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Demonstration and optimization of Green Ammonia production operation responding to fluctuating hydrogen production from renewable energy

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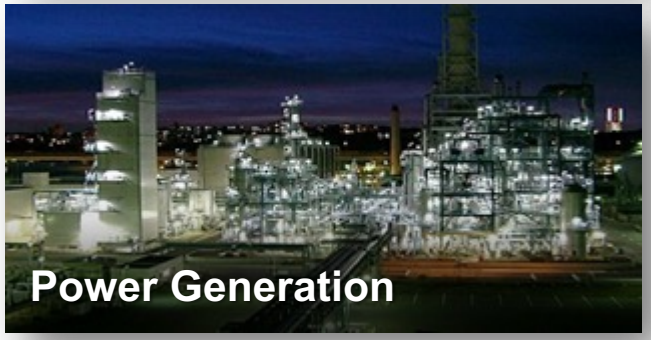
JGC's Business Field



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JGC's contribution to decarbonization in Energy Sector

Photo) http://www.japanccs.com/en/business/demonstration/

JGC focuses on CO_2-free Ammonia in Future

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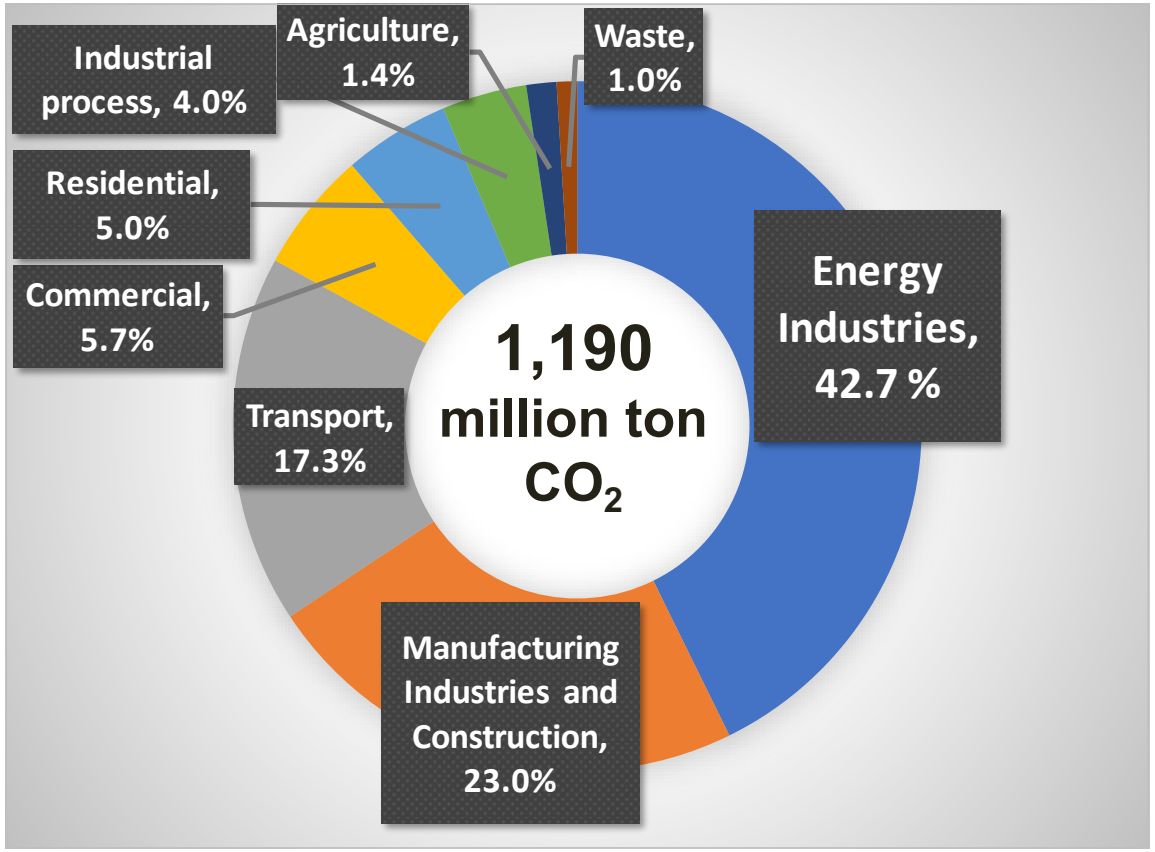
CO_2 emission in Japan and Reduction Target



CO_2 emissions in Japan in 2017

Source : National Greenhouse Gas Inventory Report of JAPAN (2019)

Japan's target for Paris agreement

【Middle Term】
Reduce GHG emissions by 26.0%
by FY2030 compared to FY2013

【Long Term】
Reduce GHG emissions **by 80% by 2050**

Zero-emission power generation should be introduced.

Supply Chain of CO_2-free Ammonia

Renewable Route

Wind

Solar
(PV or CSP)

Hydro

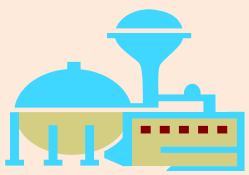
Electricity

Water

Water Electrolysis

CO_2-free Hydrogen

Nitrogen from Air

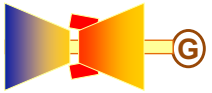


Ammonia Synthesis

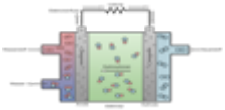
CO_2-free Ammonia

Power Generation

Coal Fired Power Station



Ammonia Gas Turbine



Ammonia Fuel Cell

Fossil Fuels (Natural Gas)

Air

Reforming & Purification

Hydrogen +Nitrogen

CO_2

CCS or
EOR (Enhanced Oil Recovery)

Fossil Fuel Route

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Development of Ammonia Synthesis from Renewables

Step 1: Development of new catalyst

- High performance at lower press. and temp.
- Industrial production of developed catalyst

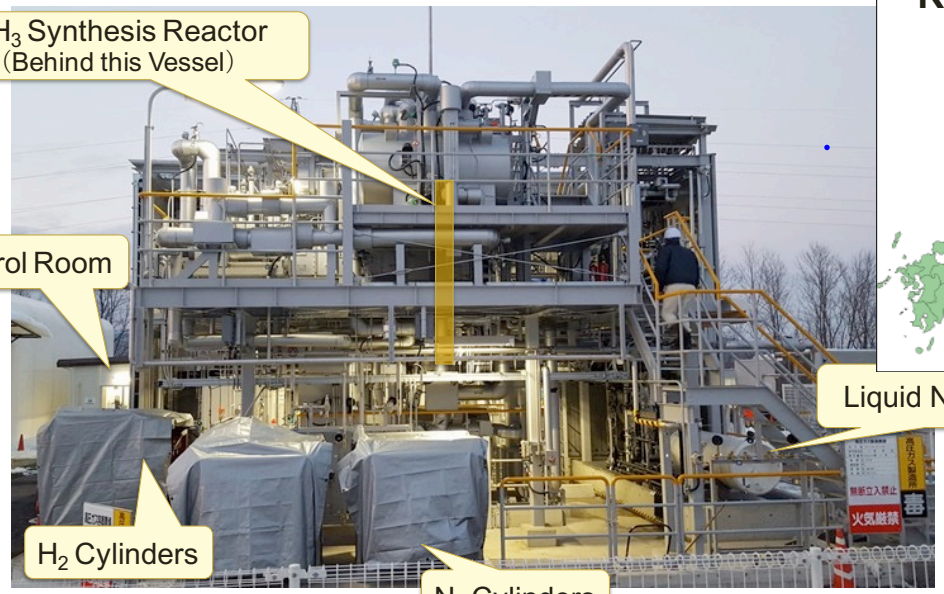
AIST　独立行政法人 国立高等専門学校機構 沼津工業高等専門学校 National Institute of Technology, Numazu College　JGC C&C

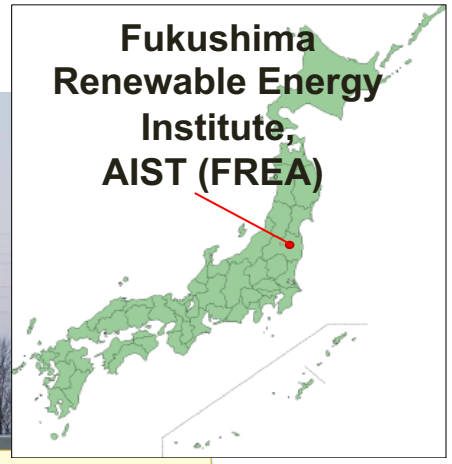
Ru/CeO_2 catalyst produced on a semi-industrial scale

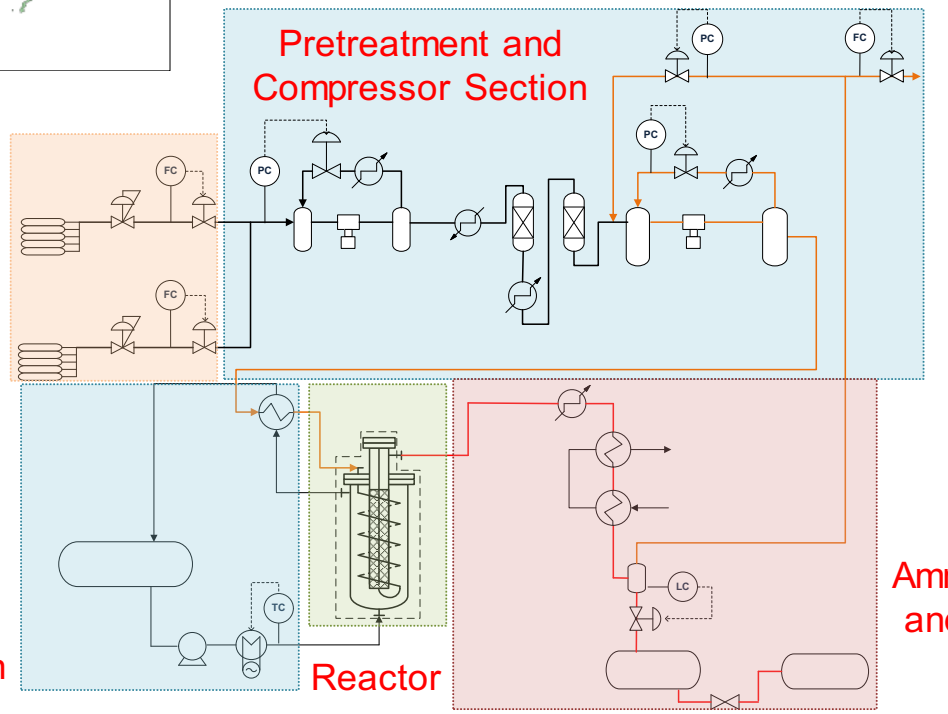
Step 2: Demonstration test of new catalyst

- Obtain Catalyst Performance Data
- Demonstrate Ammonia Chain Concept
- Confirm Operation Flexibility (Load Changing Operation)

Ammonia Synthesis Demonstration Plant







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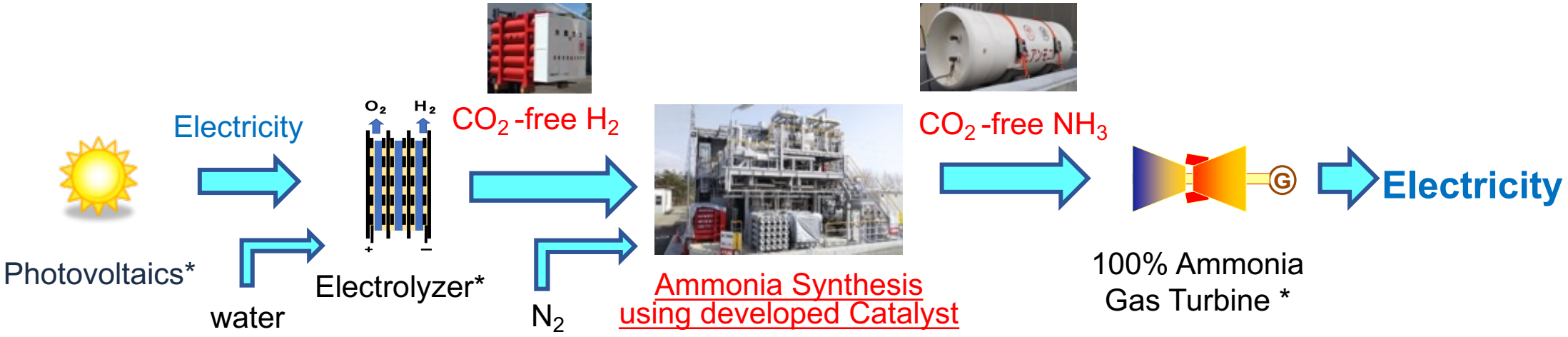
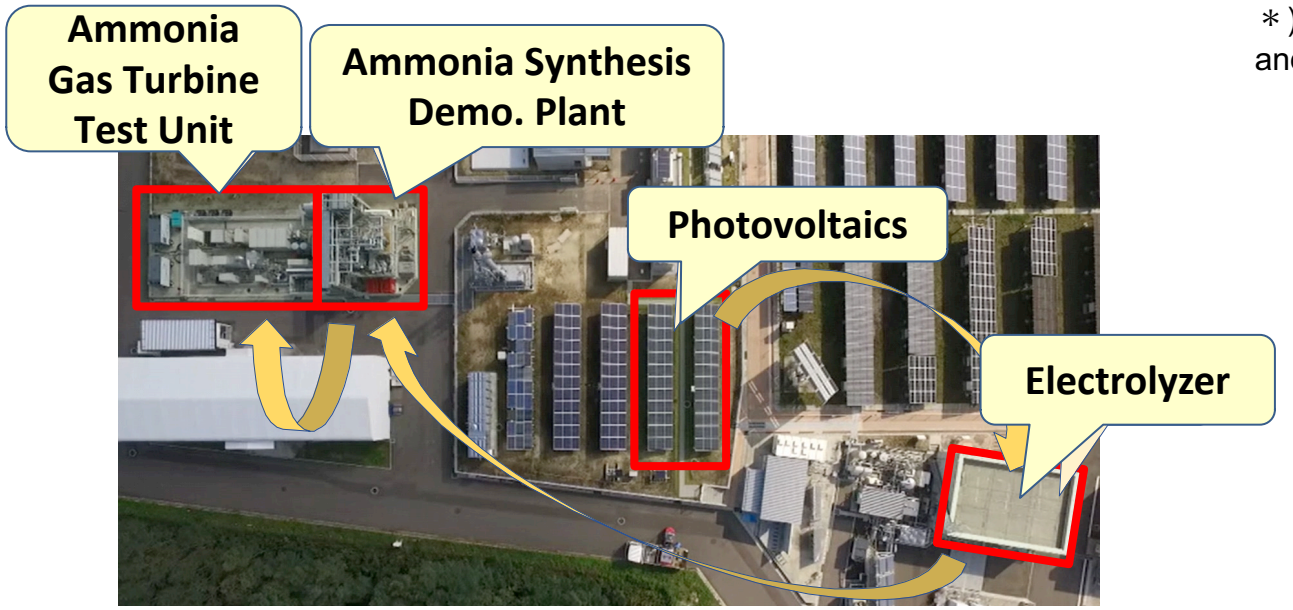
Demonstration of CO2-free Ammonia Value Chain





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

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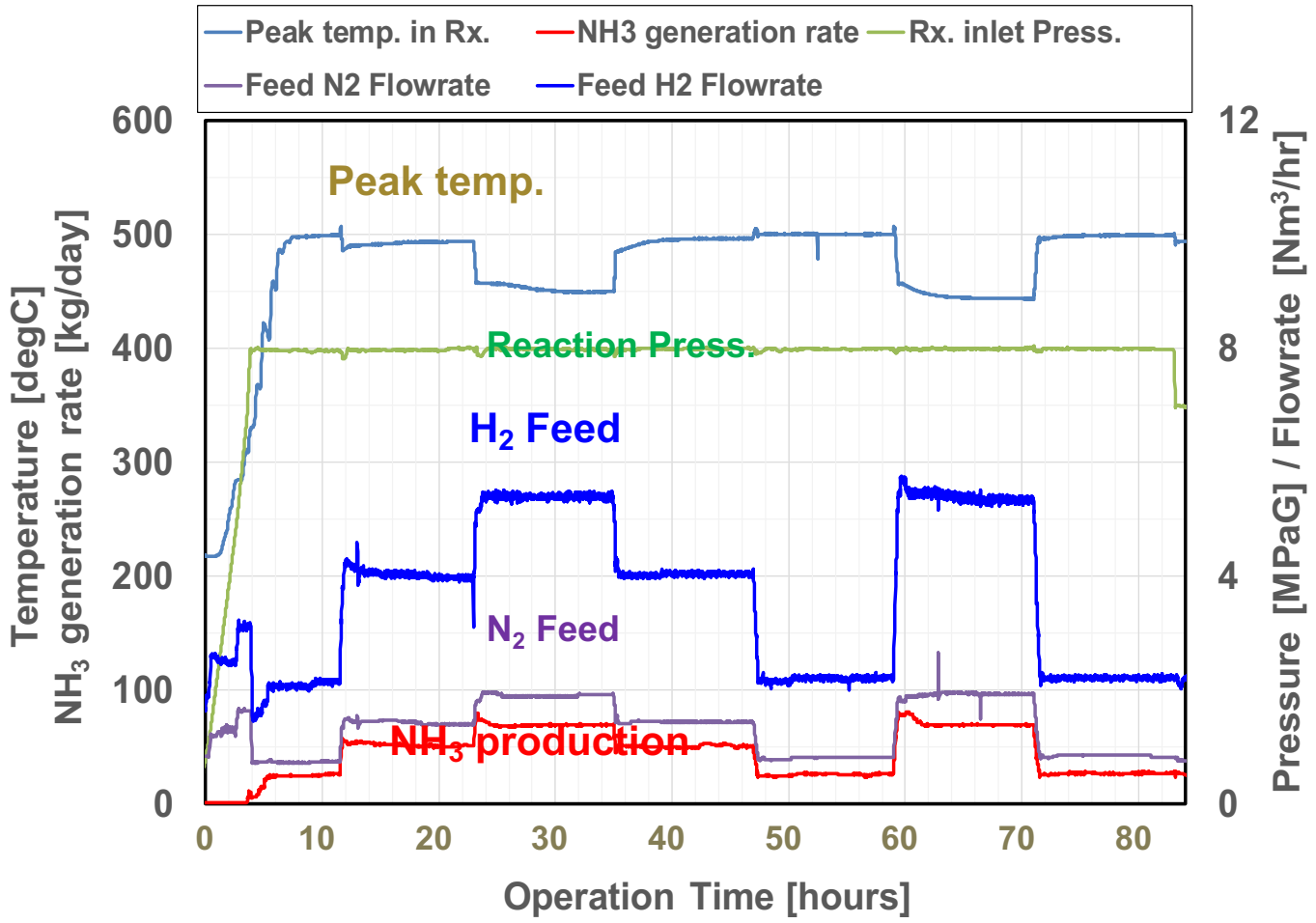
Load Changing Operation in Demonstration Plant



Succeeded in load changing operation as planned

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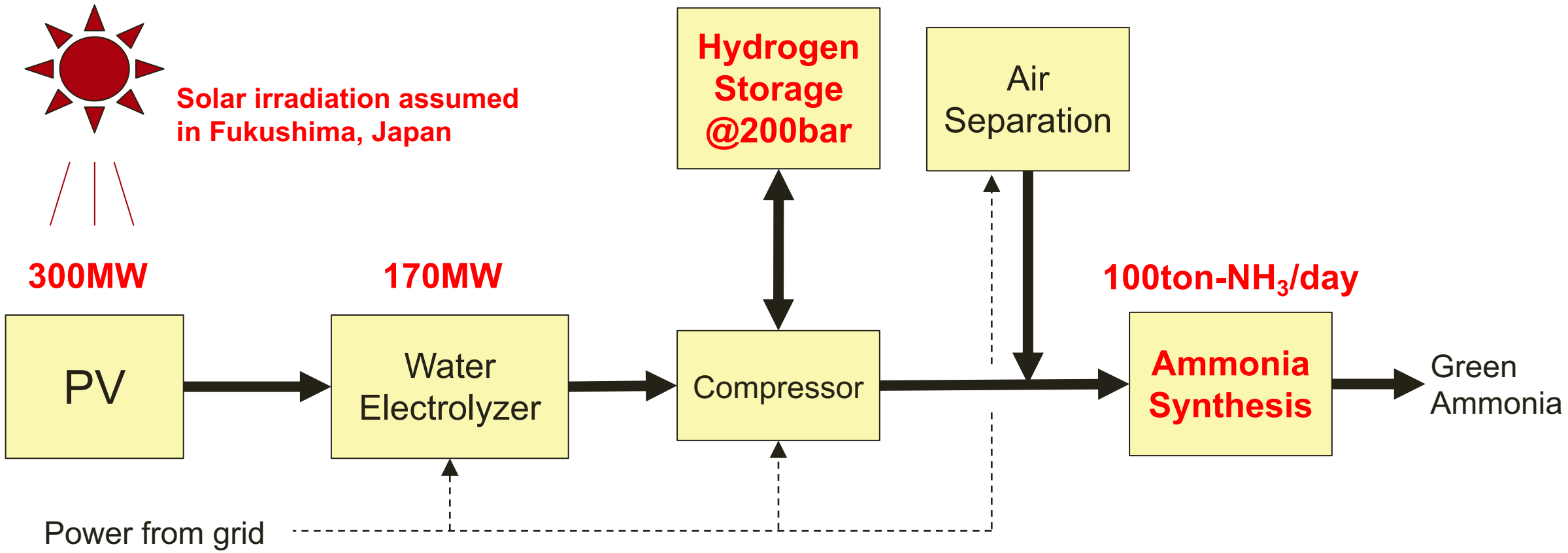
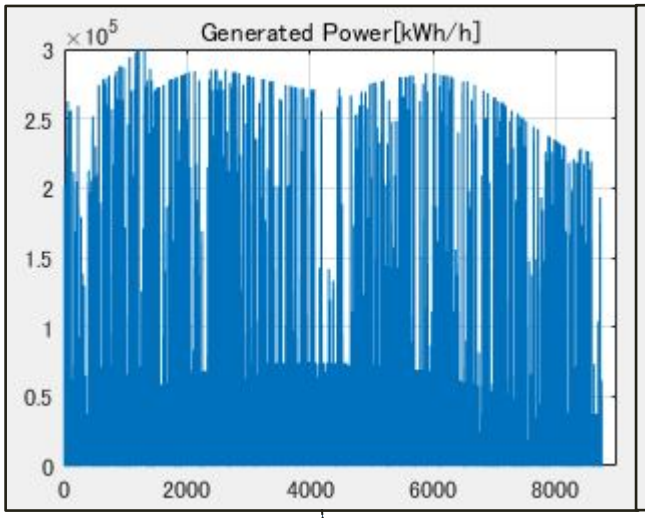
Case Study of PV based CO2-free Ammonia Production



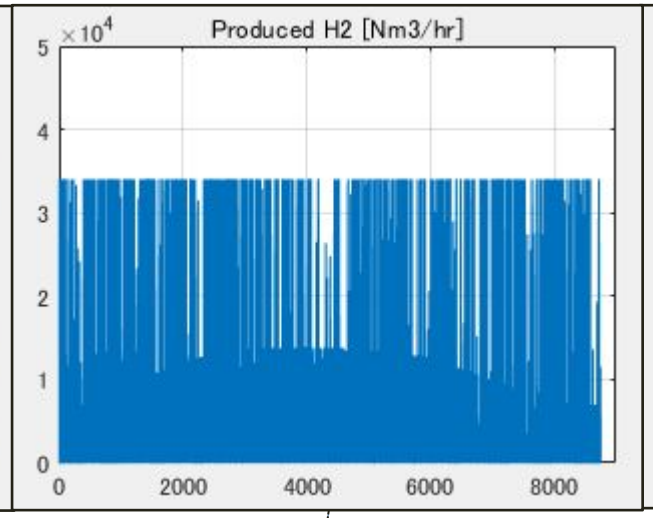
Simulation of one year operation

Case-1 : NH_3 plant operate full load for whole year

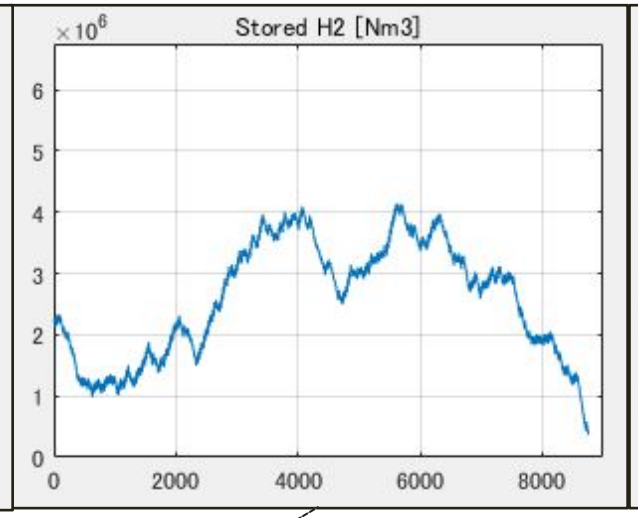
Power from PV



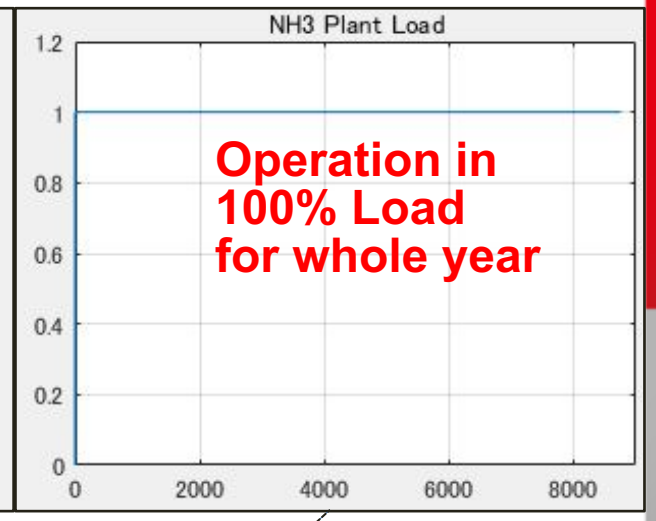
H_2 from Electrolyzer

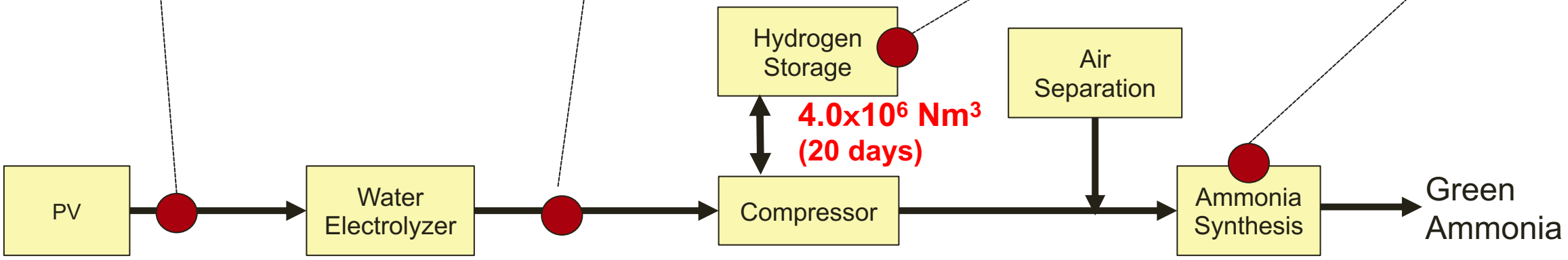


Stored H_2 Volume



Load of NH_3 Plant





300MW

170MW

Capacity factor 24.0%

100ton-NH_3/day

Capacity factor 100%

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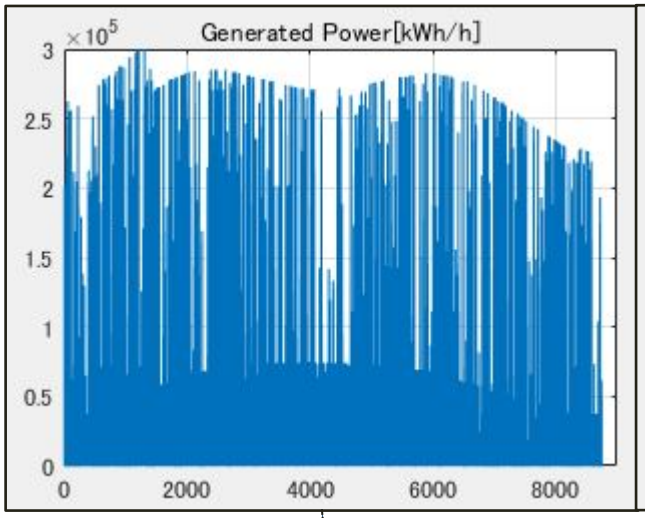
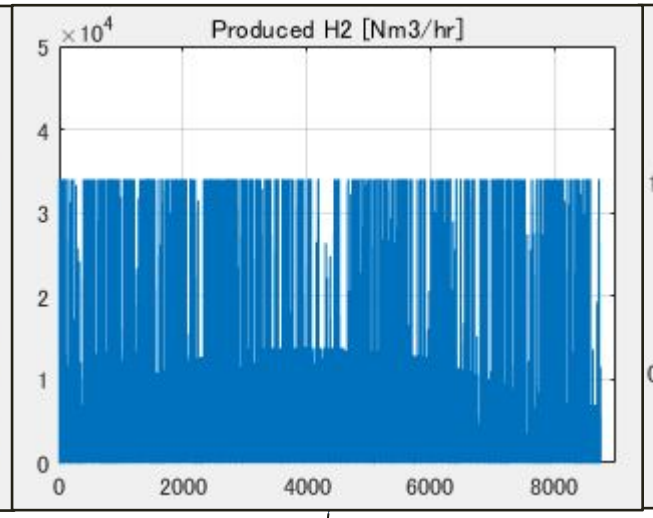
Simulation of one year operation

Case-2 : NH_3 plant load changes every 30 days

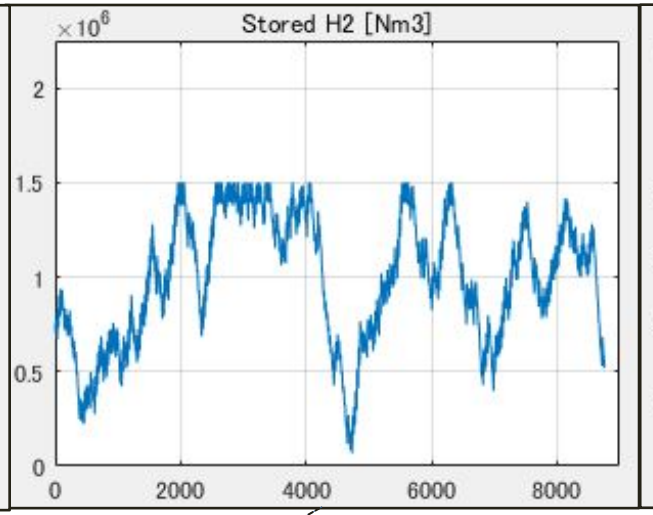
Power from PV



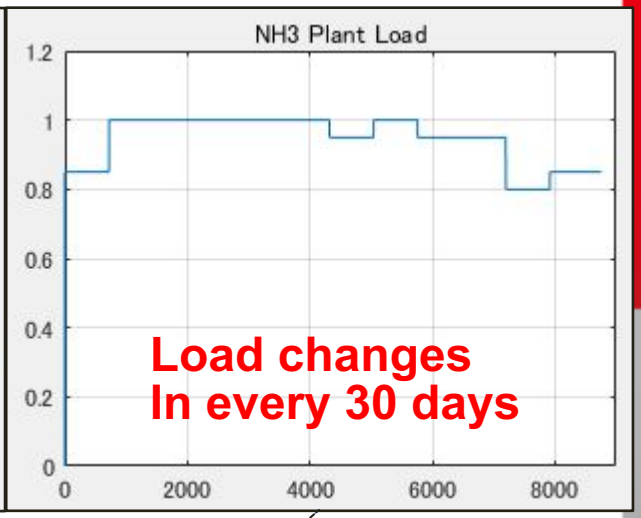
H_2 from Electrolyzer



Stored H_2 Volume



Load of NH_3 Plant



Hydrogen Storage

1.5x10⁶ Nm³ (7.5days)

Air Separation

PV

Water Electrolyzer

Compressor

Ammonia Synthesis

Green Ammonia

300MW

170MW

Capacity factor 24.0%

63% Reduction from Case-1

100ton-NH_3/day

Capacity factor 94.5%

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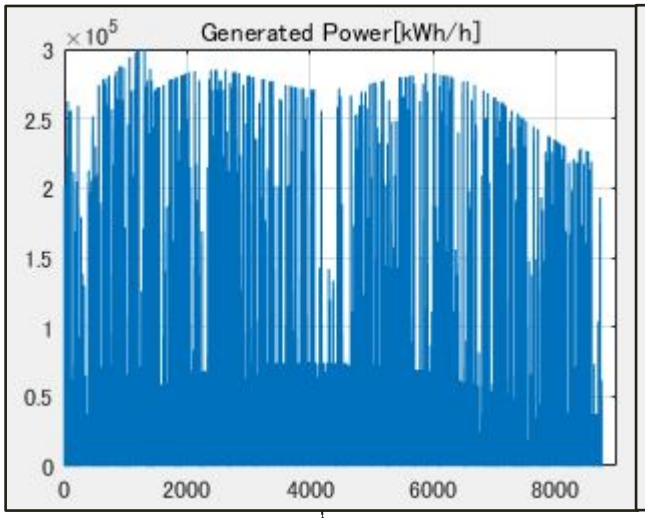
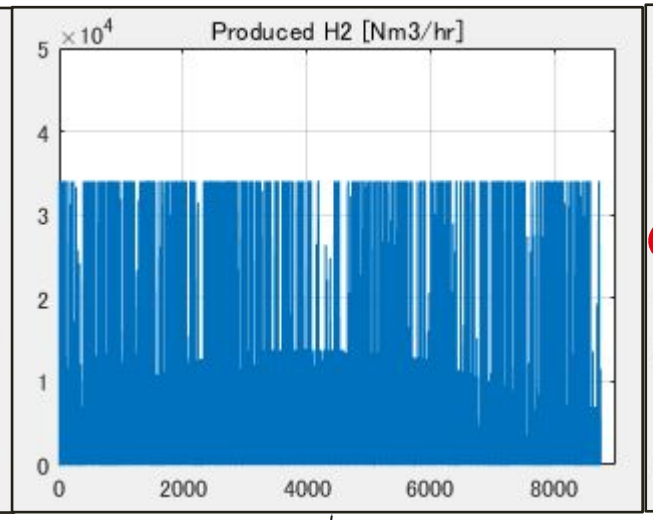
Simulation of one year operation

Case-3 : NH_3 plant load changes every 4 days

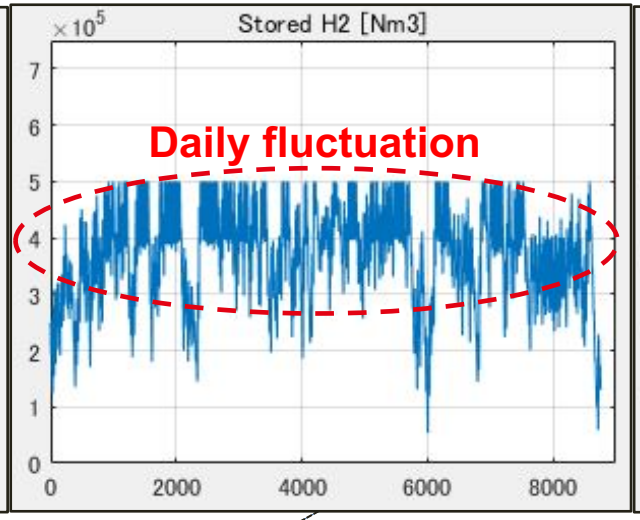
Power from PV



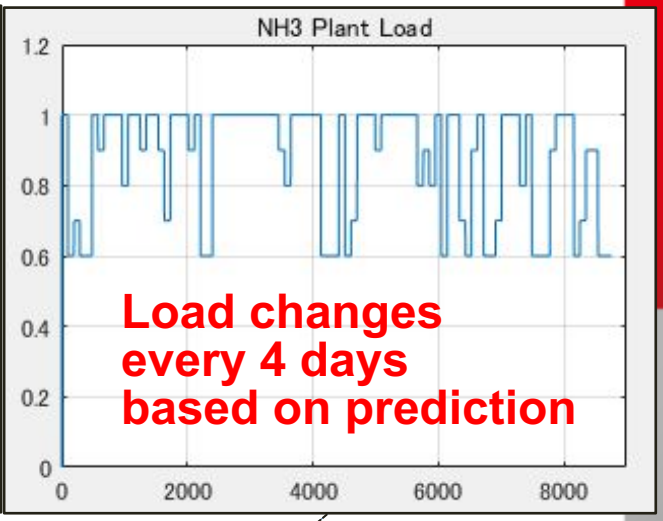
H_2 from Electrolyzer



Storied H_2 Volume



Load of NH_3 Plant



Hydrogen Storage

5.0×10^5 Nm^3 (2.5days)

Air Separation

PV

Water Electrolyzer

Compressor

Ammonia Synthesis

Green Ammonia

300MW

170MW

Capacity factor 23.5%

67% Reduction from Case-2

100ton-NH_3/day

Capacity factor 87.3%

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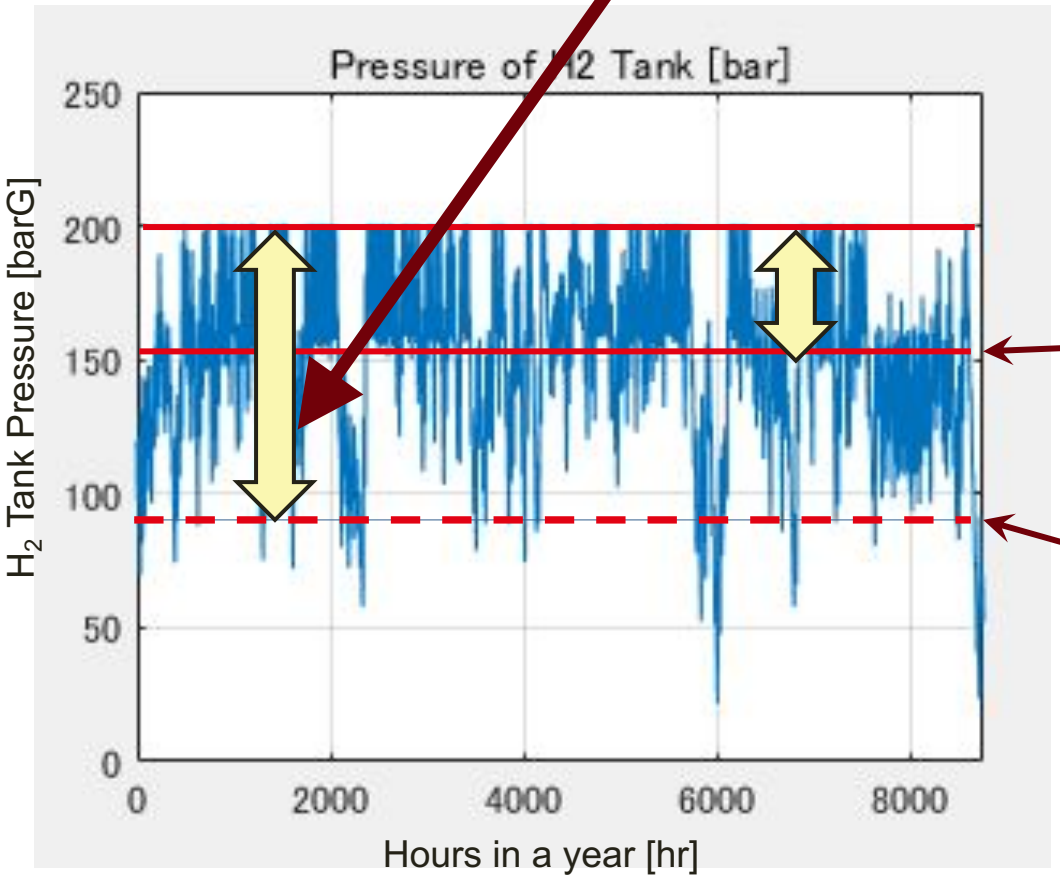
Benefit of Low Pressure Synthesis

Hydrogen can be supplied to
NH_3 synthesis using tank pressure



In the case of NH_3 synthesis at 150 bar

In the case of NH_3 synthesis at 80 bar

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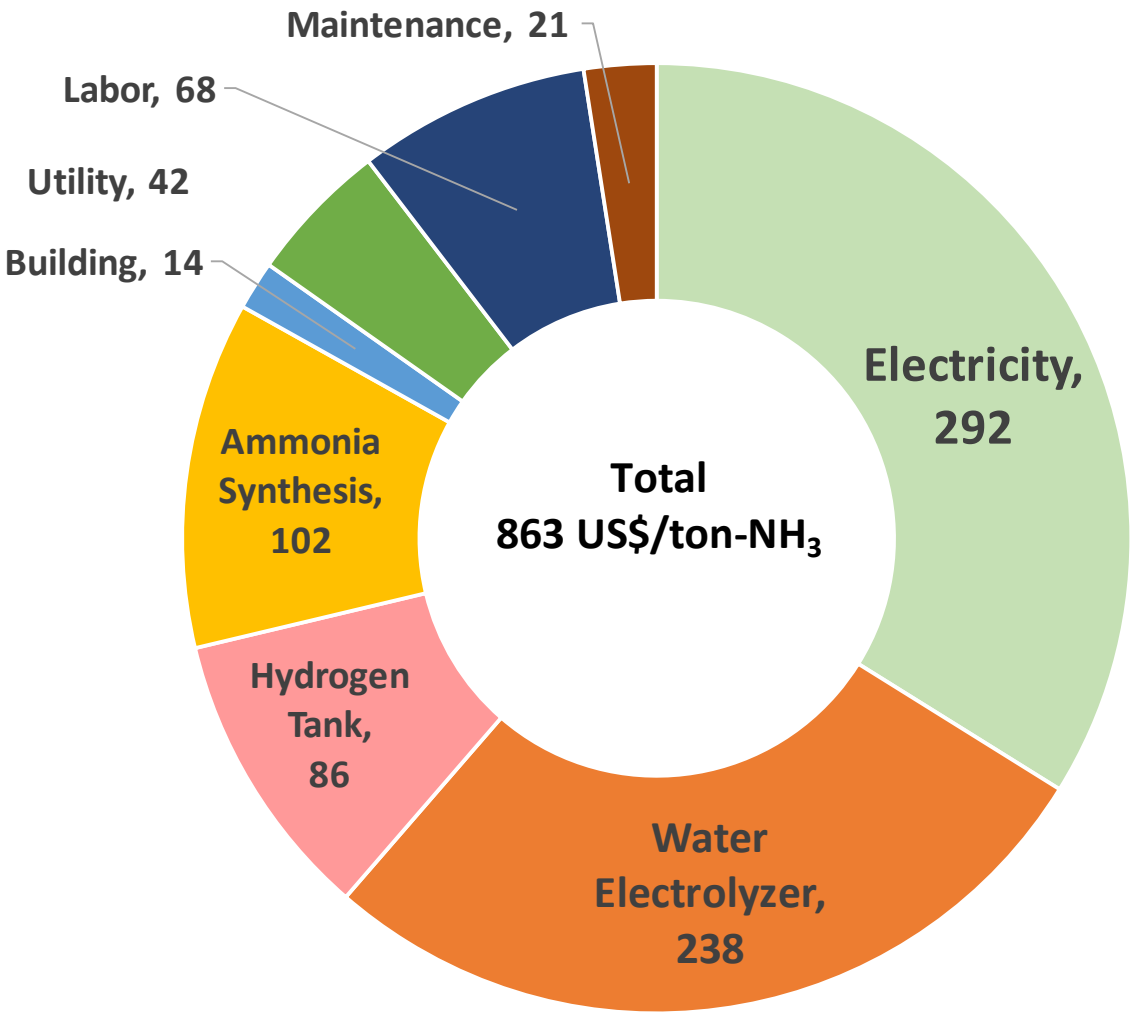
Cost Estimation for Case-3



[Unit : US$/ton-$NH_3$]

Conditions of Cost Estimation

- ✓ PV Power price : 3 ¢ /kWh
- ✓ Water Electrolyzer Efficiency : 5.0 kWh/Nm^3-H_2
- ✓ Water Electrolyzer System Cost : 570 US$/kW
- ✓ Capacity factor of Water Electrolyzer : 23.5 %

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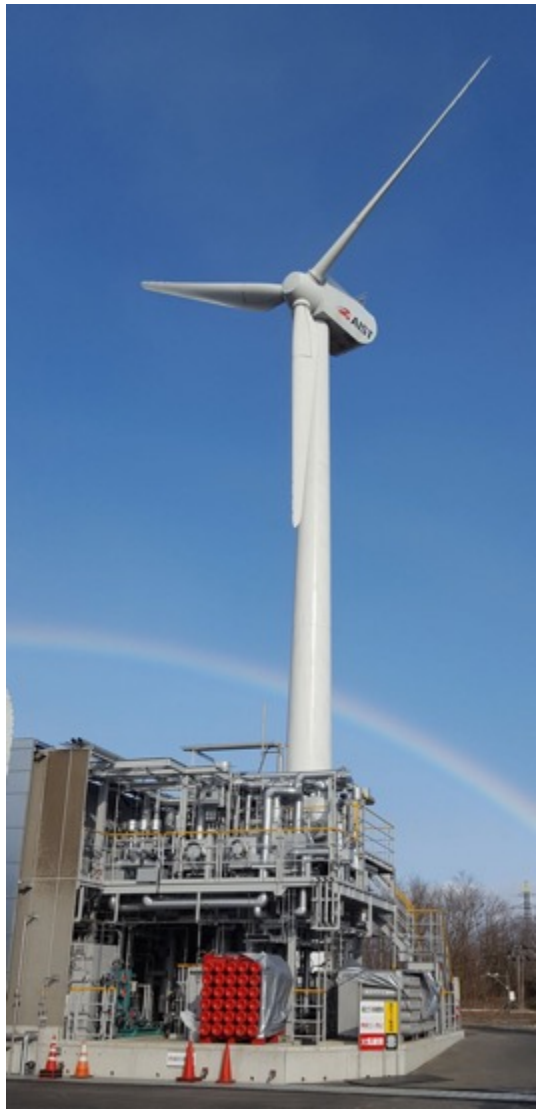
Summary

- JGC and AIST developed new ammonia synthesis catalysts and demonstrated its performance.
- Load changing operation with the prediction of hydrogen production can minimize the capacity of the hydrogen storage tank.
- PV-based green ammonia production meets the needs of ammonia in areas far from the ammonia supply chain.
- Low-cost renewable power and cost reduction of electrolyzer is essential to reduce ammonia production cost.



Thank you for your attention

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