Demonstration of CO_2-free Ammonia Synthesis using Renewable Energy-Generated Hydrogen

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(JGC Corporation)

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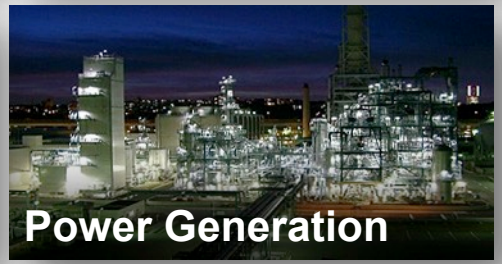
JGC's Main Business Domains



Supply Chain of CO_2-free Ammonia

Renewables

Wind

Solar
(PV or CSP)

Hydro

Fossil Fuels
(Natural Gas)

Electricity

Water

Water
Electrolysis

Air

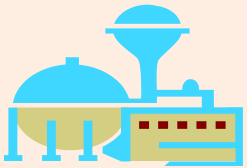
Reforming

CO_2

CCS or
EOR (Enhanced Oil Recovery)

CO_2-free
Hydrogen

Nitrogen
from Air

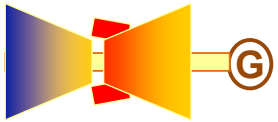


Ammonia
Synthesis

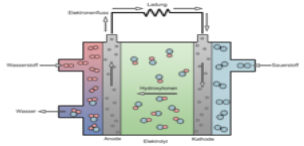
Hydrogen
+Nitrogen

CO_2-free
Ammonia

Power
Generation



Ammonia Gas
Turbine or Boiler



Ammonia
Fuel Cell

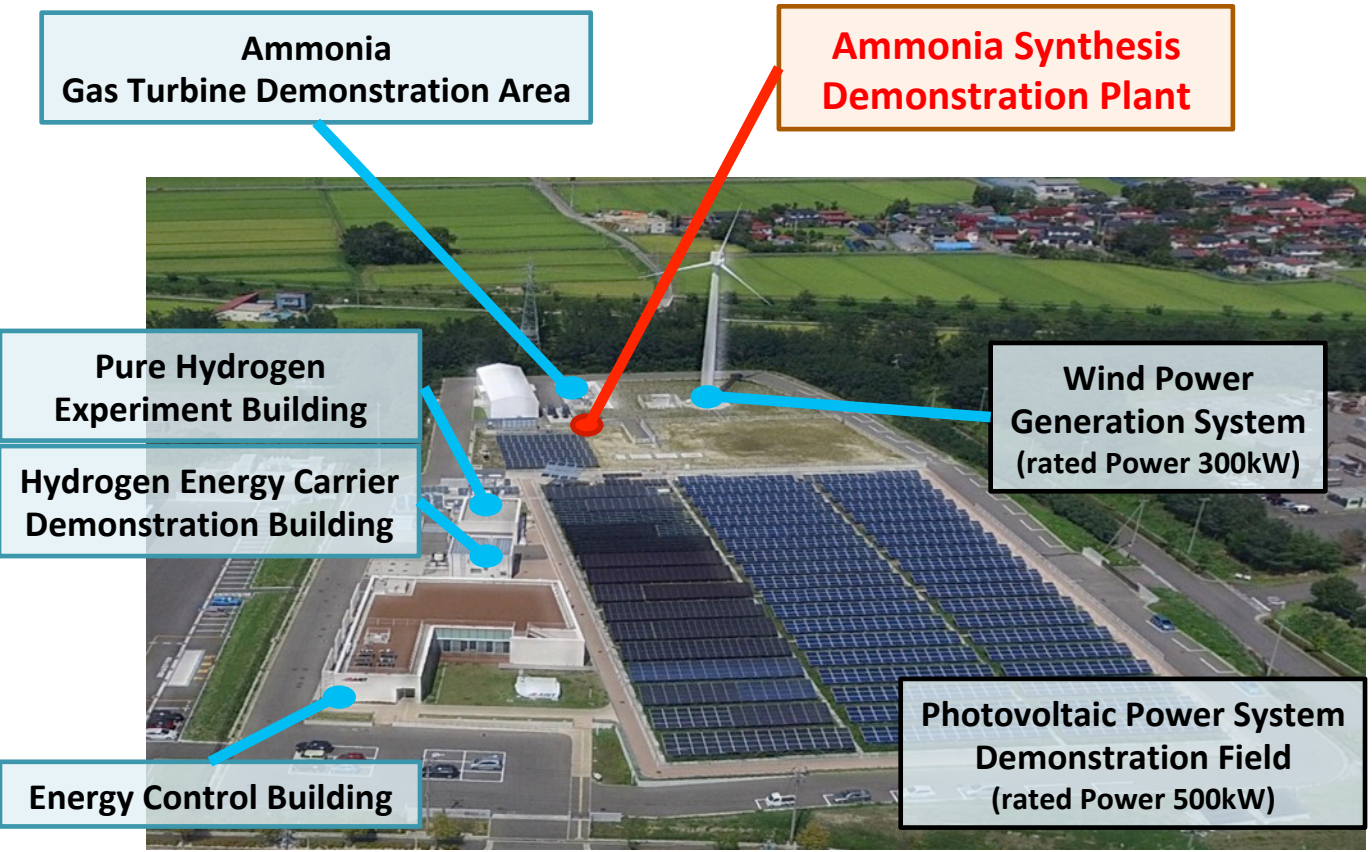
Background and Objectives

- R&D Theme “Development of Ammonia Synthesis Process from CO_2-free Hydrogen” under SIP Energy Carriers
- Major R&D Items;

(1) Development of ammonia synthesis catalyst with high activity at low pressure and temperature

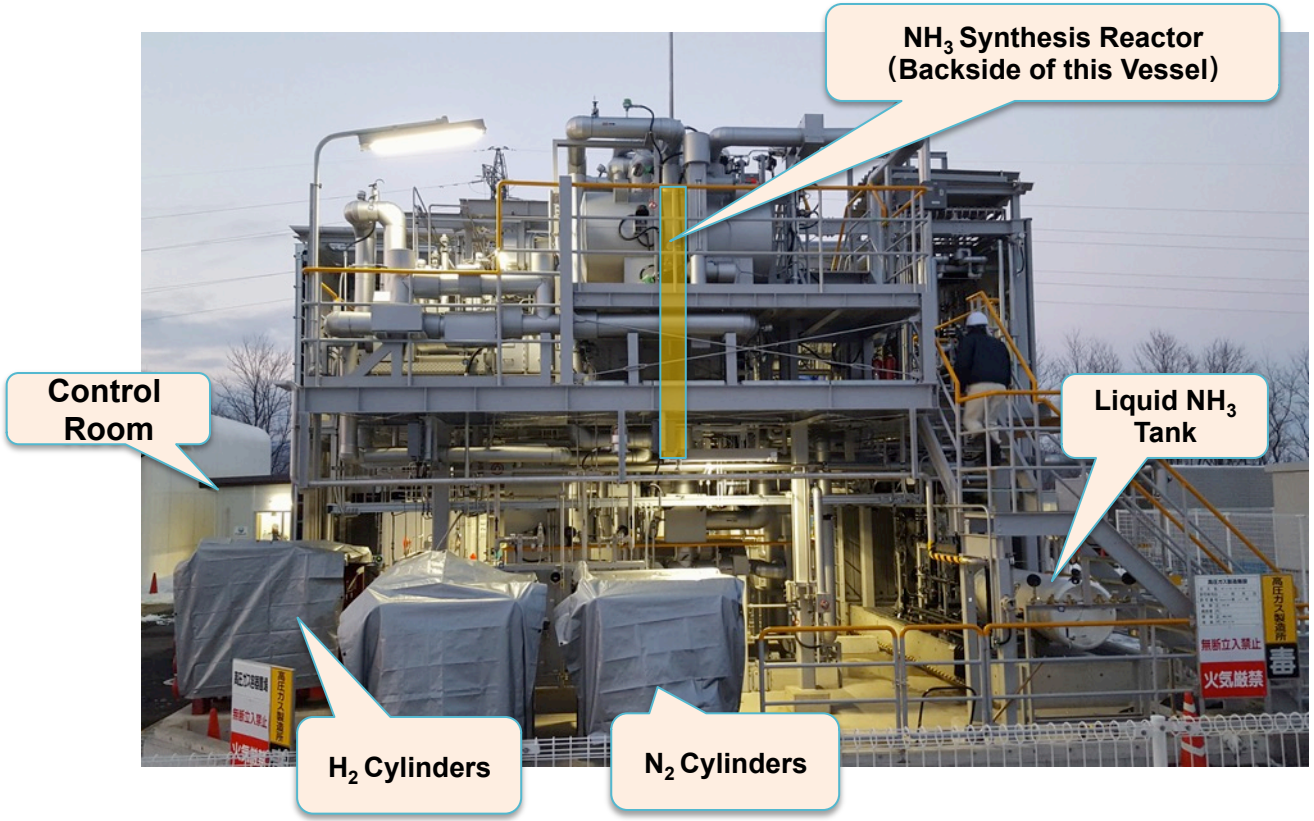
(2) Demonstration of new catalyst performance

Fukushima Renewable Energy Institute, AIST (FREA)



"Courtesy of AIST"

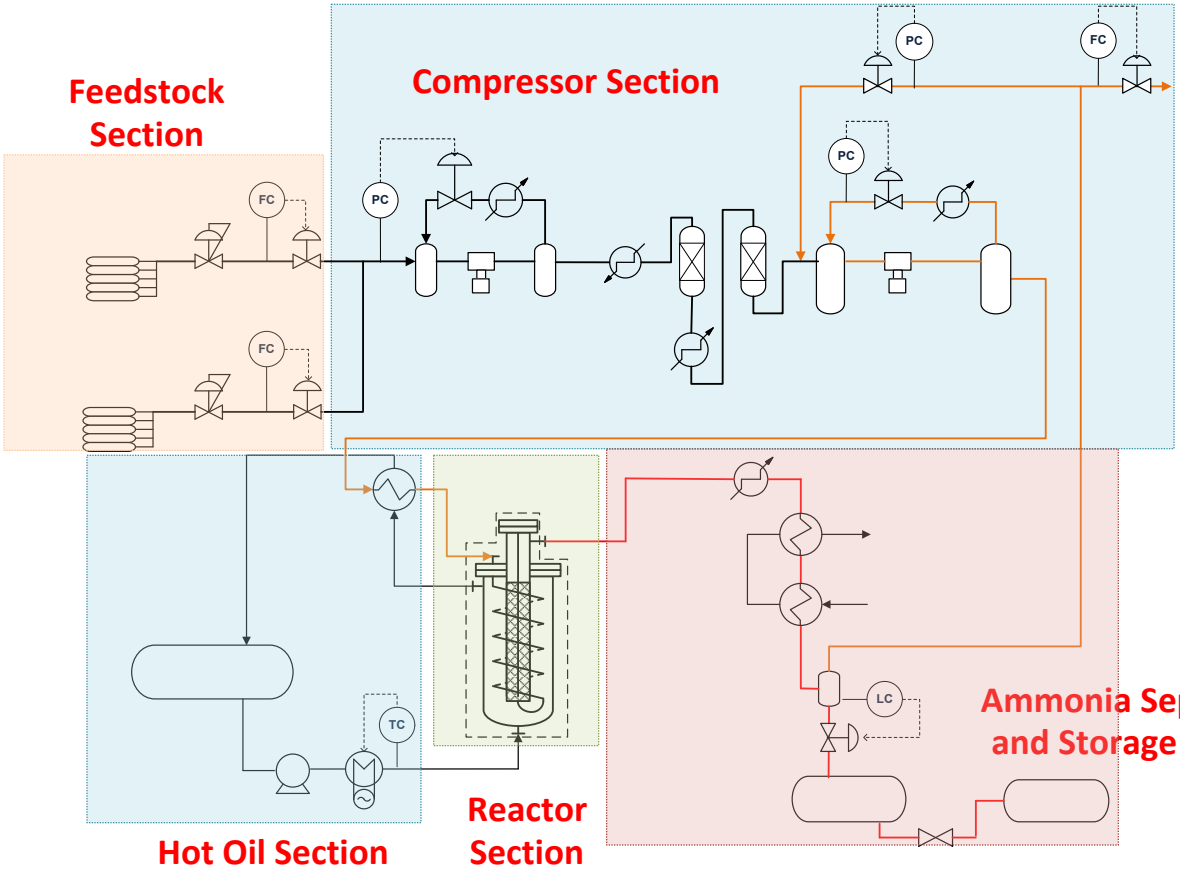
Ammonia Demonstration Plant



Reactor
Top Elevation

Ru/REO_2 catalyst produced on a semi-industrial scale By JGC C&C

Simplified Process Flow Diagram of Plant



- ✓ Location : AIST FREA (Fukushima, Japan)
- ✓ Reactor Inlet Conditions:
  < 400degC, < 8MPaG
- ✓ Feedstock : Cylinder Gas
- ✓ Product : Liquefied Ammonia

Demonstration Plant Highlights

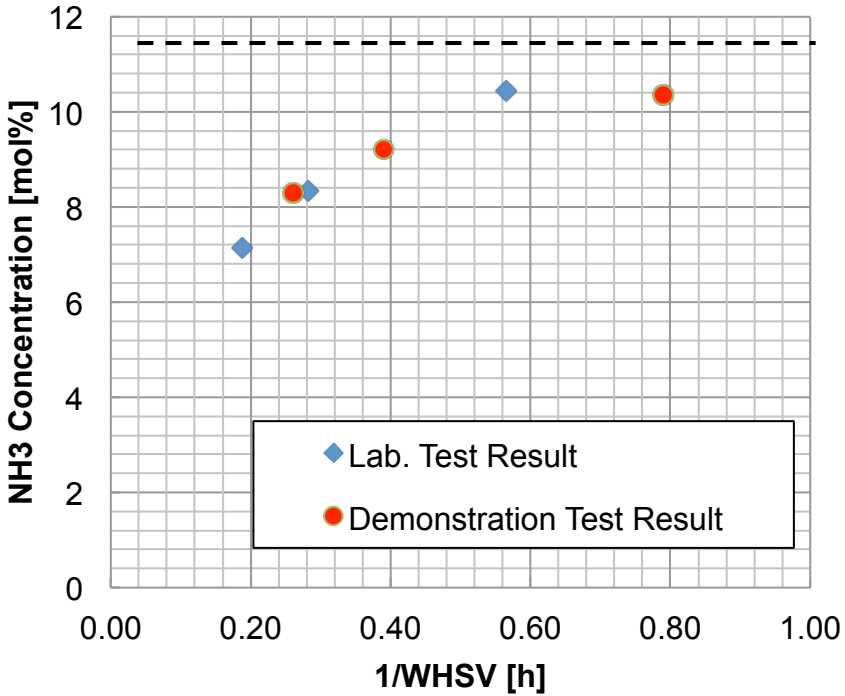
- ✓ **2018.Jan: Construction Completed.**
- ✓ **2018.Mar: Commissioning Completed.**
- ✓ **2018.Apr: Demonstration Plant Operation Started.**

(Press Release: http://www.jgc.com/en/ViewPdf/view/1940)

- ✓ **2018.May: Expected Catalyst Performance confirmed at the Design Condition.**
- ✓ **2018.Aug: CO_2-free Hydrogen based Ammonia successfully produced, and Power Generated by 100% Ammonia Gas Turbine.**

(Press Release: http://www.jgc.com/en/ViewPdf/view/2065)

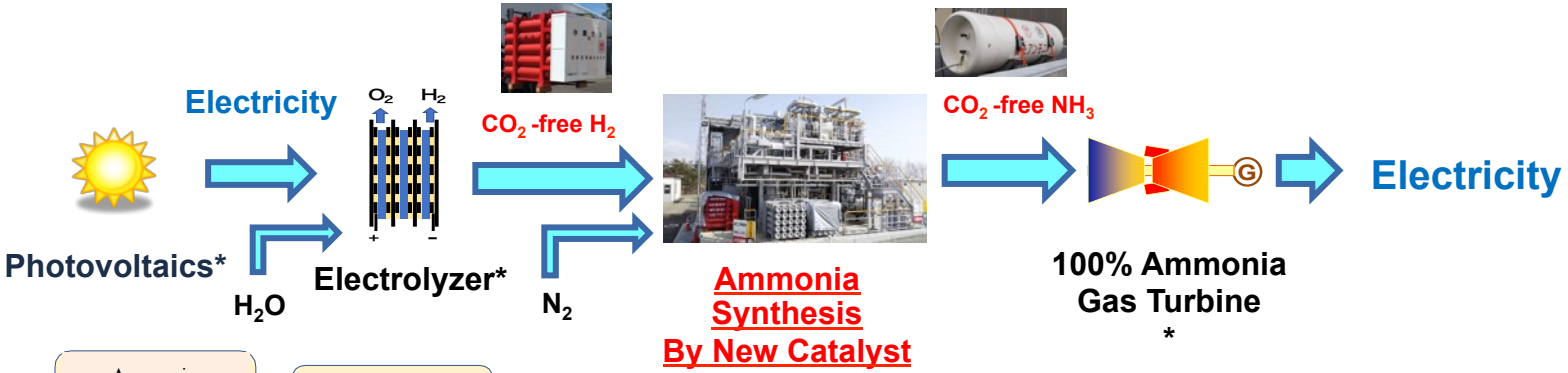
Comparison between Lab. Test and Demonstration Test

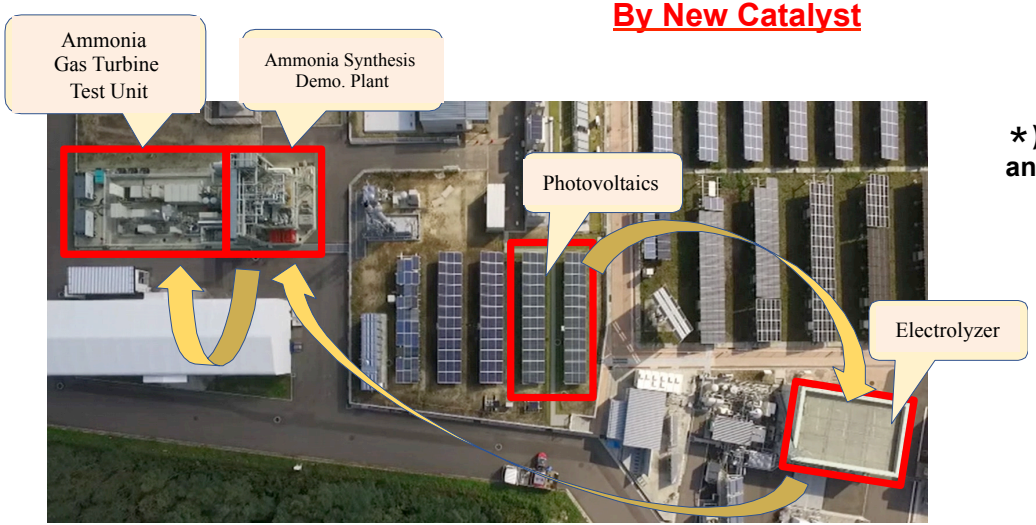


<Conditions>
Rx Inlet Temperature : 400℃
Rx Pressure : 5MPaG
H_2/N_2 Ratio : 1.0

Demonstration Test Results are almost equal to Lab. Test Results.

Demonstration of CO_2-free Ammonia Value Chain

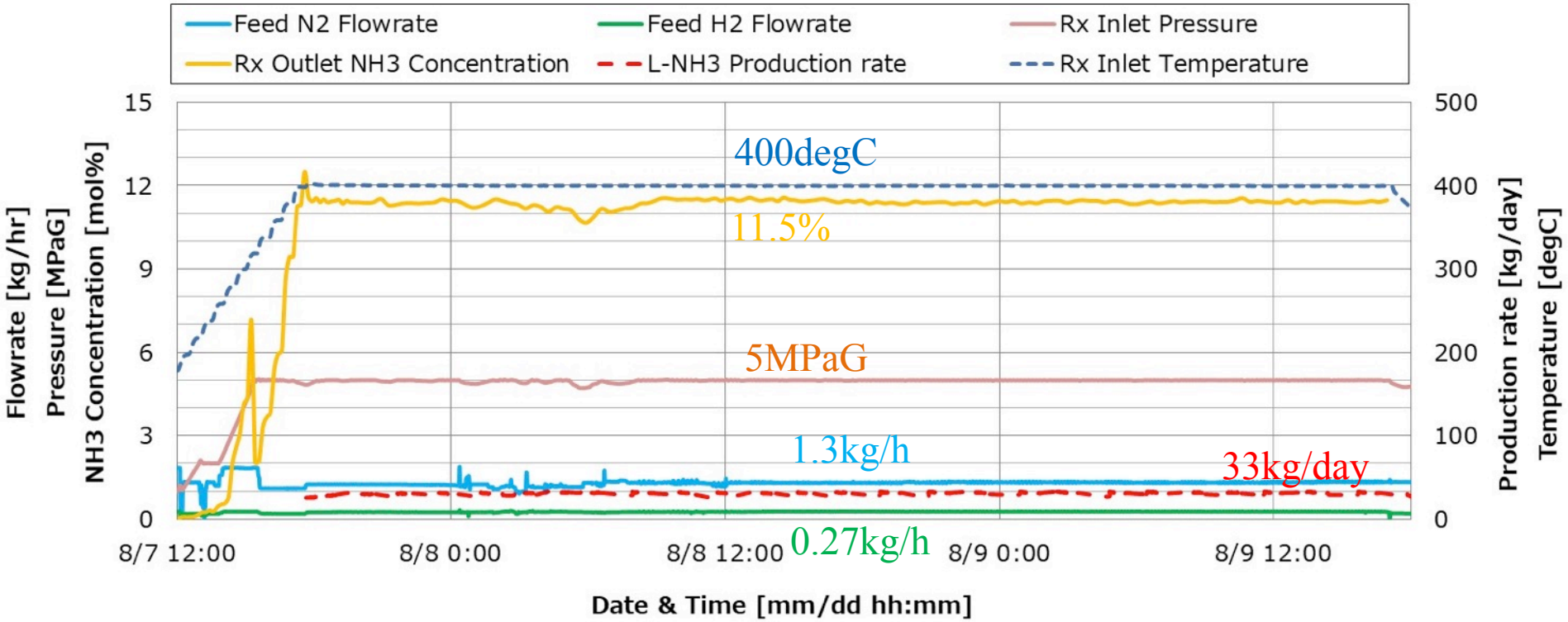




＊) Collaboration with AIST-FREA, and SIP Ammonia Direct Combustion Team

World's First Demo. by this scheme !

Operation with Renewable Energy-Generated Hydrogen



Future Plan

- ✓ In the near future, fluctuation operation simulating variable renewable energy will be conducted, to confirm -

(a) Ru Catalyst high activity under feed gas flowrate rapid increase/decrease operation,

(b) ammonia plant operation flexibility (allowable turn down range)

- ✓ In the near future, commercial scale plant design and cost study will be conducted.

Summary

- ✓ Ammonia is a promising energy carrier for CO_2-free power generation.
- ✓ The demonstration plant of ammonia synthesis using the developed catalysts has been in operation from early 2018.
- ✓ CO_2-free ammonia production using renewable energy - generated hydrogen as feedstock has been conducted.
- ✓ In the near future, fluctuating operation simulating variable renewable energy will be conducted. And commercial scale plant design and cost study will be conducted.
- ✓ JGC will contribute to decarbonization and energy supply chain.

Acknowledgement

Thank you very much

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