International Conference

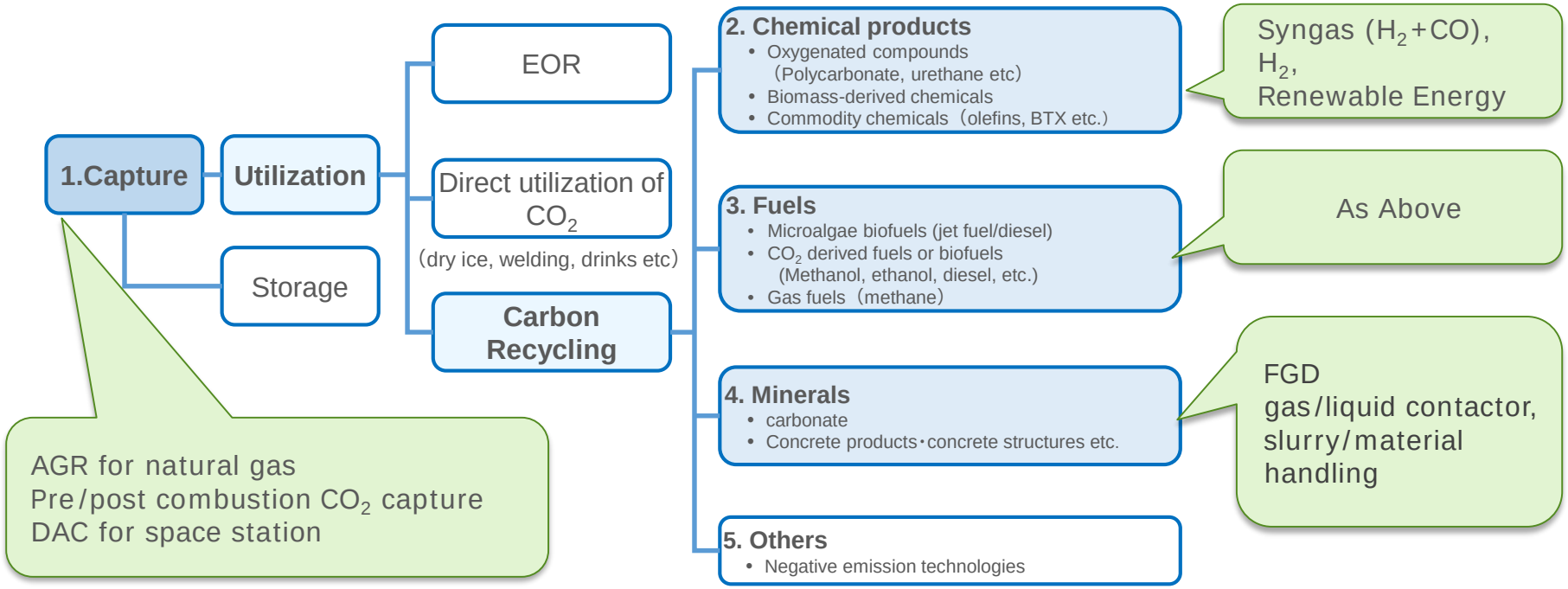
on Carbon Recycling 2021

Introduction to Chiyoda's Carbon Recycling Activities

Chiyoda Corporation

Contents

1. Classification of Carbon Recycling Technologies



【Records & Base Technology】
- CO_2 Capture
- Syngas, Hydrogen
- Renewable Energy
- FGD (Chiyoda Technology)

【Synergy with Carbon Recycling】
- Chemical products & Fuels have synergy with syngas, H_2 and Renewable Energy
- Minerals has synergy with FGD

Made by Chiyoda based on "Roadmap for Carbon Recycling Technology" by Ministry of Economy, Trade and Industry
AGR : Acid Gas Removal DAC : Direct Air Capture,
FGD : Flue Gas Desulphurization EOR : Enhanced Oil Recovery

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2. Chiyoda's Carbon Recycling Activities

- Chiyoda's CCU business from CO_2 capture to utilization.
- Chiyoda is aiming to establish a Carbon Recycle Supply Chain in the near future.

CO_2 capture

- Records of Acid Gas Removal to capture CO_2 from natural gas for liquefied natural gas

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- Records of CO_2 capture for pre/post combustion CO_2 capture

×

- Integration of CO_2 capture and Ethylene synthesis for NEDO moonshot project.

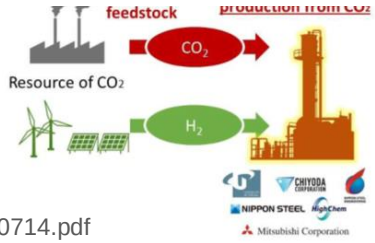
Para-xylene（Polyester clothes/plastic bottles）

- Para-xylene production from CO_2 and H_2

・Para-xylene is essential to manufacture polyester clothes and drink bottles

・R&D stage in NEDO project (July 2020 – March 2024)

・Partnership with the University of Toyama, Nippon Steel Engineering Co., Ltd., Nippon Steel Corporation, HighChem Company Ltd. and Mitsubishi Corporation



https://www.chiyodacorp.com/media/200714.pdf

Carbonate（Concrete）

Waste concrete

Capture/Fix CO_2 by Calcium

Recycled aggregate

Aggregate

- Technology by Blue Planet (a start-up company in the USA).
- Chiyoda has entered into an MOU with Blue Planet and Mitsubishi Corporation.
- Chiyoda participates in a demonstration project in the USA, providing technical support and accelerating commercialization.

https://www.chiyodacorp.com/media/210205.pdf

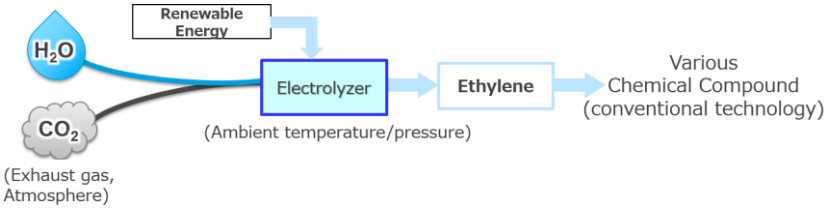
Ethylene

- Ethylene production from CO_2 + H_2O by Integrated Electrochemical Systems.

・Reaction under ambient pressure/temperature

・Ethylene can be made into chemical products such as e-fuel.

・R&D stage in NEDO project (July 2020 – March 2030)



https://www.chiyodacorp.com/media/200909%20.pdf

Blue Planet: Blue Planet Systems Corporation
NEDO: the New Energy and Industrial Technology Development Organization

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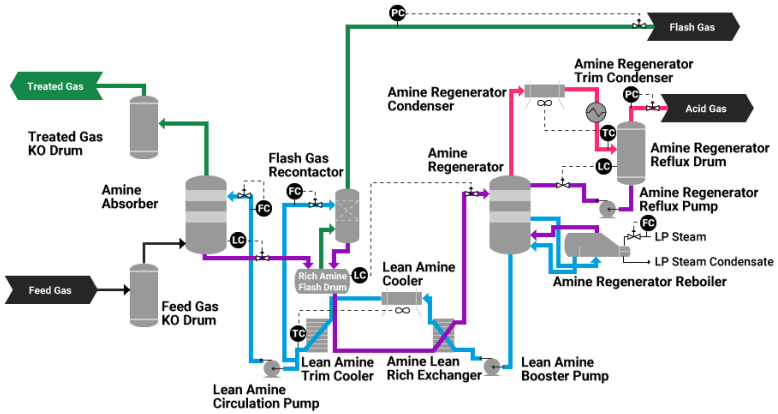
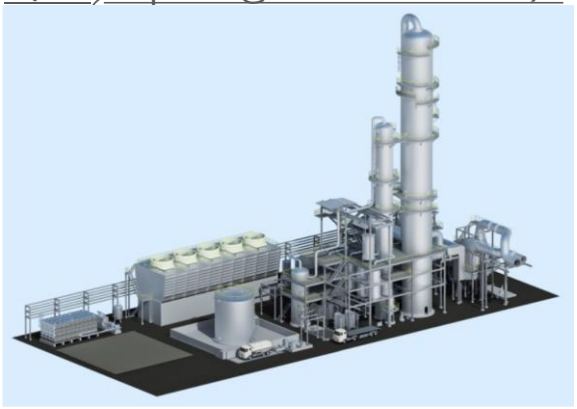
3. CO_2 Capture Records

◆ Chiyoda has delivered many CO_2 capture technologies.

For Liquid Natural Gas plant（Acid Gas Removal）



For Coal Fired Power Plant
（CO_2 capture @Post-combustion）

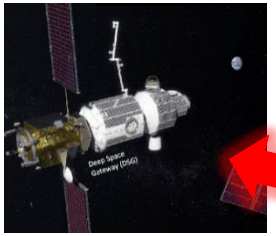


Source：Toshiba Corporation

For Coal Gasification
(CO_2 capture @Pre-combustion）

Source：Electric Power Development Co.,

For Space Platform（Direct Air Capture Technology）



Space station in 2025

CO_2 Direct Capture trial device

Source：JAXA

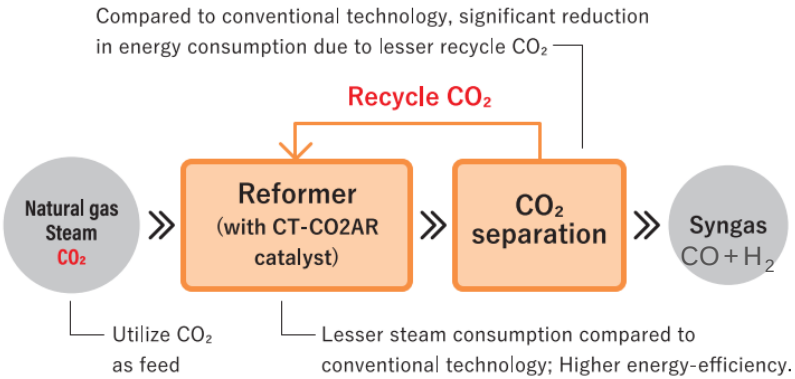
4. Reformer to use CO_2 as Feedstock (Commercialized)

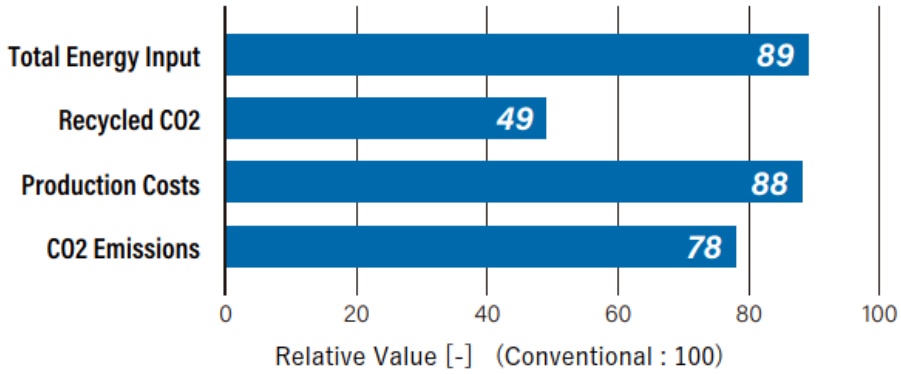
- Chiyoda has commercialized a reforming catalyst to use CO_2 as feedstock
- Synthetic gas with wide range of H_2/CO ratio can be produced.
- This Chiyoda technology is currently being used by a chemical company in Japan.

https://www.chiyodacorp.com/jp/service/gtl/co2-reforming/

https://www.youtube.com/watch?v=f6TtfF_vm-E

Conceptual Diagram of CT-CO2AR



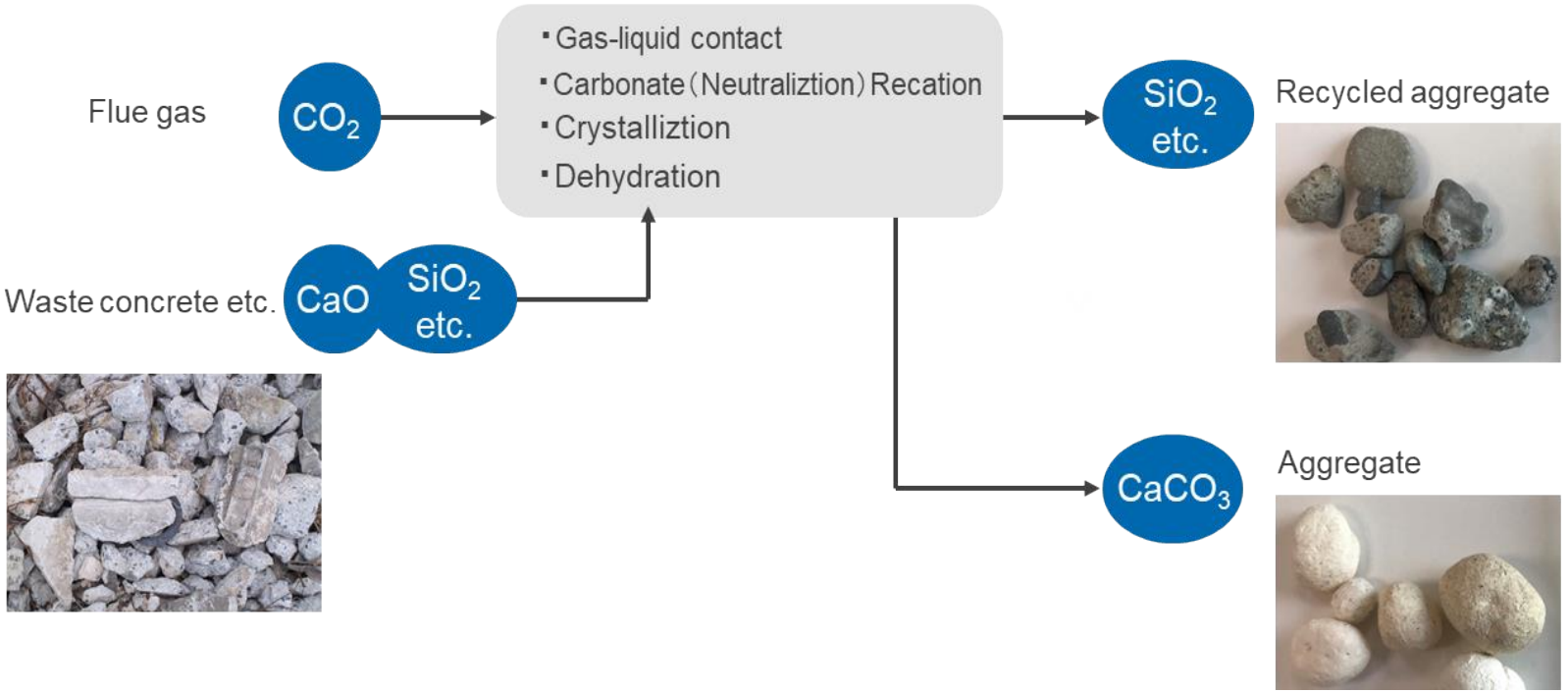


By adjusting CH_4/CO_2 ratios in feed gas, synthetic gas with a wide range of H_2/CO ratios can be produced.
Example: $H_2/CO=2.0$ for Methanol, Synthetic fuel
$H_2/CO=0.5$ for acetic acid, resin

When the H_2/CO ratio =1.0 (for oxo-synthesis), CO_2 emissions are reduced by 22%.

5. Mineralization (R&D)

- CO_2 is sequestrated as the mineral, $CaCO_3$.
- MOU signed with Blue Planet Systems Corporation (a start up company that owns technology in the USA) and Mitsubishi Corporation
- Joint demonstration is ongoing in the USA



* SiO_2: Silicon Dioxide, $CaCO_3$: Calcium Carbonate, CaO: Calcium Oxide

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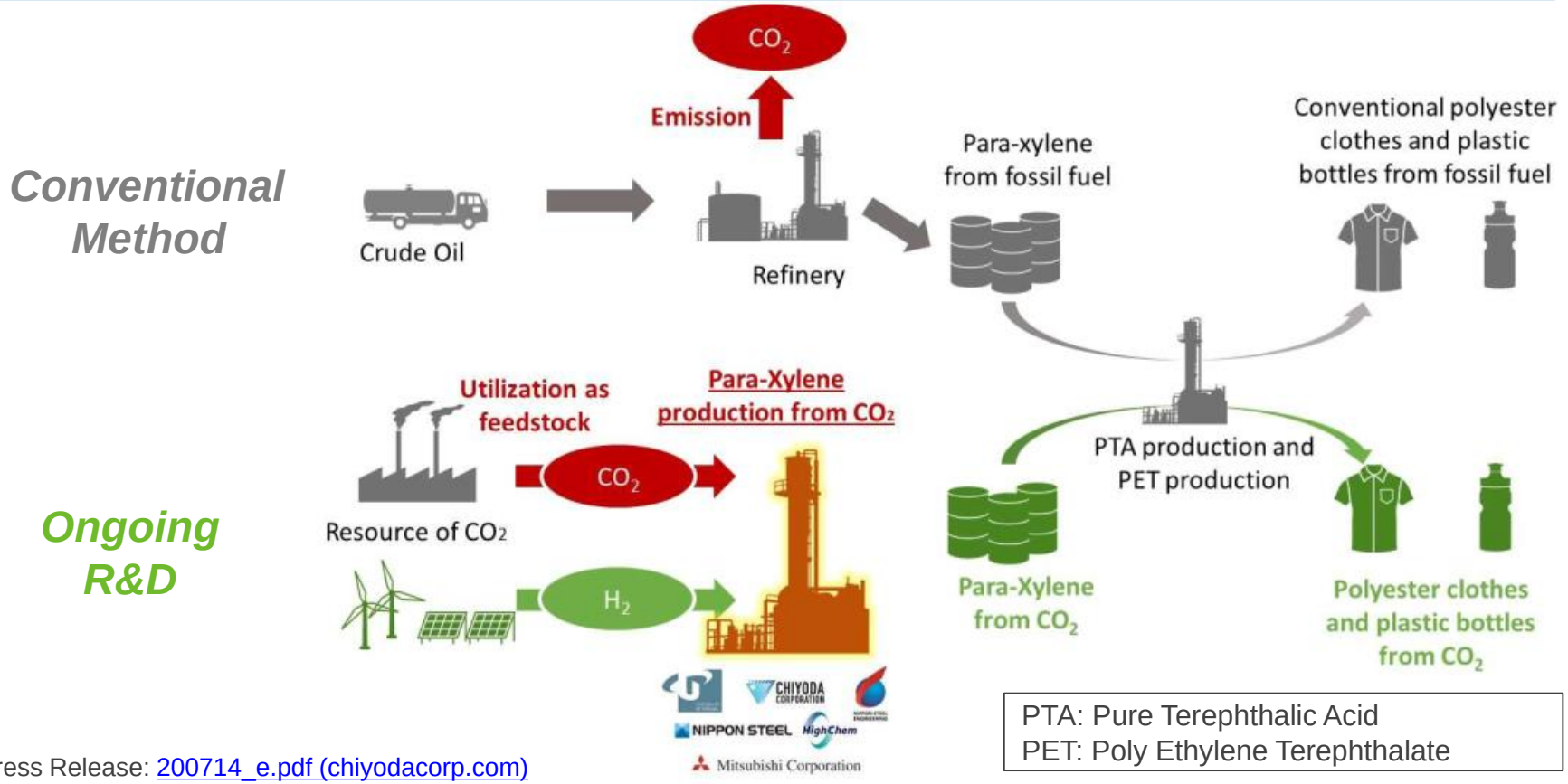
6. Para-xylene Synthesis (R&D)

- Para-xylene synthesis from CO_2 and H_2 ("CCU-PX") [*1] to substitute existing fossil fuel-derived chemicals.
- This R&D project is fully funded by NEDO. (Budget: US$20M, Duration: July 2020 to March 2024)
- Joint R&D by University of Toyama, Mitsubishi Corporation, Nippon Steel, Nippon Steel Engineering and Chiyoda

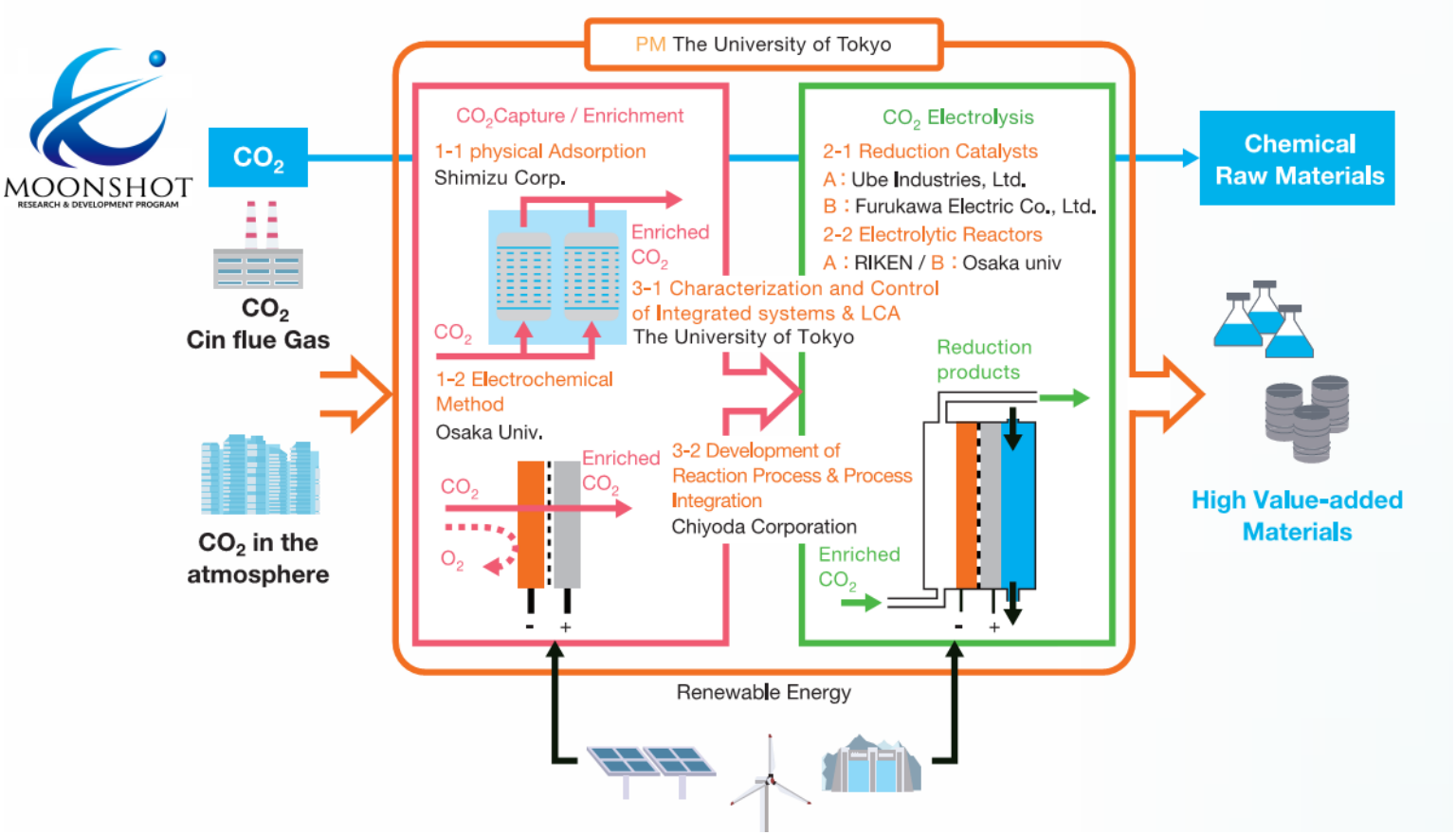


PTA: Pure Terephthalic Acid
PET: Poly Ethylene Terephthalate

Press Release: 200714_e.pdf (chiyodacorp.com)

7. Ethylene Electrochemistry Synthesis (R&D)

- Ethylene production from CO_2 + H_2O by Integrated Electrochemical Systems.
- Funded by NEDO Moonshot Research & Development Program
- Duration: Maximum 10 years from August 2020



Press Release: 200909_e.pdf (chiyodacorp.com)

Thank you