

Research and Development Toward Saving Energy for Direct Air Capture With Available Cold Energy



PM : NORINAGA, Koyo

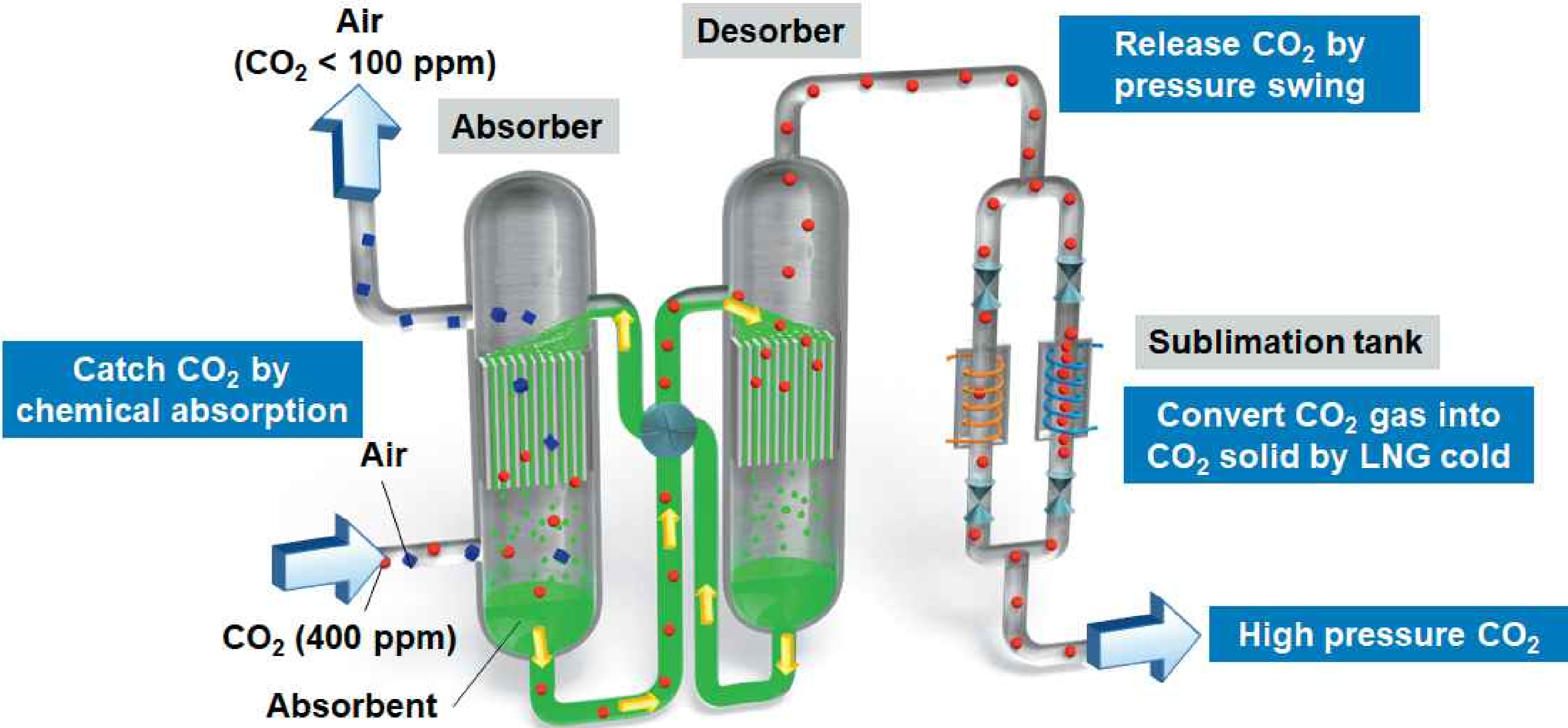
Institute of Innovation for Future Society, Nagoya University

TEAM : Nagoya University, TOHO GAS, Tokyo University of Science, JGC, The University of Tokyo, Chukyo University



Cryo-DAC®

A pressure swing amine process driven by the cryogenic pumping with LNG cold



Cryo-DAC®



Cryo-DAC®

Experiment



名古屋大学
NAGOYA UNIVERSITY

則永研究室

未来社会創造機構
脱炭素社会創造センター

名古屋大学大学院工学研究科化学システム工学専攻

名古屋大学工学部マテリアル工学科



実験開始

Cryo-DAC® our team



- **Cryo-DAC® concept design**
- **High-performance amine development**



- **Process simulation for cost and energy analysis**



- **Cryo-DAC plant design and construction**



- **Material selection and analysis**

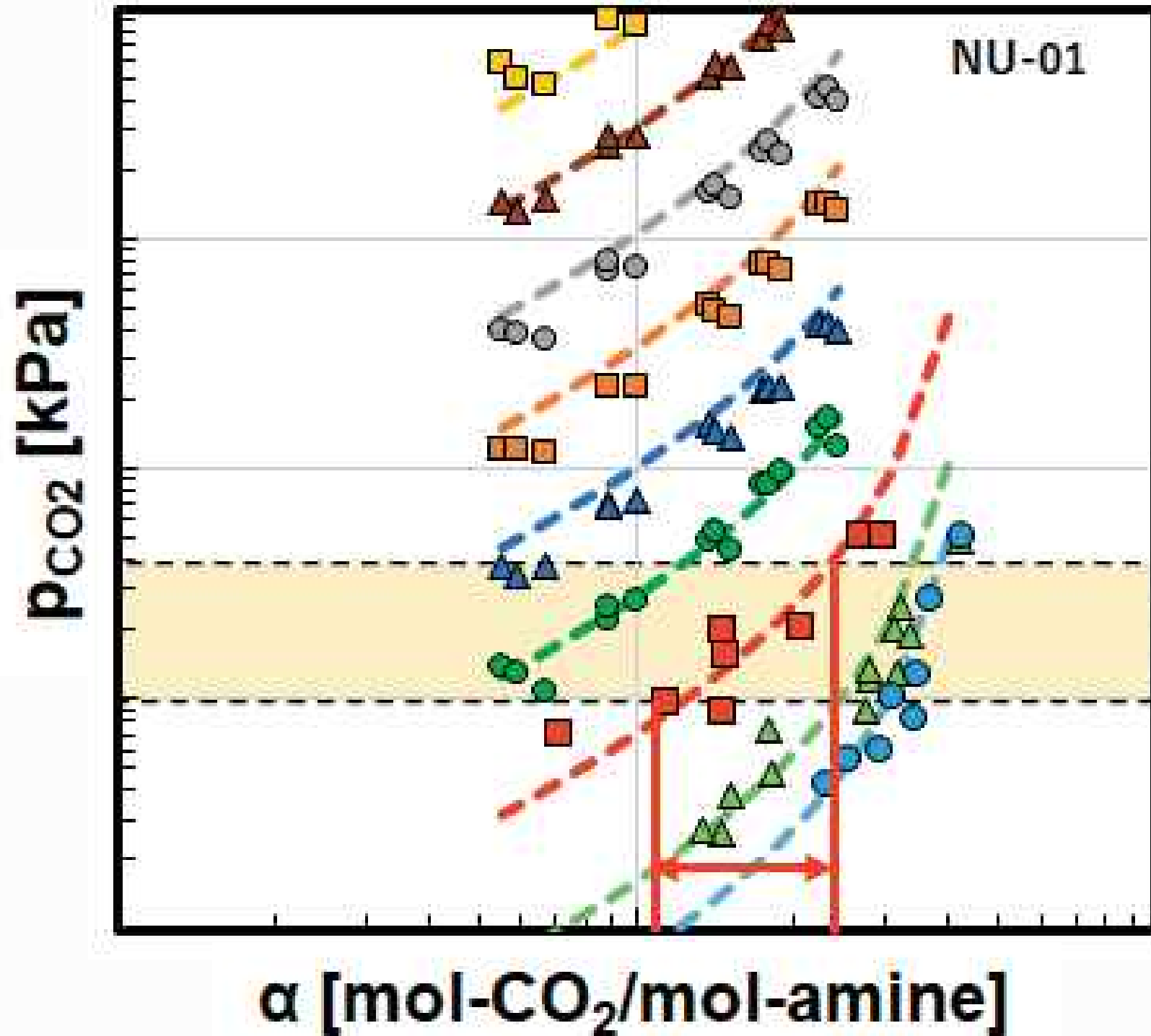


- **Exergy-based process analysis**
- **Sensing device for stable operation**



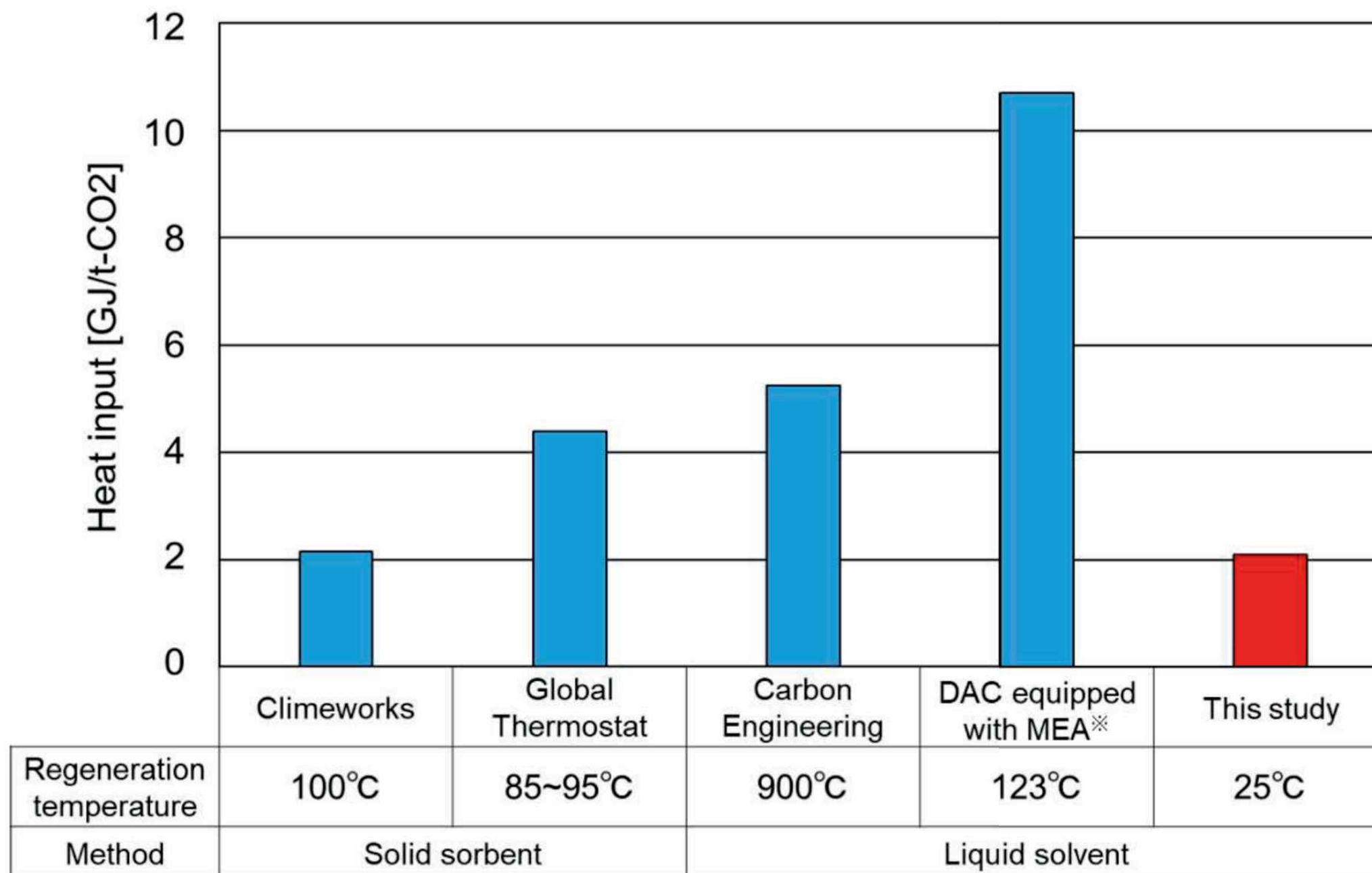
- **Environmental and economic analysis**

Cryo-DAC[®] liquid absorbent



Screening good amine/solvent mixtures by high throughput CO₂ solubility measurements

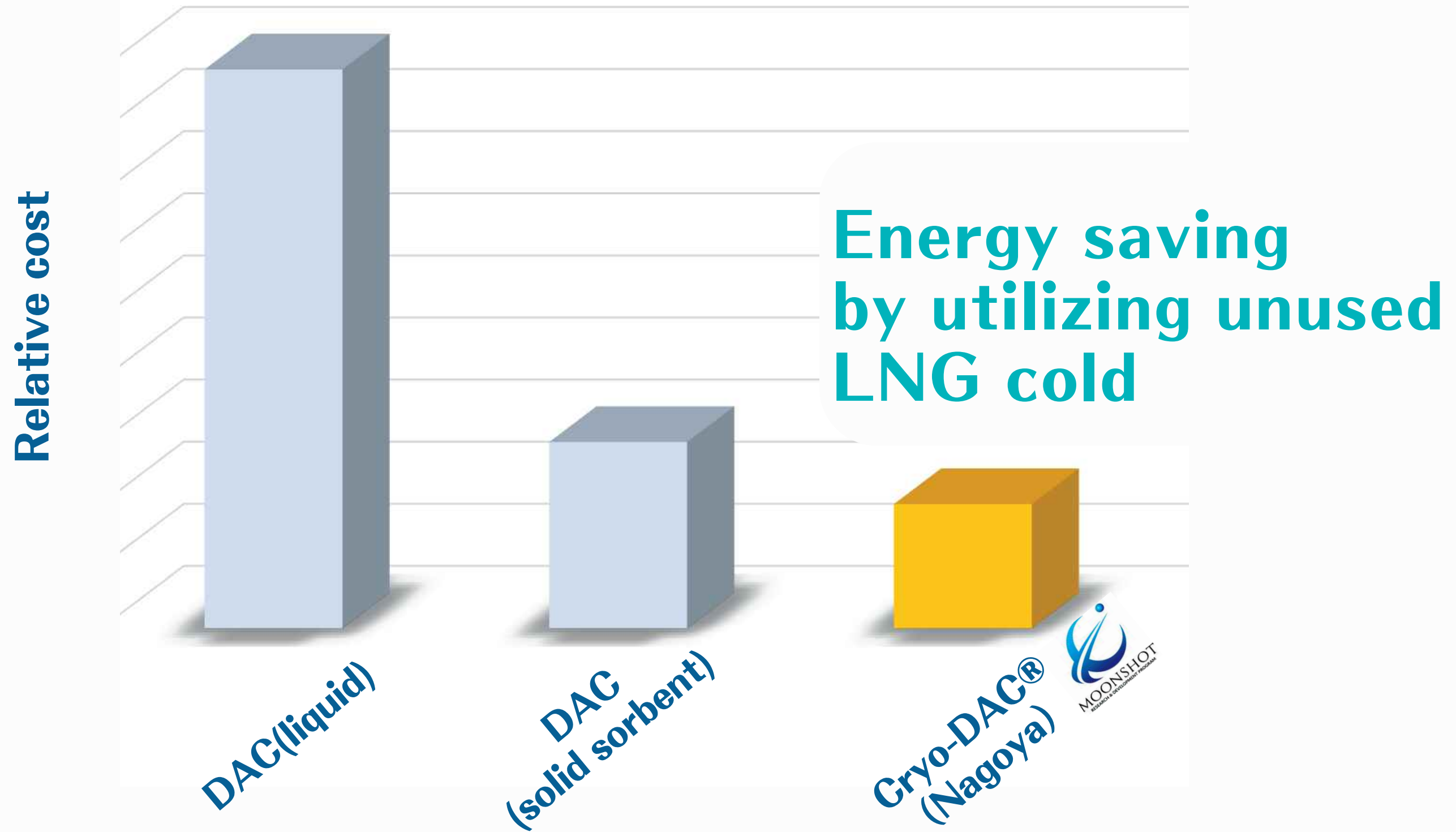
Cryo-DAC® thermal energy requirement



*MEA = monoethanolamine

Fasihi, M et al., J. Clean. Prod., 224, 957 (2019).
Kiani, A et al., Front. Energy Res., 8, 92 (2020).

Cryo-DAC[®] Cost



Cryo-DAC® plant design

JGC JGC HOLDINGS CORPORATION

Bench scale 1t-CO₂/y
2022 Design

(↓ tentative)
2023 Construction
2024 Operation

Pilot scale 50t-CO₂/y
2028 Operation

Cryo-DAC® Roadmap

2020 2021 2022 2023 2024 2025 2026 2027 2028 2029

**Start
Proof of concept**



**Design, construction, operation
of a bench-scale plant**



**Design, construction, operation
of a pilot-scale plant**



Cryo-DAC® Perspective

LNG import share % (2021)

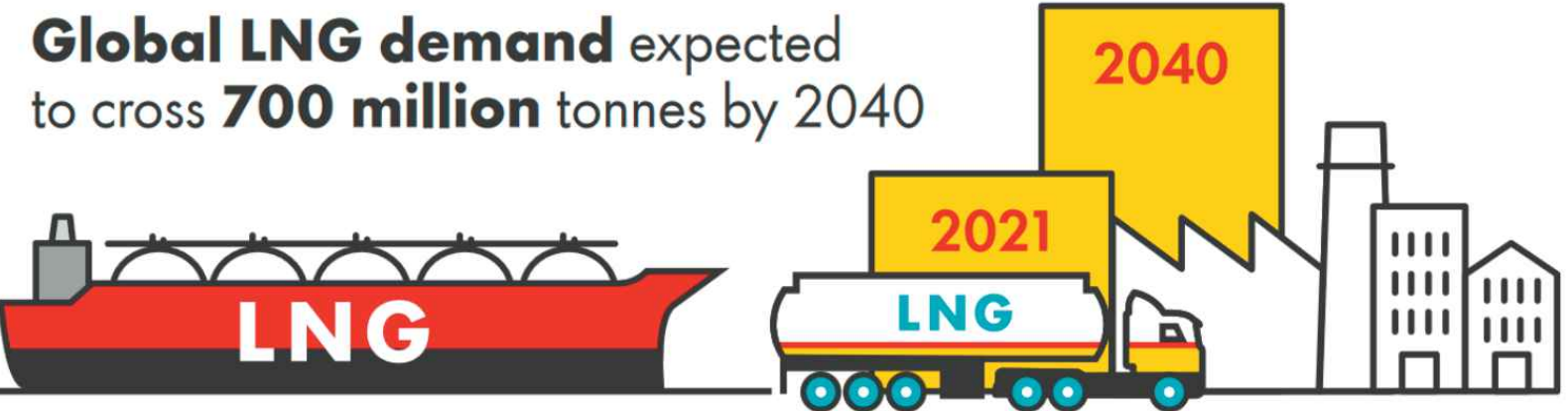
BP Statistical Review of World Energy 2022 | 71st edition

China	21.2
Japan	19.6
South Korea	12.4
India	6.5
Taiwan	5.2
Total Europe	21

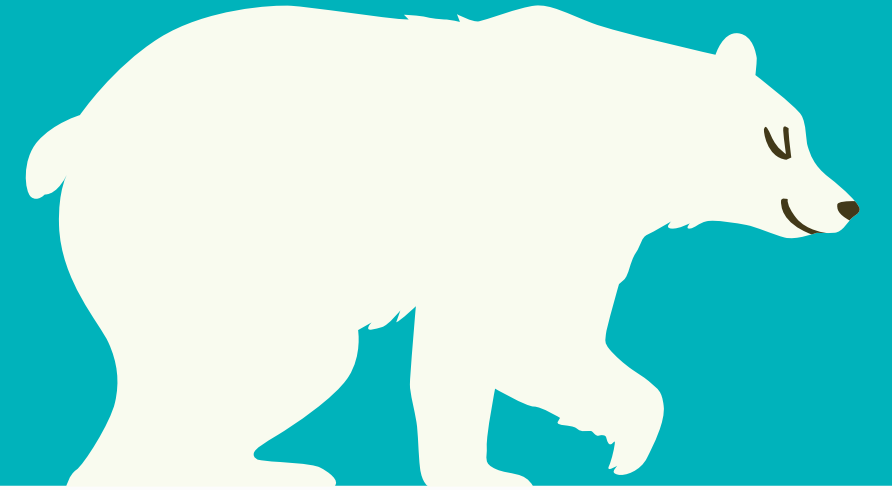
Use liquid hydrogen coldness

Shell LNG Outlook 2022

Energy security, emissions and economic growth in Asia to drive future LNG demand



A direct air capture with LNG coldness Cryo-DAC® 7 goals



- 1. Develop good sorbents**
- 2. Pursue an efficient use of LNG cold**
- 3. Find suitable materials for construction**
- 4. Develop sensing device for stable operation**
- 5. Design & construct bench/pilot plants**
- 6. Draw scenarios pleasing to our society**
- 7. Offer a unique DAC to the world**

Acknowledgement



MOONSHOT
RESEARCH & DEVELOPMENT PROGRAM



NAGOYA
UNIVERSITY



TOHO GAS



TOKYO UNIVERSITY OF SCIENCE



JGC HOLDINGS CORPORATION



UTOKYO



CHUKYO
UNIVERSITY