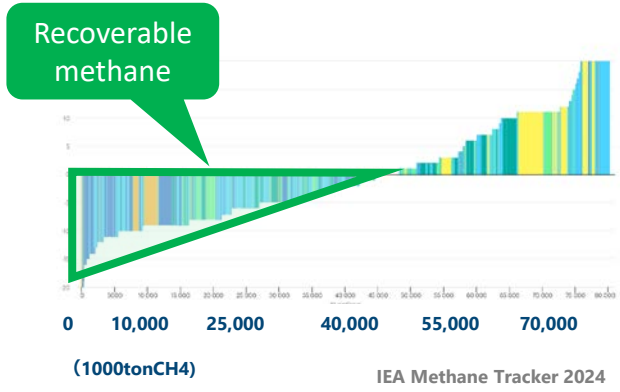
- Methane has higher GWP (**28 times** as CO2) according to IPCC Report
- There is a lot of methane emission/leakage **from Oil and Gas plant**
- Methane recovery from O&G plant has **economical benefit**
- There are significant **differences** between factoring calculation and actual measurement



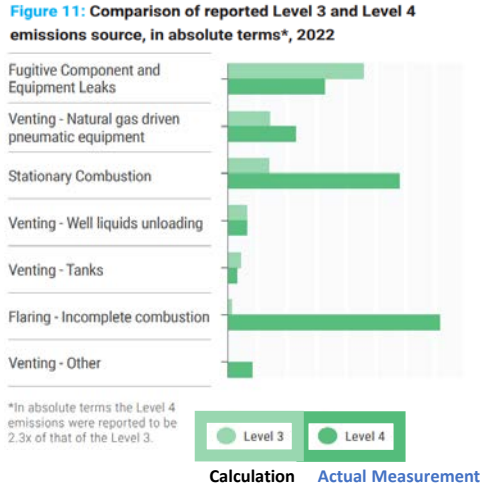
Higher GWP



Emission from O&G Sector



Abatement cost curve

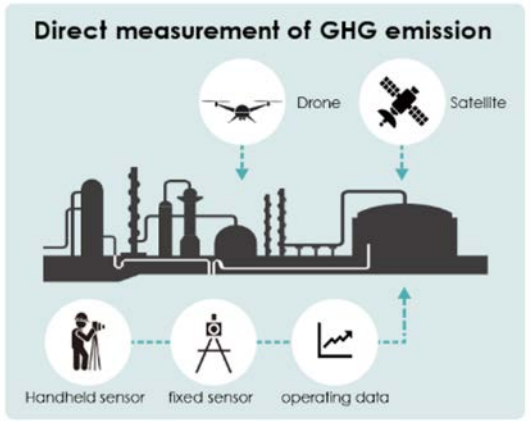


Difference between Calculated and Measured Values

JGC's Methane initiative

Initiative of Methane emission management

Total Engineering



1 Technical evaluation

- ✓ Only company in Asia to evaluate methane quantification technology in own facilities.

2 Project execution

- ✓ Methane emission quantification project

3 Technical consultation

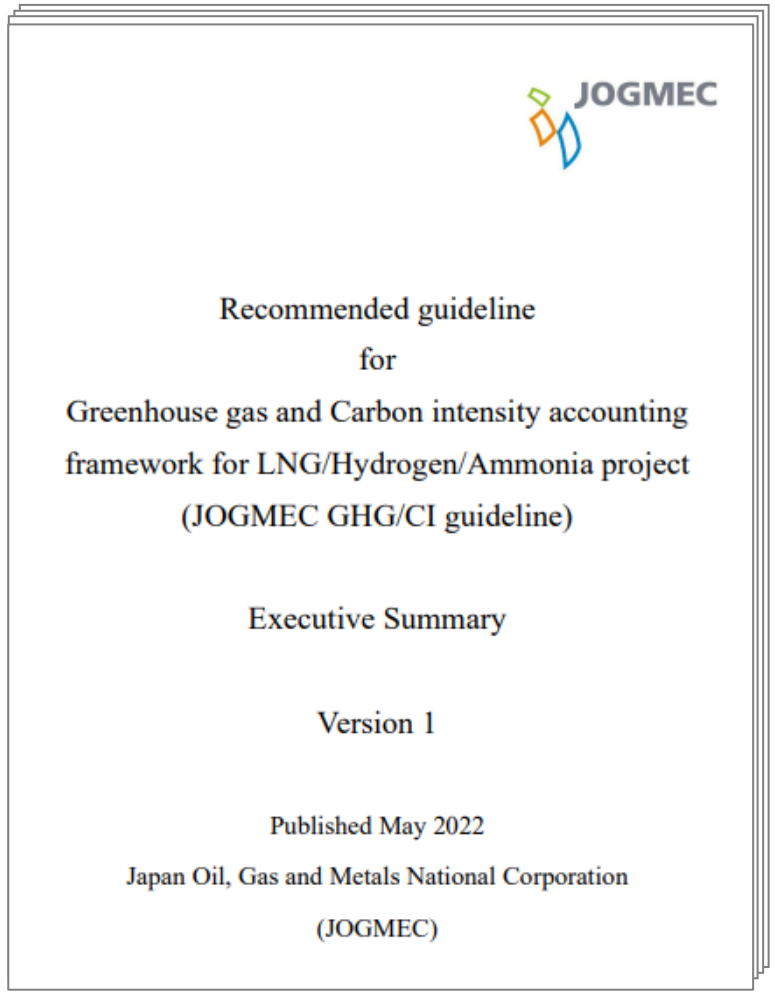
- ✓ Zero routine flare
- ✓ Operation optimization
- ✓ Measuring implementation

Full range solution for methane abatement

JGC's advantages

- **Independent party to evaluate the technologies**
- **One stop solution & Project Management**
- **Technical expertise of plant engineering**

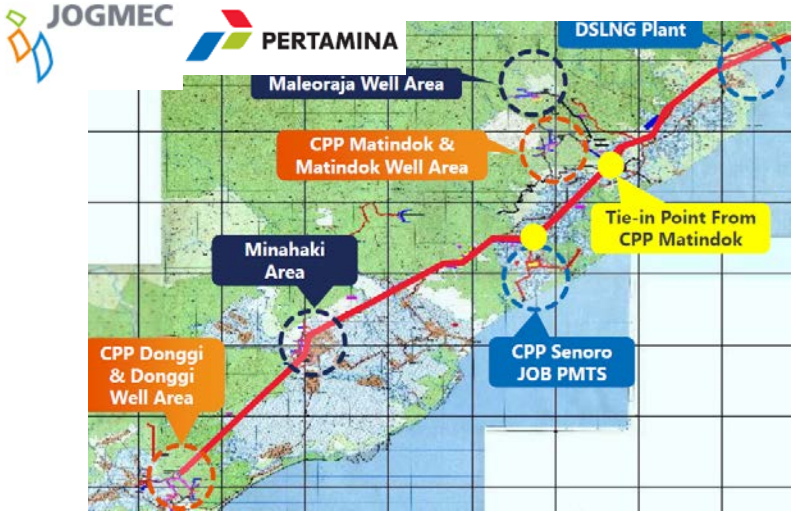
GHG CI Guideline by JOGMEC



1. **Complies with the regulations** of each country through analyzing the MRV methodology published earlier.
2. Proposes the **optimal mix** of measurements and calculations.
3. Is verified in actual plants and is continuously updated based on the results.
4. Is based on JGC's and JOGMEC's extensive knowledge of the gas industry.
5. Can be used for LNG, hydrogen, and ammonia production / receiving plants.
6. Appropriately asserts the effect of efforts by CCUS/carbon offset.
7. Emphasizes on **methane emission measurement**.

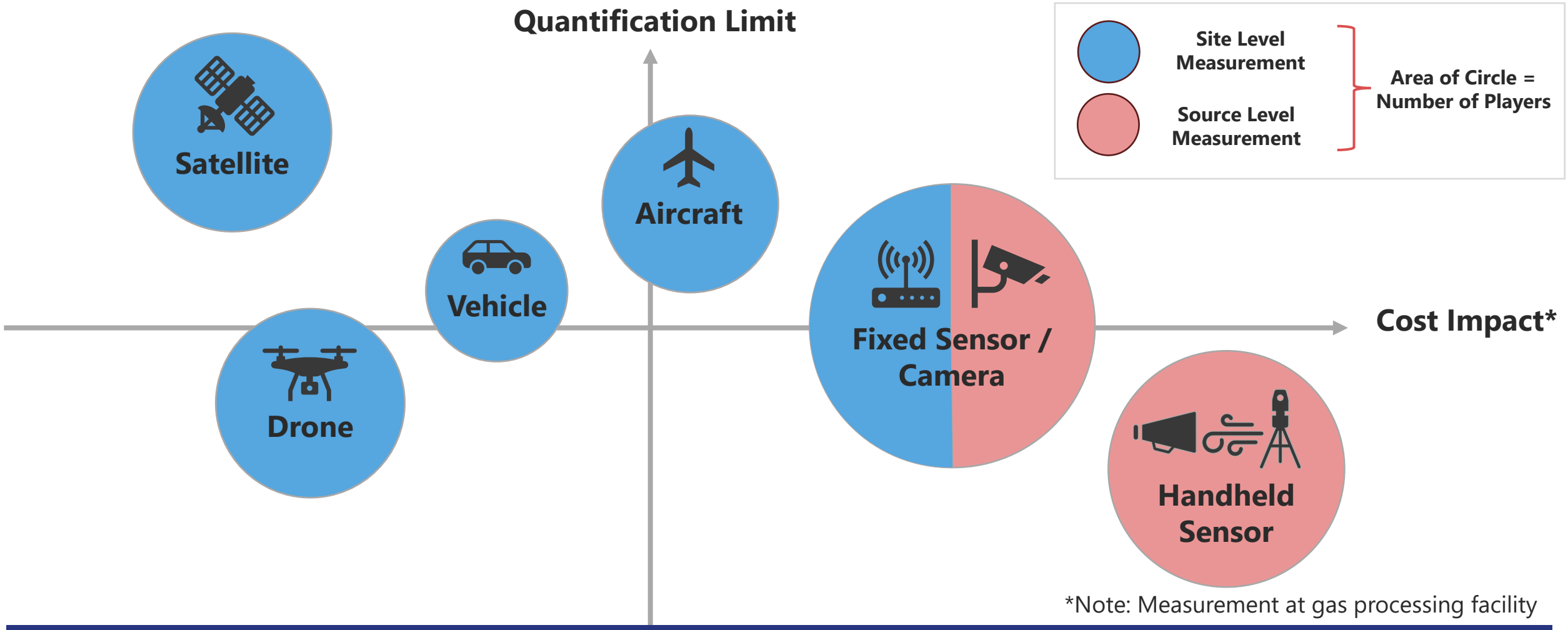
Current Project

- **Actual Measurement and Zero Routine Flare(ZRF) Study for PETRONAS offshore facility.**



- **Actual Measurement and ZRF study for PERTAMINA onshore facility.**

Methane quantification solutions map

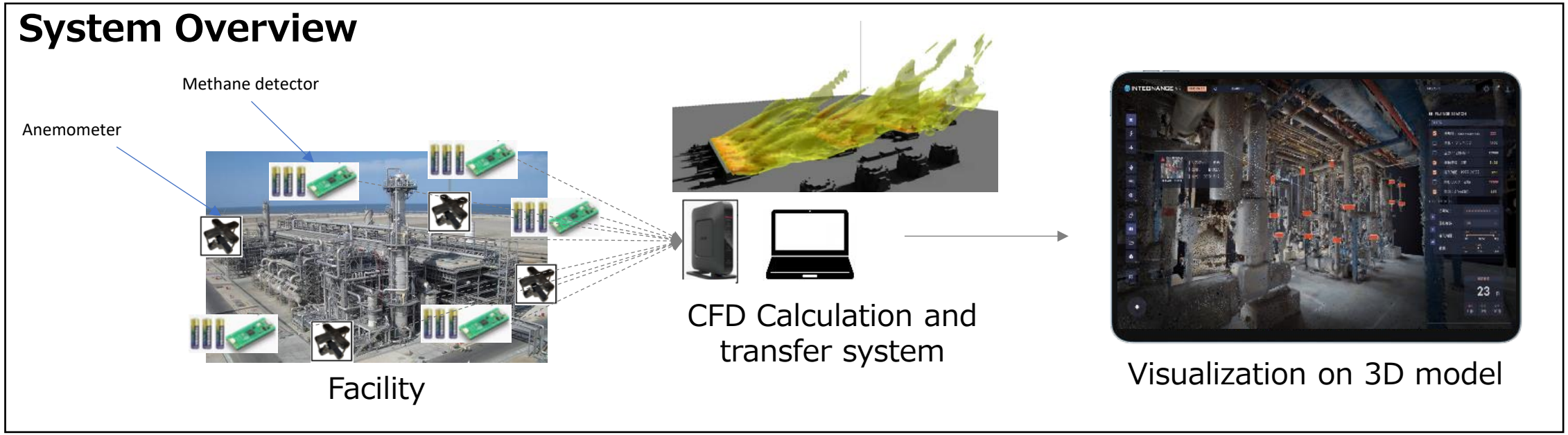


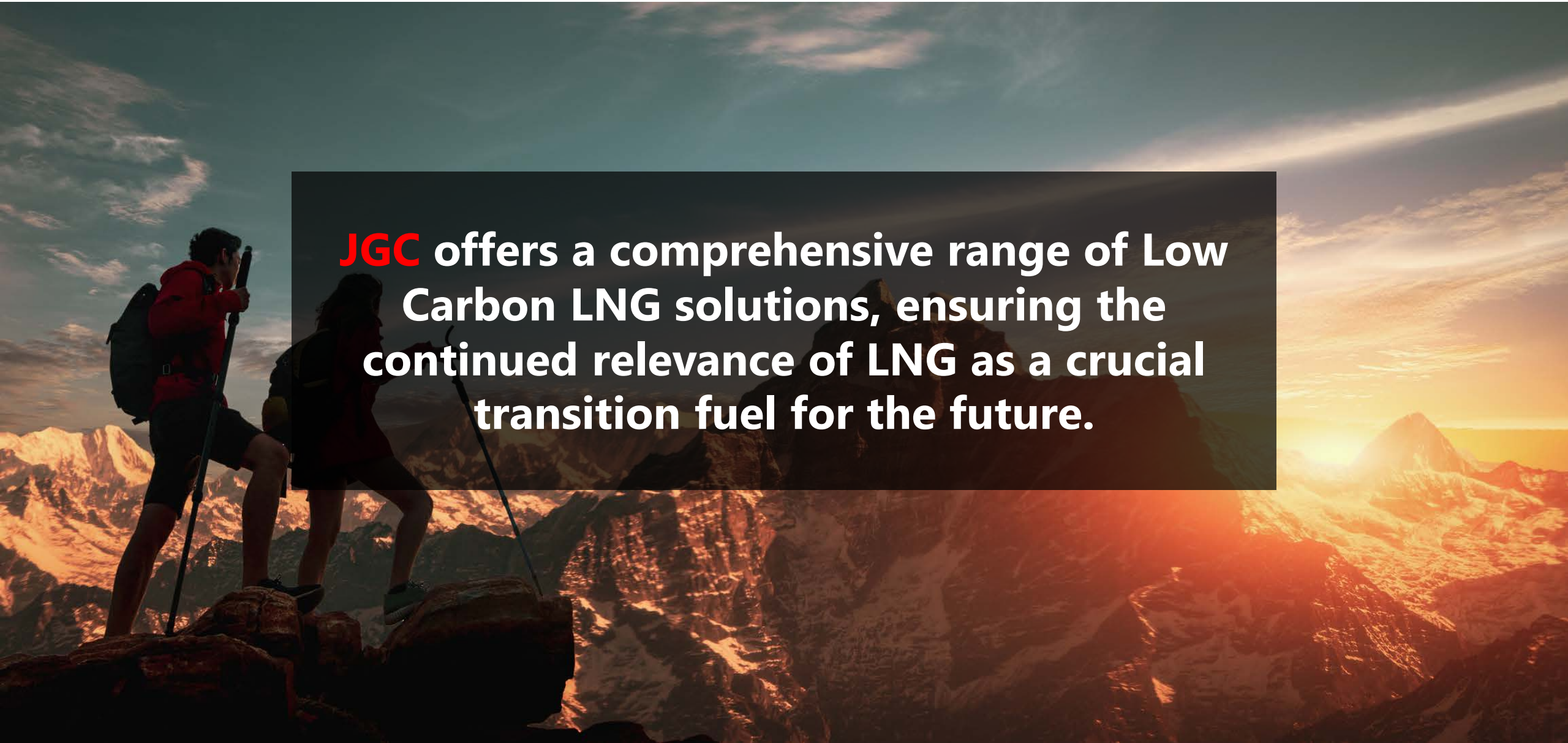
*Note: Measurement at gas processing facility

JGC has surveyed more than 100 technical solutions of methane emission quantification

JGC's technology development

- Visualizes methane emissions and locations using data from sensors in complex oil and gas facilities.
- Improves accuracy in large, complex plants with advanced computational fluid dynamics (CFD) analysis.
- Collects and analyzes data via a data transfer system.
- Displays results on a 3D model of the plant.




JGC offers a comprehensive range of Low Carbon LNG solutions, ensuring the continued relevance of LNG as a crucial transition fuel for the future.