Energy Transition & Energy Technologies:
Moving towards sustainable future in Denmark and Japan
22 November 2017 (Wed.)

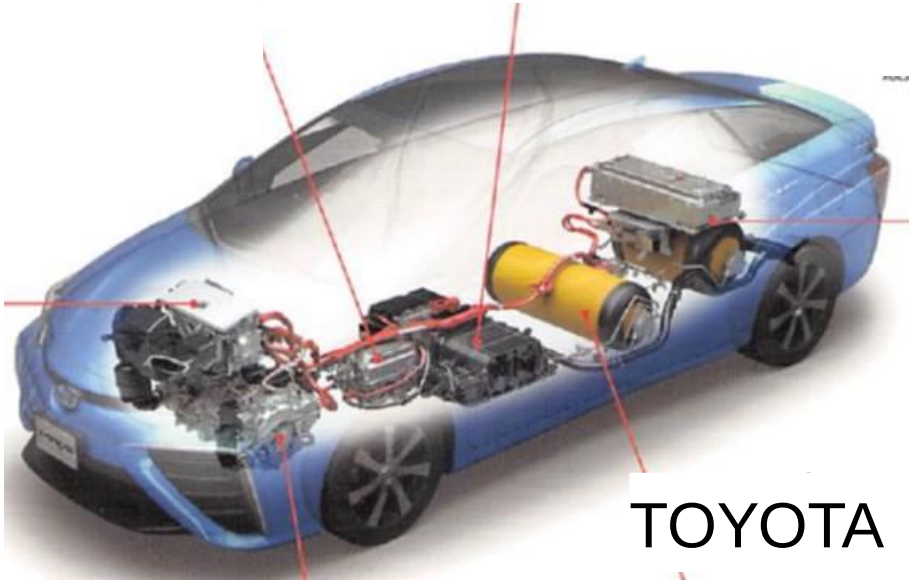
Recent topics of Hydrogen Energy & Renewable Energy in Japan

- Topics of Hydrogen Related Technology
- Hydrogen Generation using SC-Water
- ”Eco-Island“ Miyakojima, Okinawa
- Next step of Renewable Energy / Importance of Creativity Education

Dr. Haru-Hisa Uchida
Department of Environment Science,
School of Humanity and Cultures
TOKAI University

New Vehicles in Japan

- **FCEV Fuel Cell Electric Vehicle**
  - TOYOTA MIRAI、HONDA CLARITY
- **PHV Plug-in Hybrid Vehicle**
  - TOYOTA PRIUS
- **EV Electric Vehicle**
  - NISSAN LEAF



TOYOTA

FCEV ~60kWh

H_2 station ~100

114kW(3.1kW/L、2.0kW/kg, 37L, 56kg)

Ni-H, 34stack, 6.5Ah (0.3kWh)

H_2 tank: 70MPa 5.7wt% 3min 650 km/charge /4.3kgH_2

¥7,240,000 - ¥2,250,000 (support) = ¥4,990,000

PHV ~40kWh

125kW

(1.8L,72kW/5.2krpm+53kW E-motor(68.2km),37.2km/L)

Li-ion 8.8kWh, 53kW

200V/16A: 2h20m, 100V/6A: 14hr, 20min

¥3,700,000 - ¥350,000 (support) = ¥3,350,000

EV ~40kWh, 150kW

E-charge station ~7100 (Rapid)

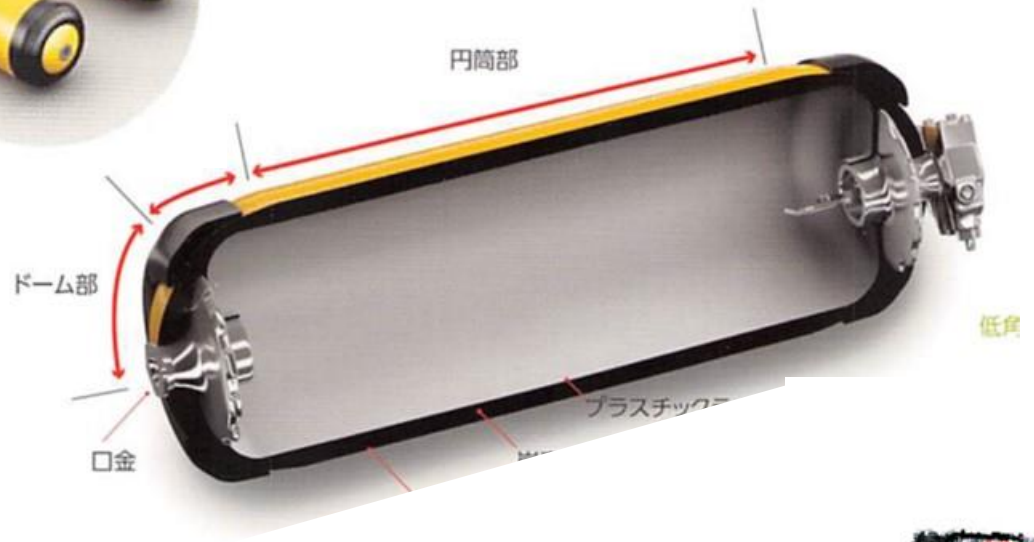
Li-ion

400km / charge 40min ~6km/kWh (1000km: ~¥2000)

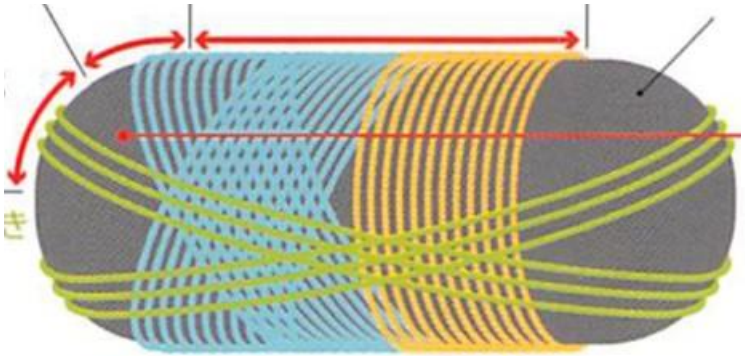
¥3,500,000 -

Topics of Hydrogen Related Technology

H_2 Tank



- 70 MPa
- 5.7 wt% H_2
- 122.4 L
  （60+62.4)L
- ~5.0 kg



TOYOTA “MIRAI” 2015.Feb.

insulator
+ Carbon Fiber Plastic
+ Glass Fiber Plastic

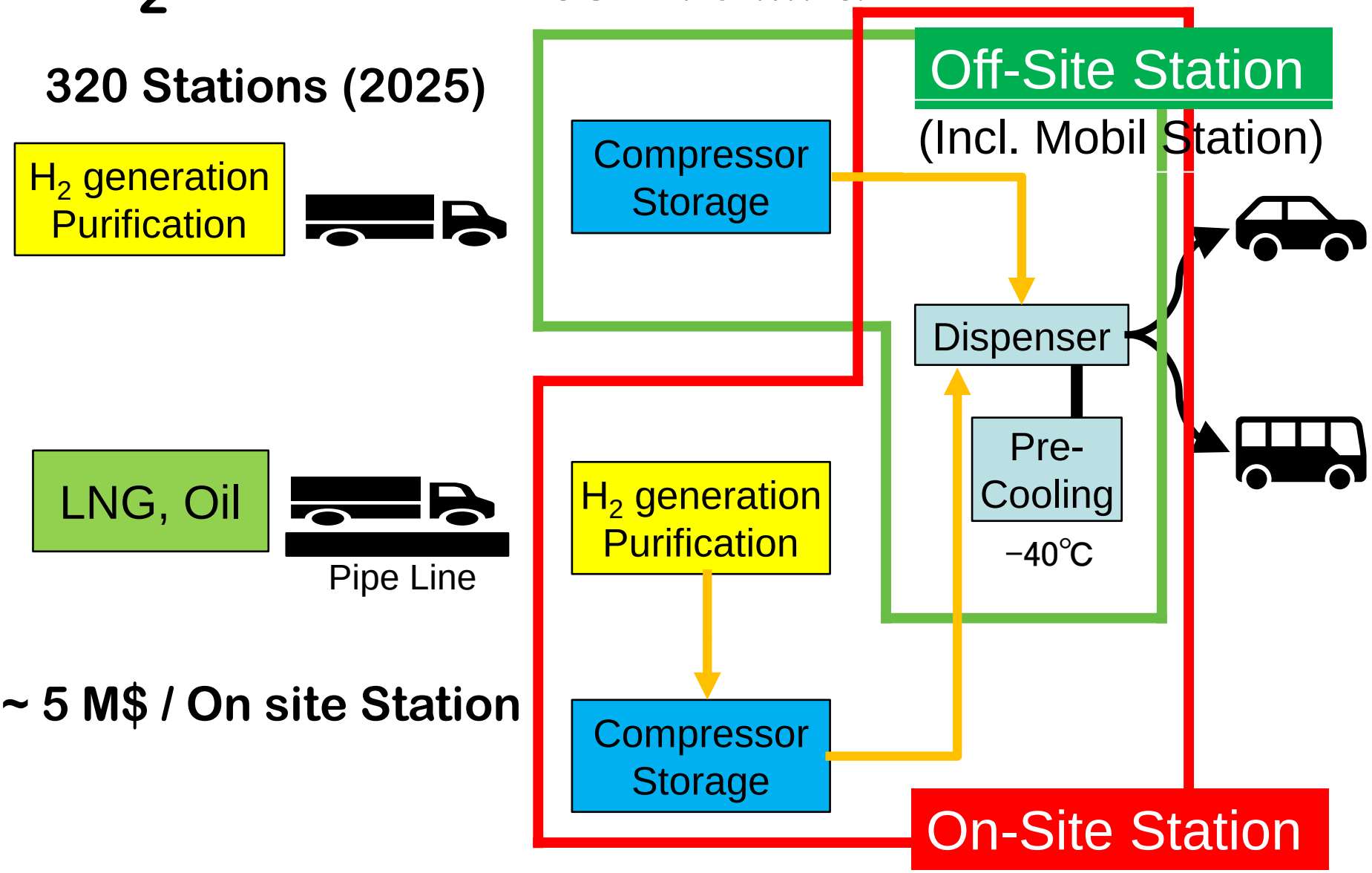
Topics of Hydrogen Related Technology

H_2 Station

320 Stations (2025)

35 ~ 70 MPa

¥1000 / kg H_2



~ 5 M$ / On site Station

H_2 Station, Ebina, Kanagawa Off-Site

ENEOS Nikko-Nisseki

Opened : 9:30～17:00
Closed : Saturday + National Holiday

H_2 Station, Mobile-Site

H_2 Station, Nerima, Tokyo On-Site

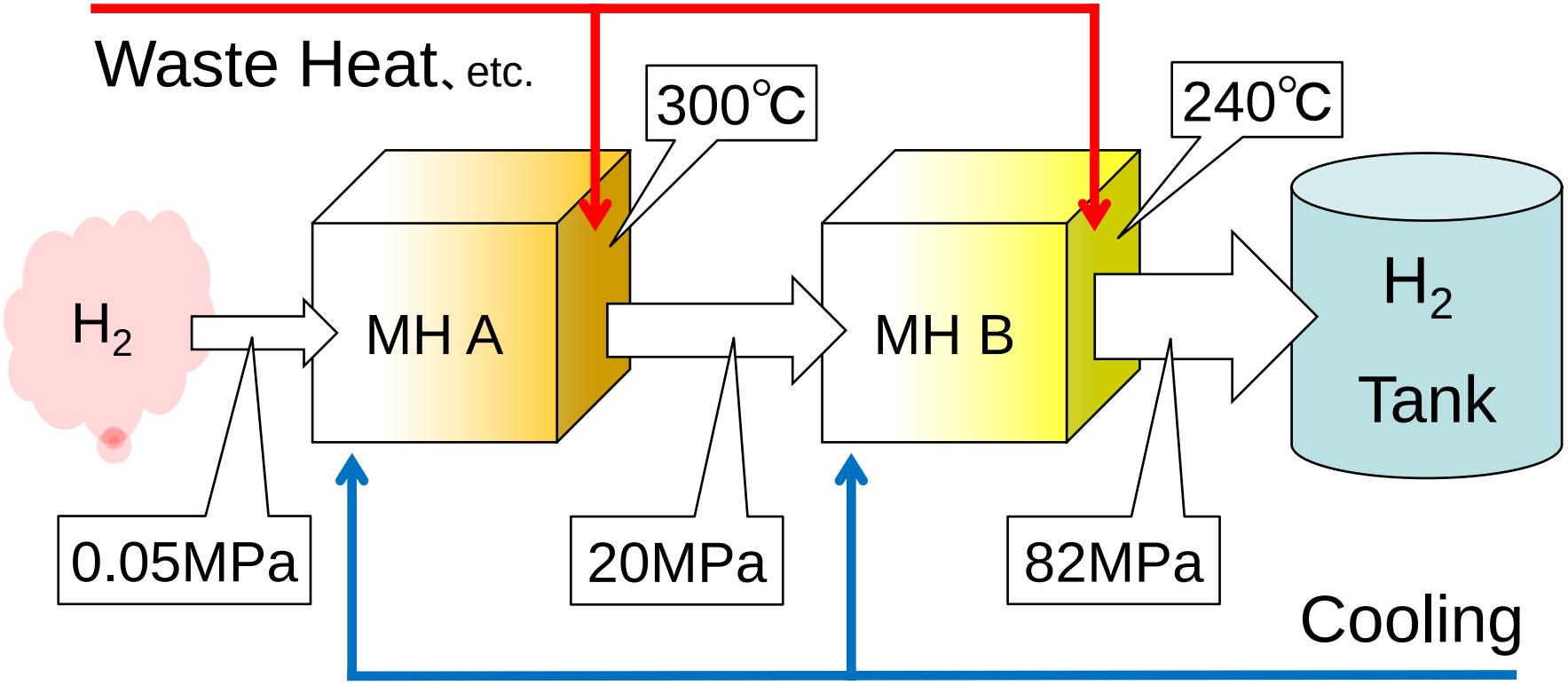
Opened : 13～15 hr Wednesday, Friday

Opened : 10～19 hr
Closed : Tuesday, Wednesday

Tokyo Gas

Topics of Hydrogen Related Technology

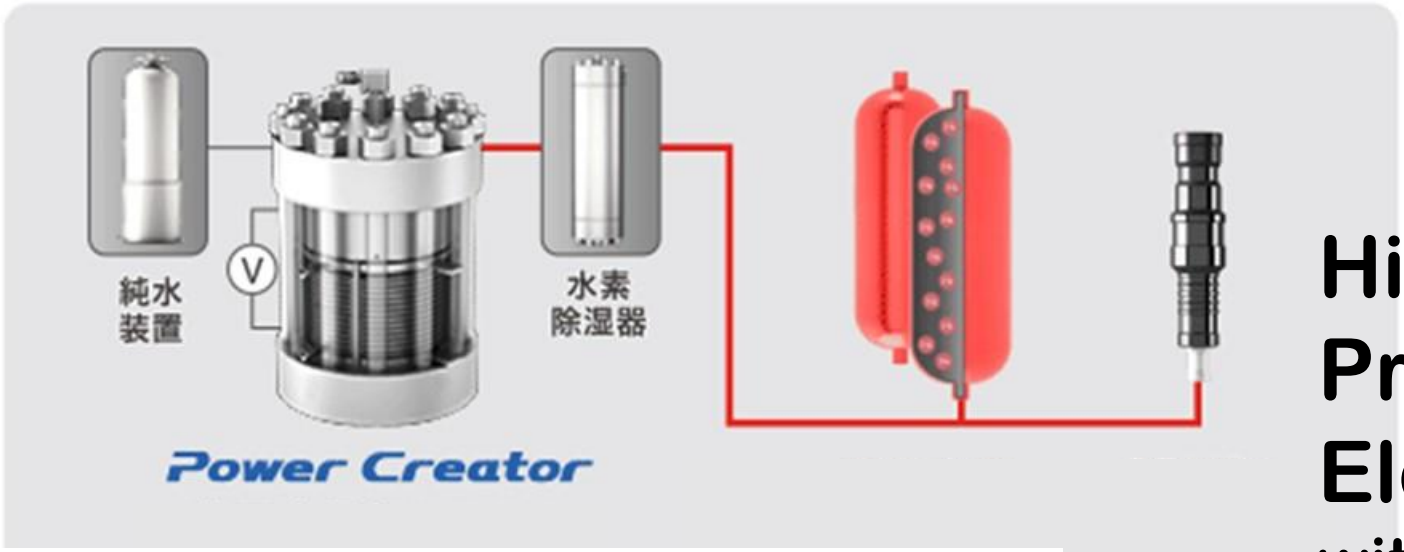
Chemical Heat Pump



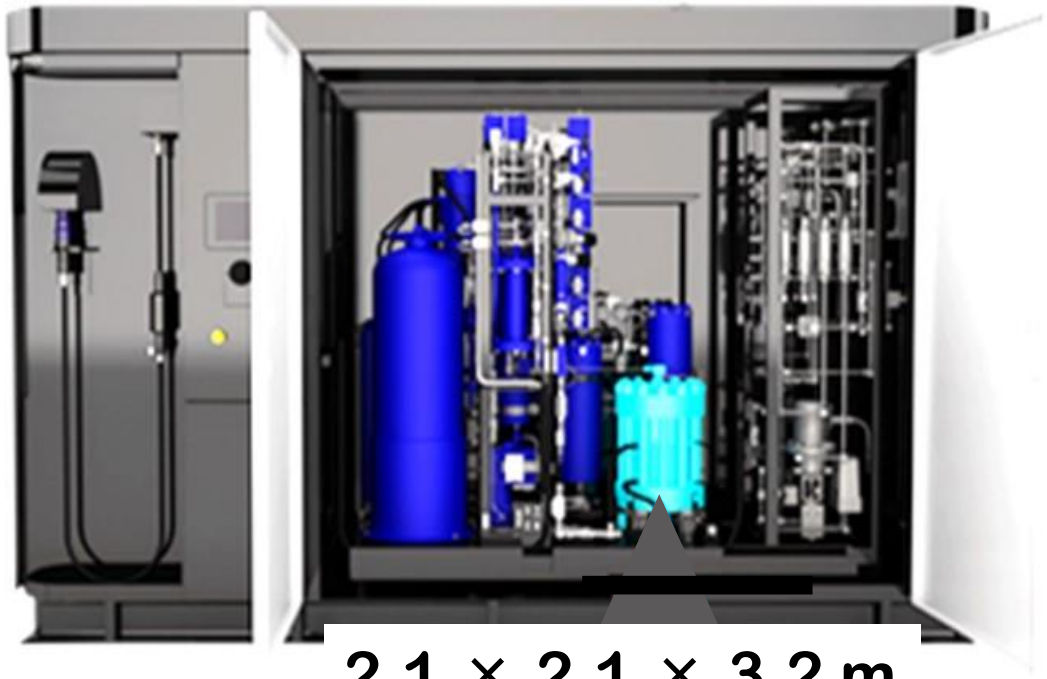
- Without compressor
- Safety
- Cost decreasing

Ichikawa et al., Hiroshima Univ.

Topics of Hydrogen Related Technology



High Pressure Electrolysis
without compressor



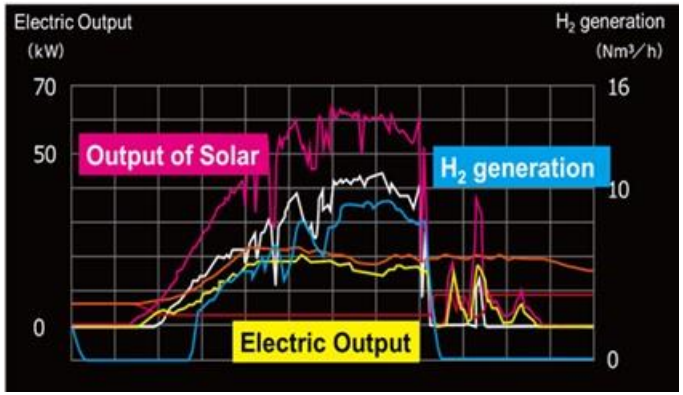
2.1 × 2.1 × 3.2 m

FCEV

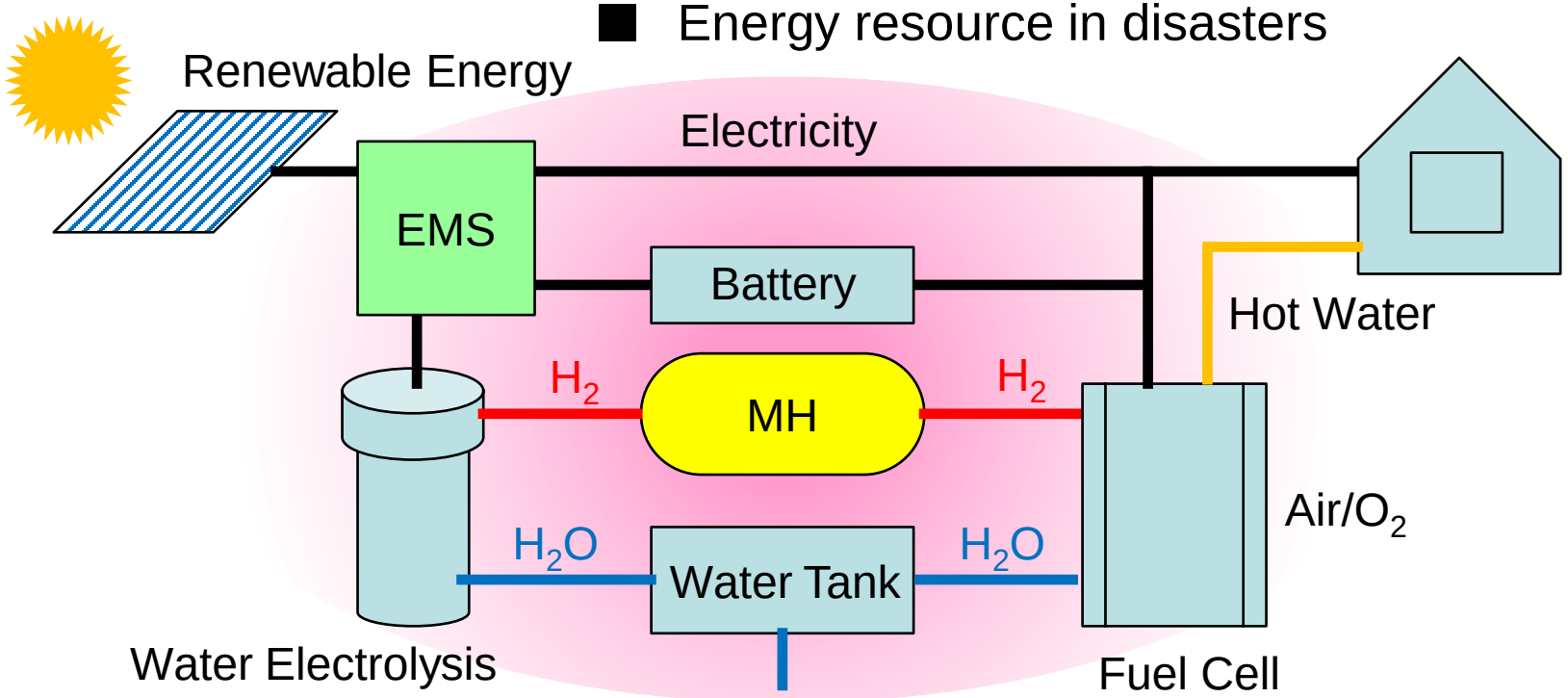
HONDA System

TOSHIBA

Solar-Hydrogen System



- Peak cut
- Energy resource in disasters



Roadmap to 2040 by METI

Ministry of Economy, Trade and Industry, Japan

- Saving Energy
- Energy Security
- Decreasing Environmental Load
- Industry Promotion, Regional Vitalization

2014 June 23
2016 March 22 Rev.

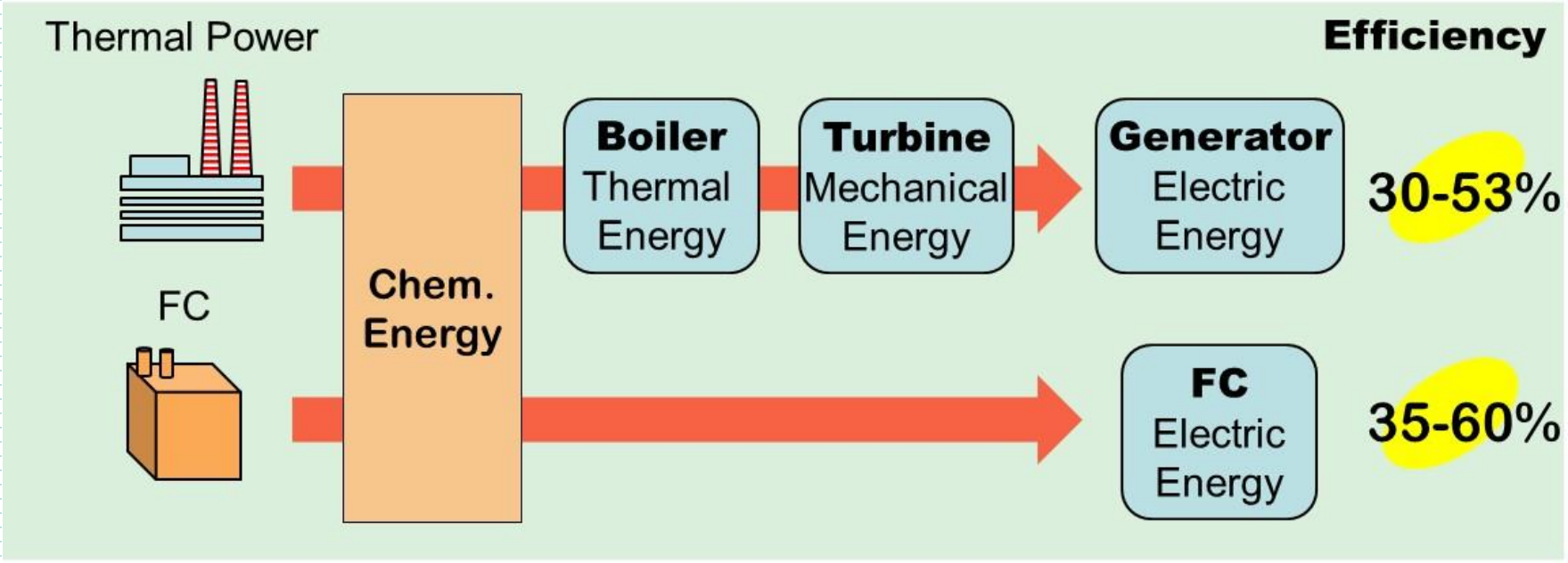
Phase 1 Dramatic enlargement of H_2 utilization Practical Installation of FC
~2020 PEFC 0.8MYen, SOFC 1MYen, H_2 cost ~ HV Fuel (~35km/L-G)
FCV 40,000 cars, 160 H_2 stations
~2025 FCV 200,000 cars, 320 H_2 stations
~2030 FCV 800,000 cars

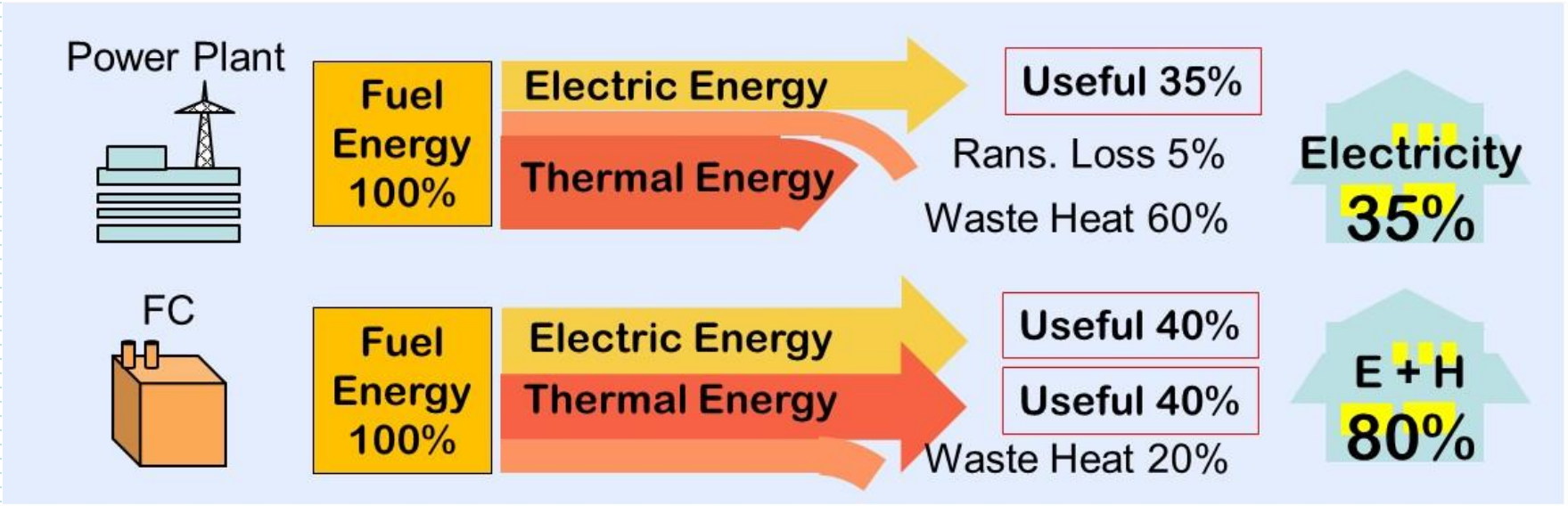
Phase 2 E-Power Plant by H_2, Large scale H_2 supply system
~2020 H_2 from abroad ¥30 / Nm^3
~2030 Large scale installation of H_2 supply and power generation

Phase 3 CO_2 free H_2 system
~2040 Large scale H_2 system with CCS
(generation, storage, transportation)

Efficiency of Fuel Cell

METI
NEDO

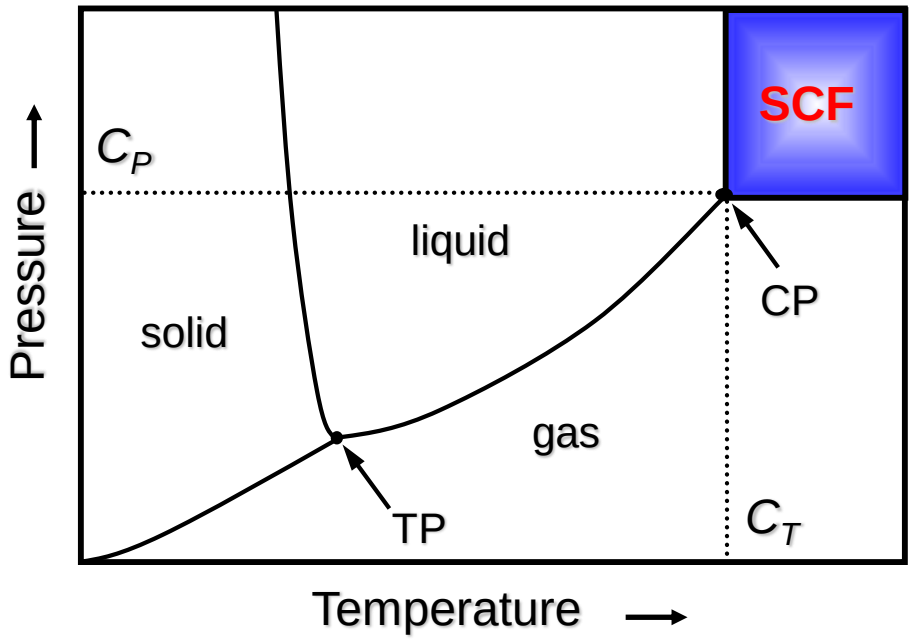




Super Critical State of Liquids

Table. Critical point of various liquids.
C_T: critical temperature ,
C_P: critical pressure

	C_T(K)	C_P(MPa)
H_2O	641.7	22.12
CO_2	304.1	7.83
CH_4	190.4	4.60
CH_3OH	512.6	8.09
CH_3CH_2OH	513.9	6.14



Phase diagram (schematic) of super critical fluid.

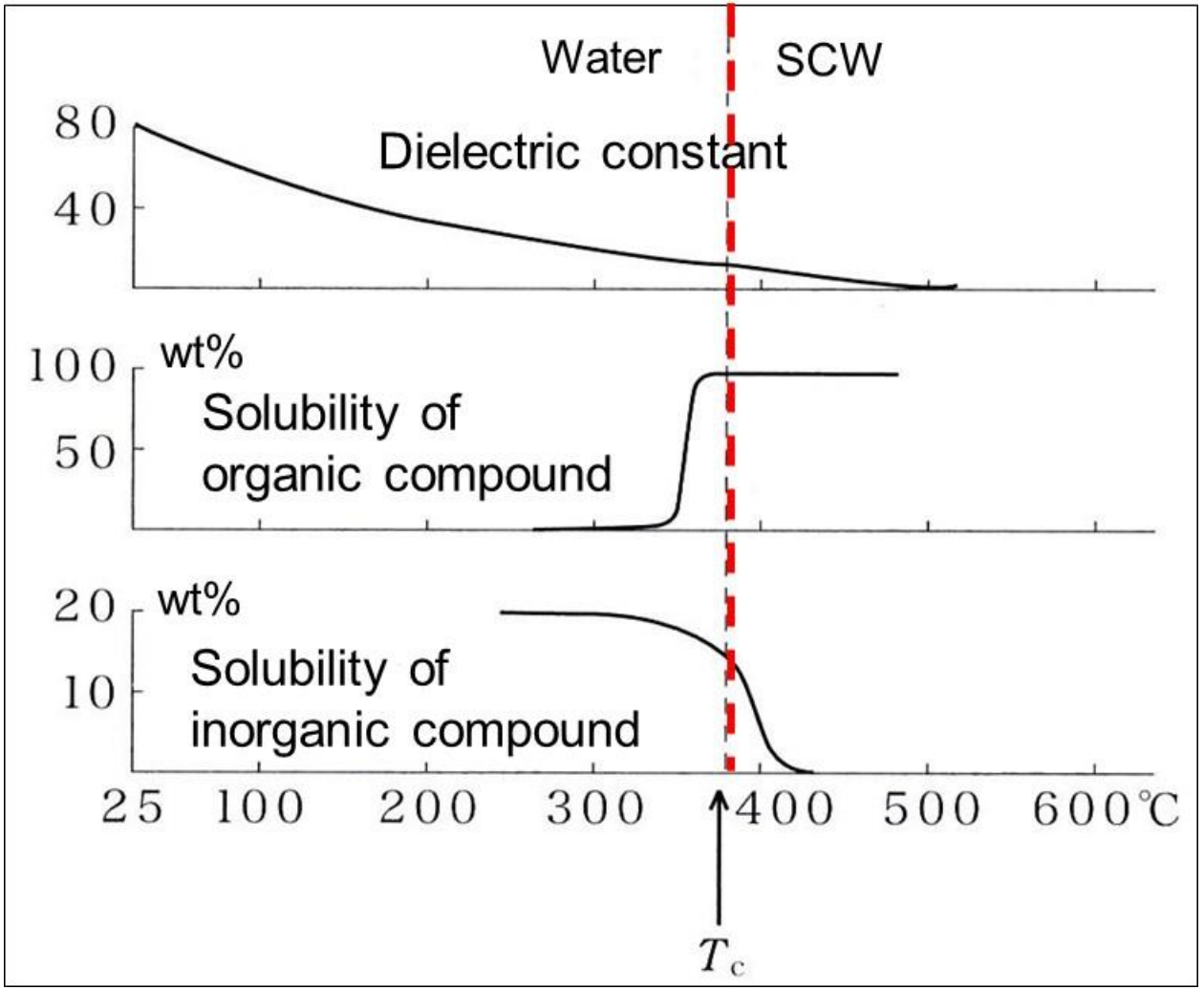
SCF: supercritical fluid state,
CP: critical point,
TP: triple point

Application of Super Critical Water

- Decomposition of organic materials
- Recycle of plastics

Super Critical State of Water

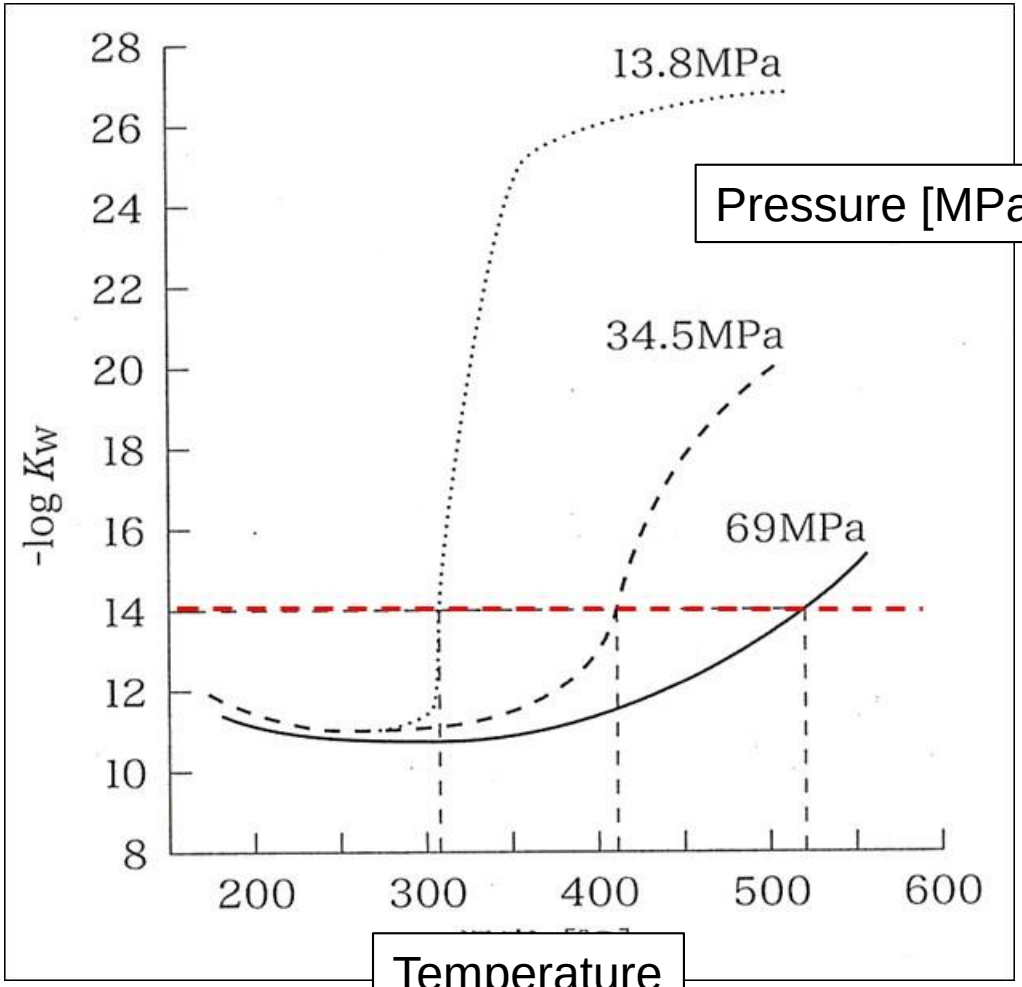
Temperature Dependence



Ref. Sako et al. ”Super Critical Liquid", AGNE, 2001

Super Critical State of Water

Ion products of water, Pressure and Temperature dependence



SCW experimental (continuous reaction)

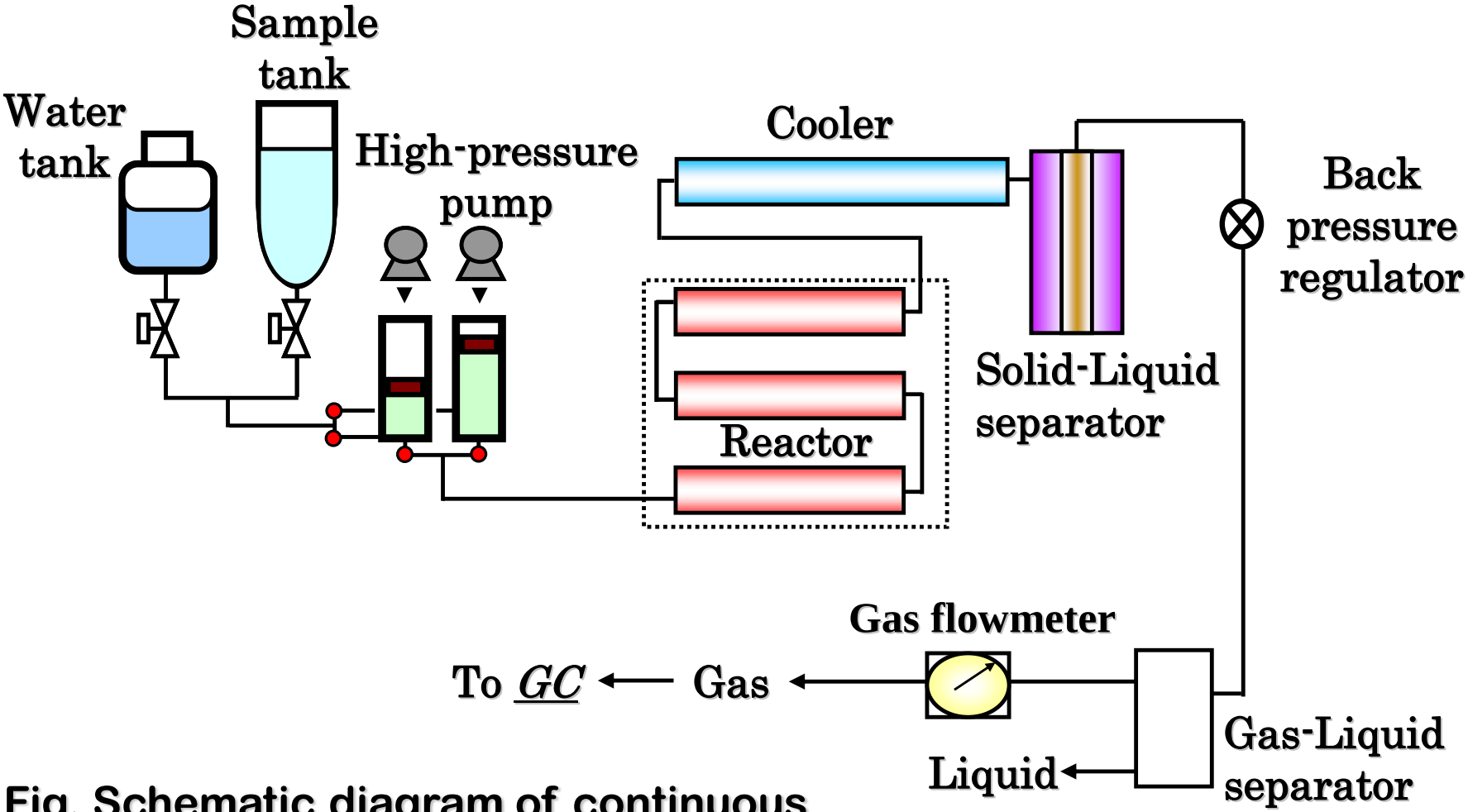
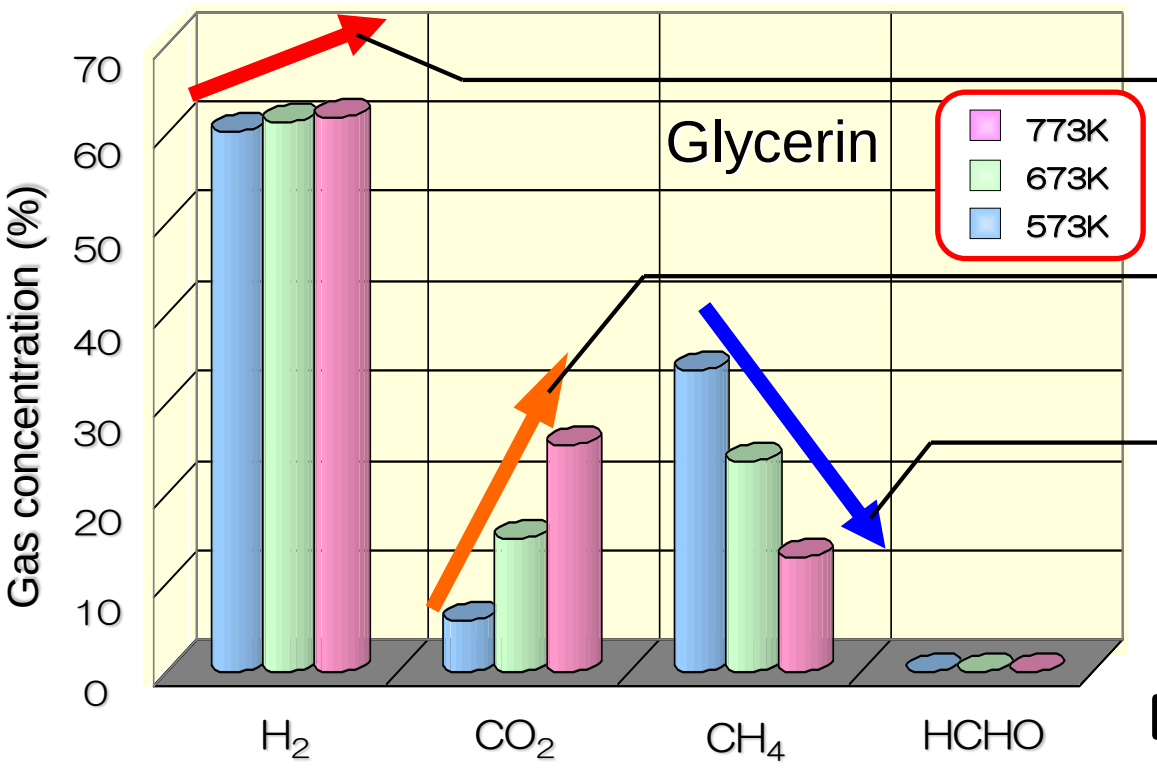


Fig. Schematic diagram of continuous SCW test equipment.
GC: Gas Chromatograph

Temperature dependence



Increasing Temp.,

Increasing H_2

Increasing CO_2

Decreasing CH_4

By increasing Temp,
$CH_4 \rightarrow H_2 + CO_2$

Fig. The concentration of gases from Glycerin decomposition.

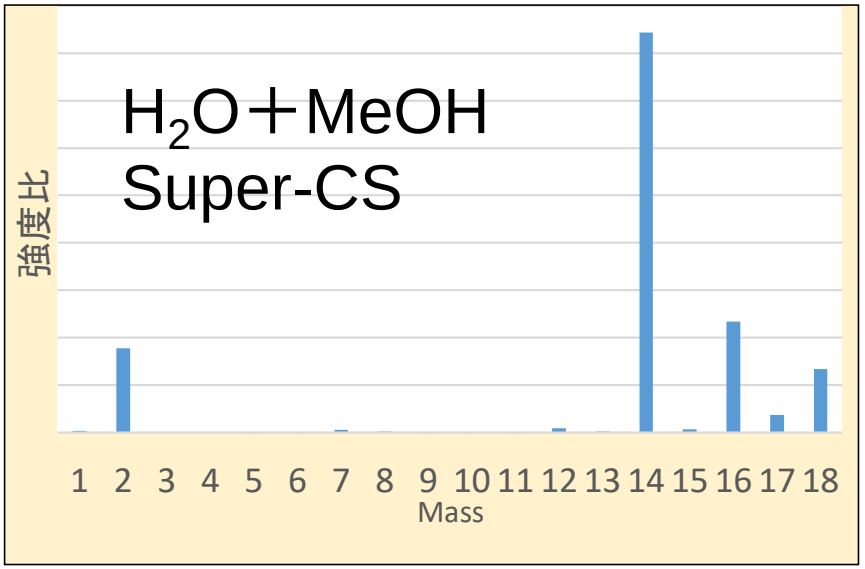
Condition
Press : 25MPa
Conc. : 1wt%
Time : 7.5min

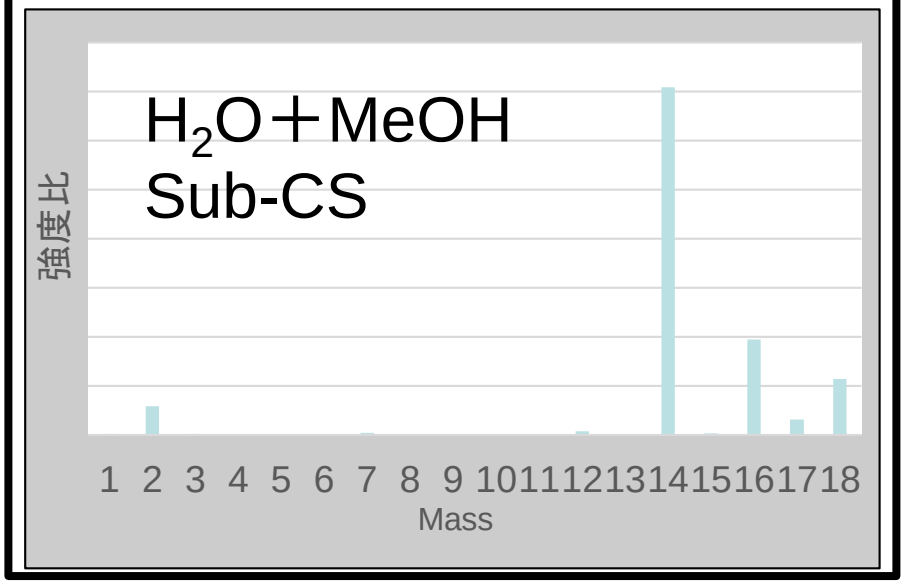
H_2 concentration ↑

Hydrogen Generation using SC-Water

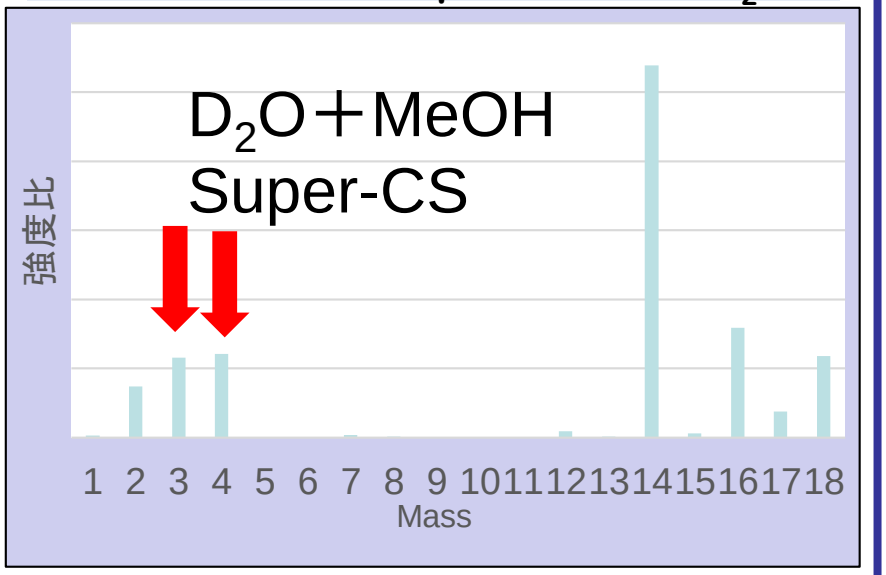
Experiments with Isotopes (H, D)

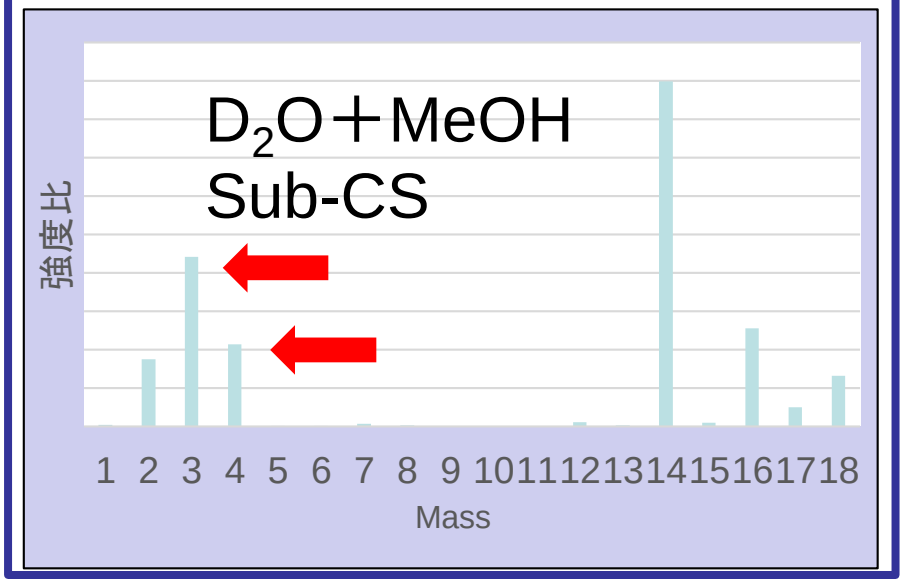
Methanol Decomposition with H_2O



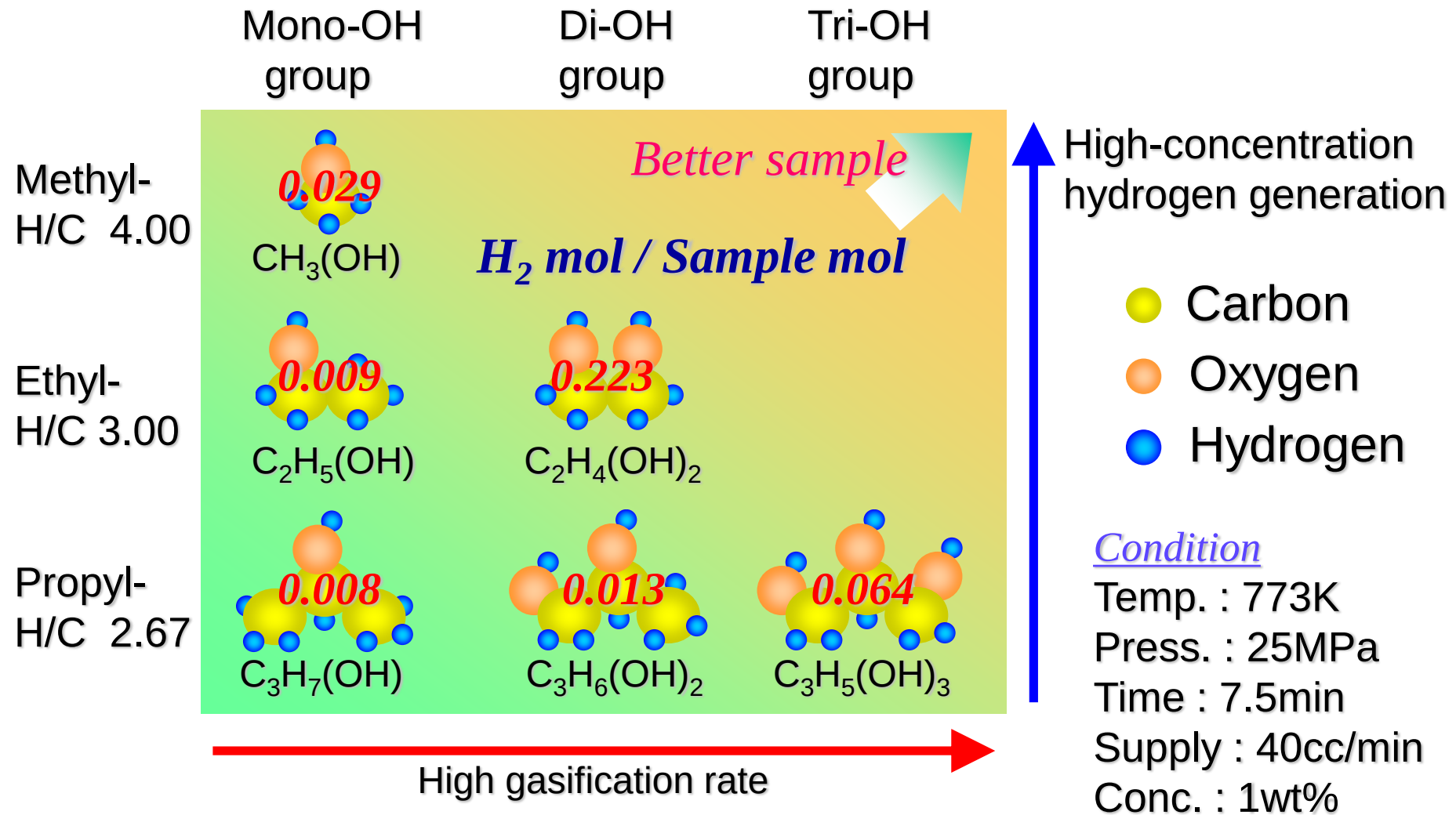


Methanol Decomposition with D_2O



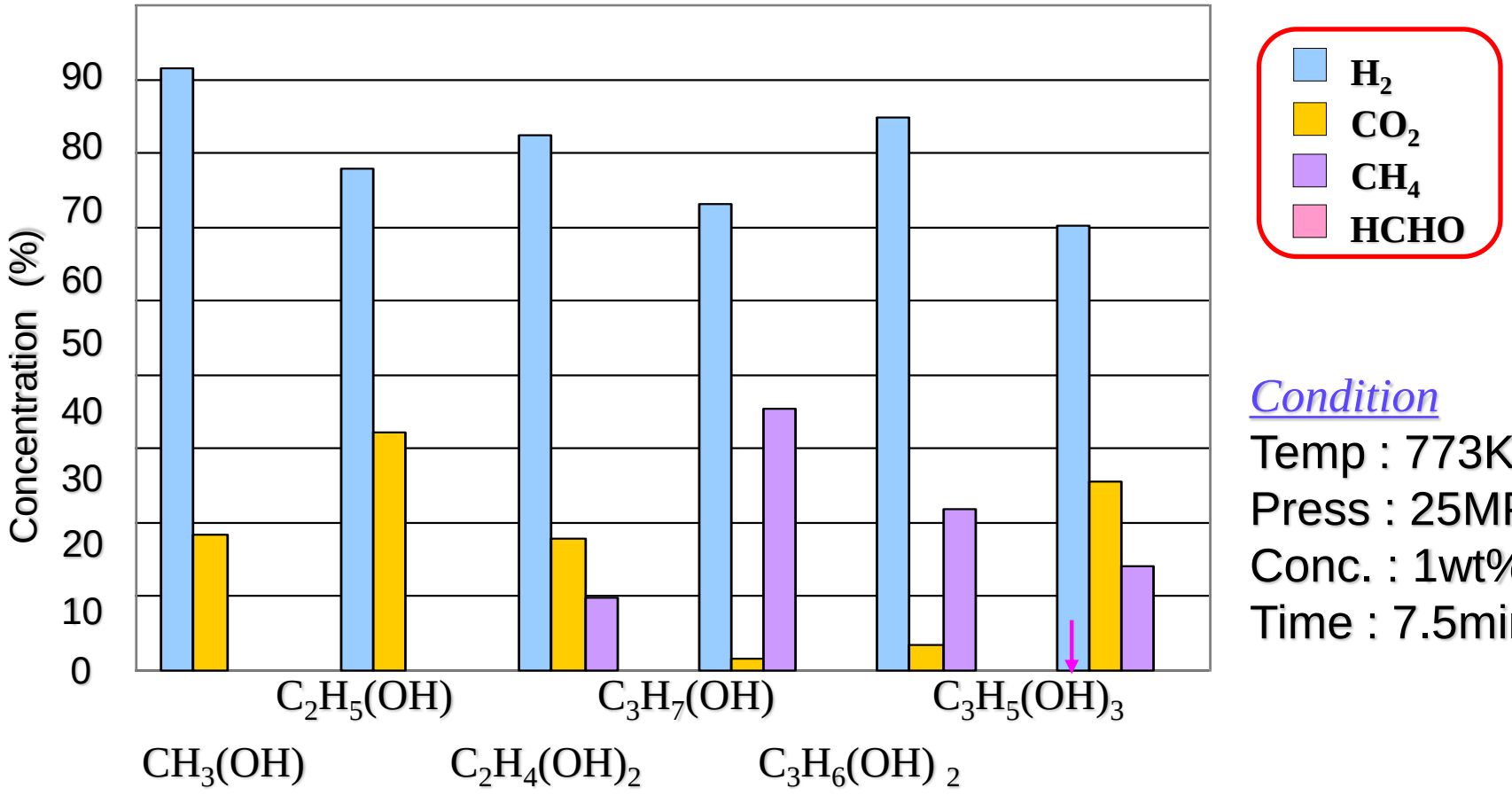


Systematic Experiments



Hydrogen Generation using SC-Water

Generated Gases （GC-TCD）



Condition

Temp : 773K

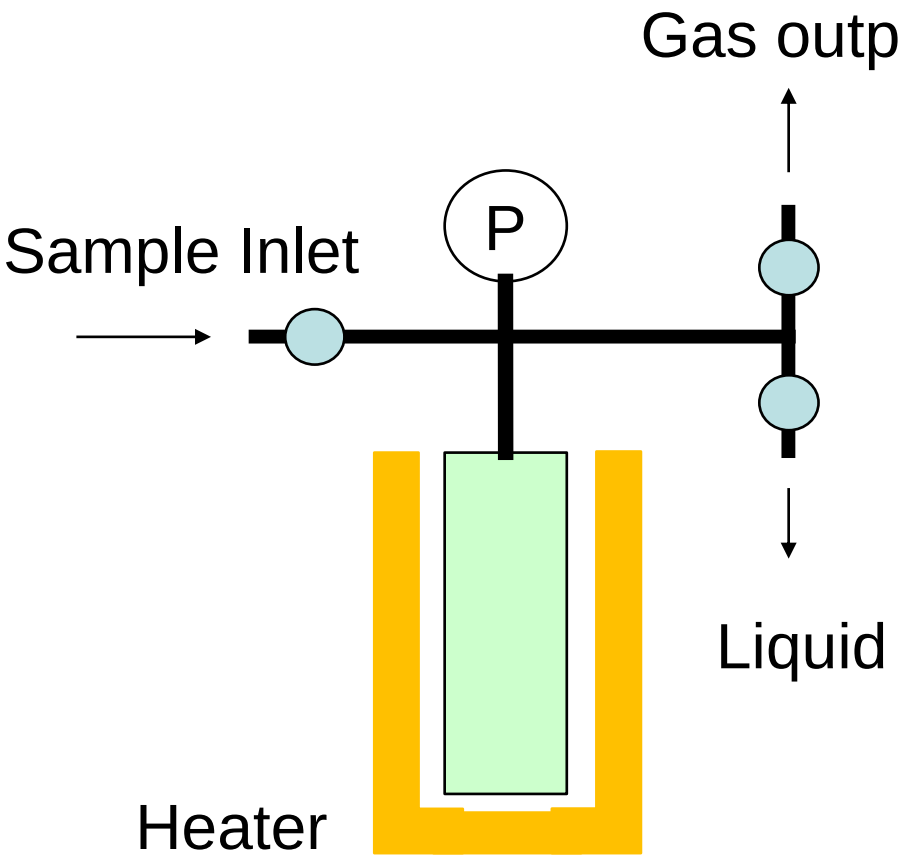
Press : 25MPa

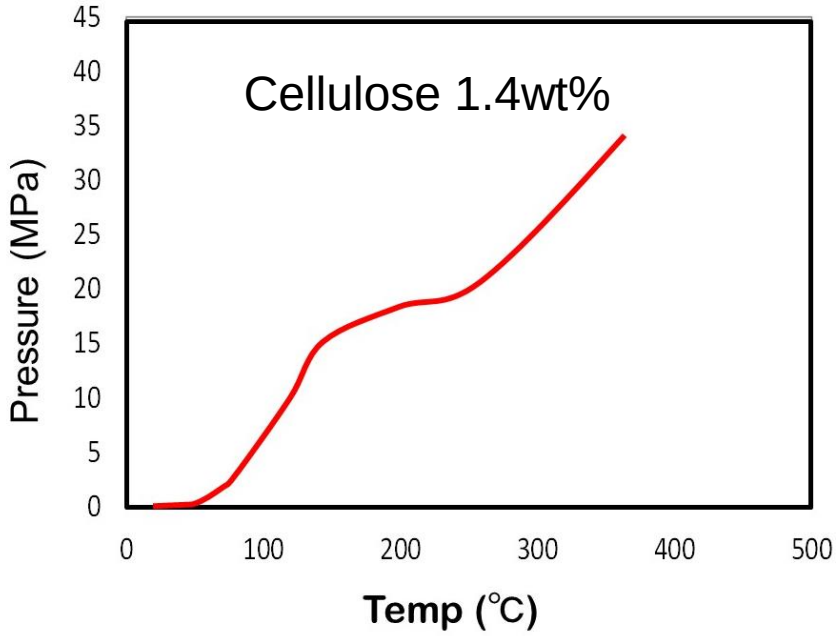
Conc. : 1wt%

Time : 7.5min

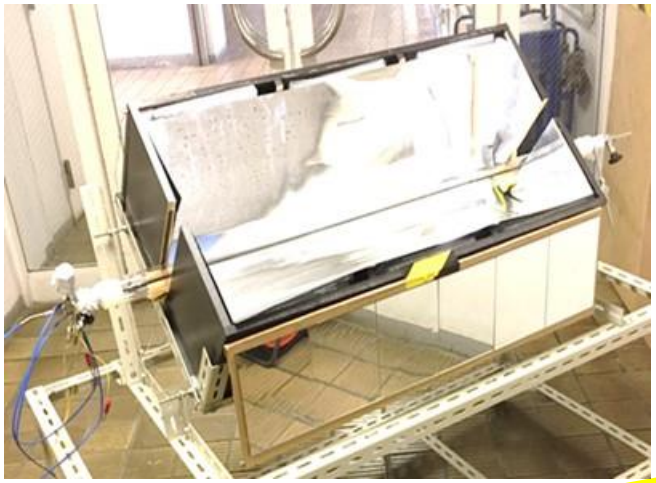
Fig. Concentration of gases from samples decomposed.

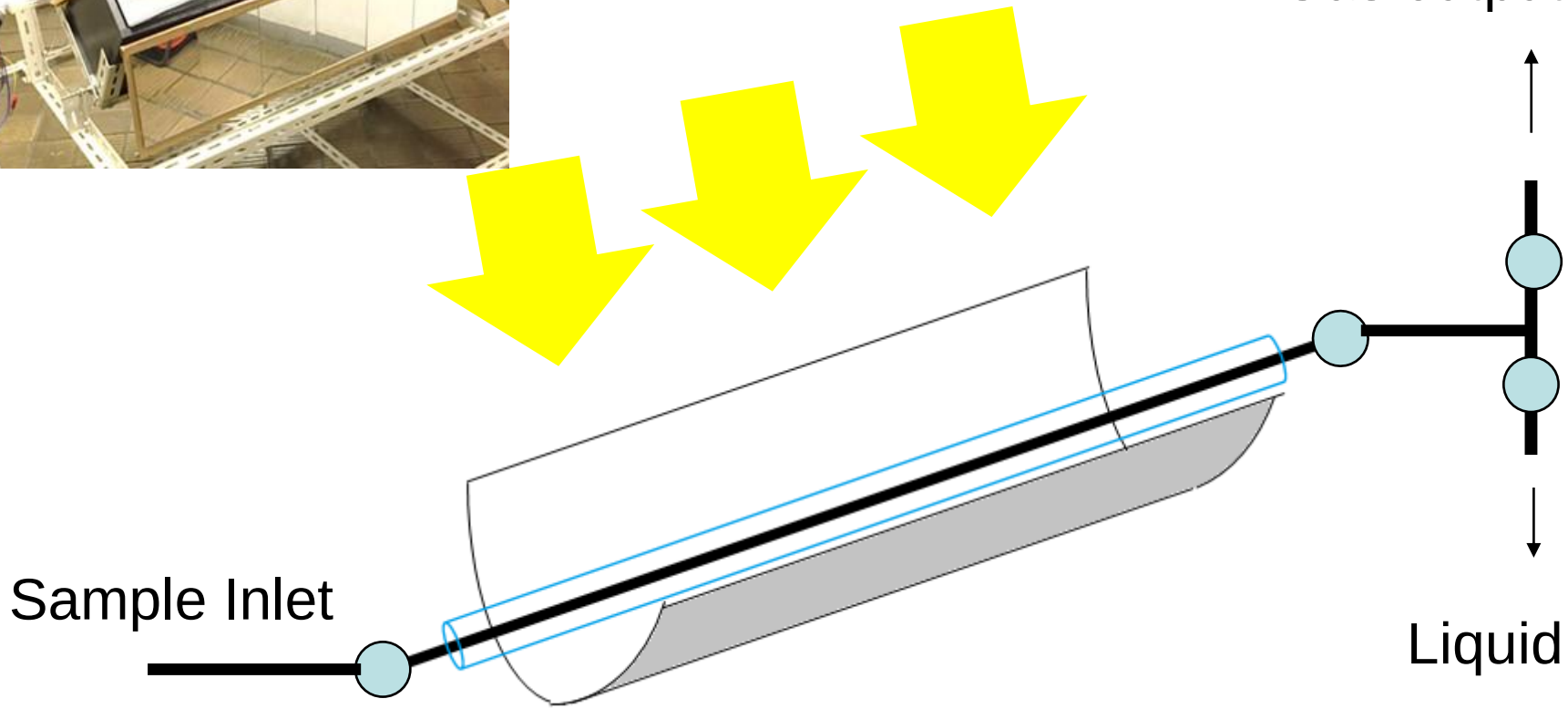
SCW experimental (closed reaction)



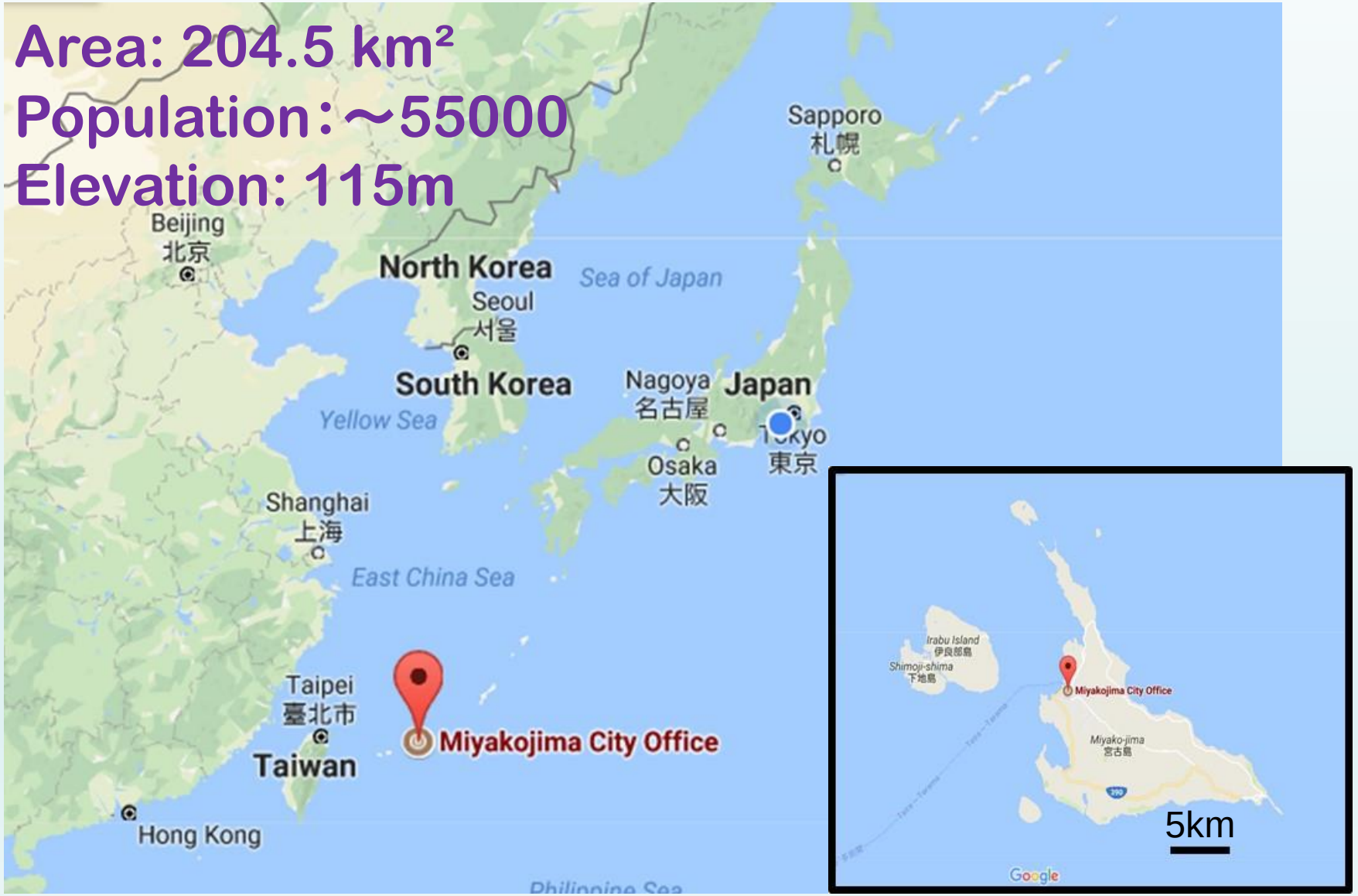


SCW experimental (closed reaction) With Solar Energy





Miyakojima Island



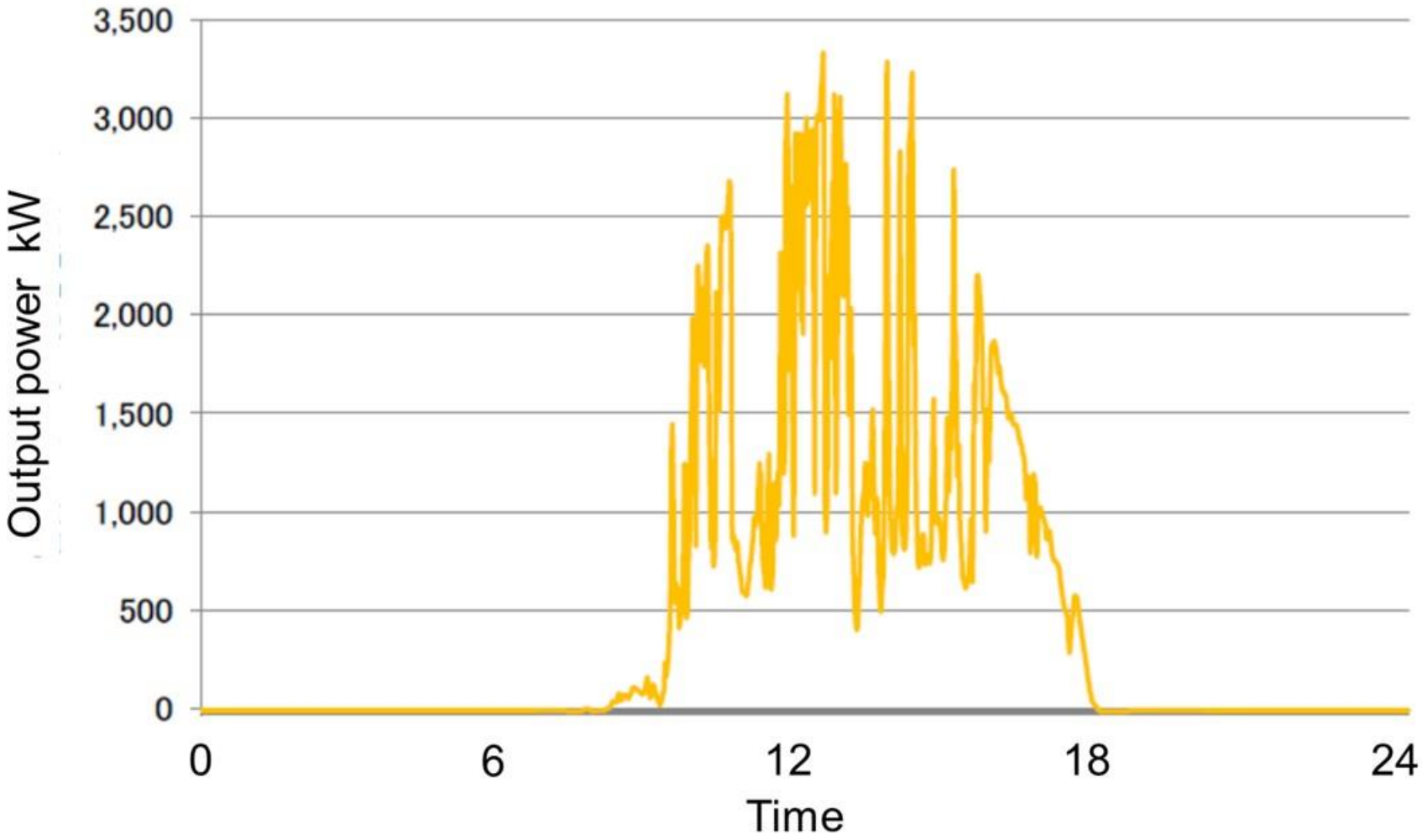
Eco-Island Miyakojima

Mega-Solar Demonstration Facility
4MW + NAS 4MW (28,800kWh)

+ > 4MW at private sector

Eco-Island Miyakojima

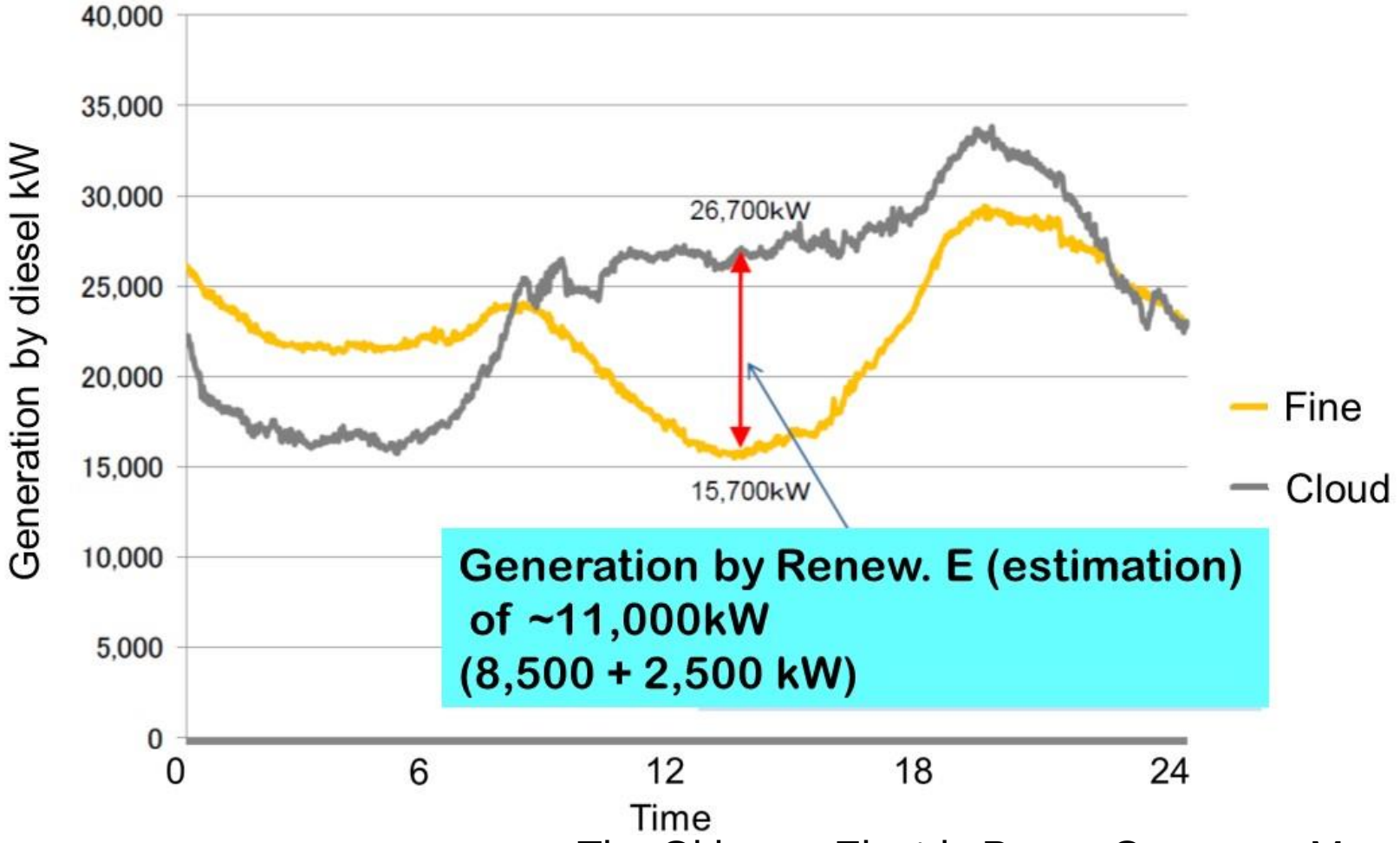
Ex. Generation of 19 Jan 2015 16.5℃



The Okinawa Electric Power Company, May 2014

Ex. Influence of weather

1.Jan 2014 (Fine weather with 8.8hrs sunlight 18.3C) and
21.Jan 2014 (Cloud with 0hr sunlight 14.3C)



The Okinawa Electric Power Company, May 2014

Ikema Island

Ohgami Island

Irabu Island

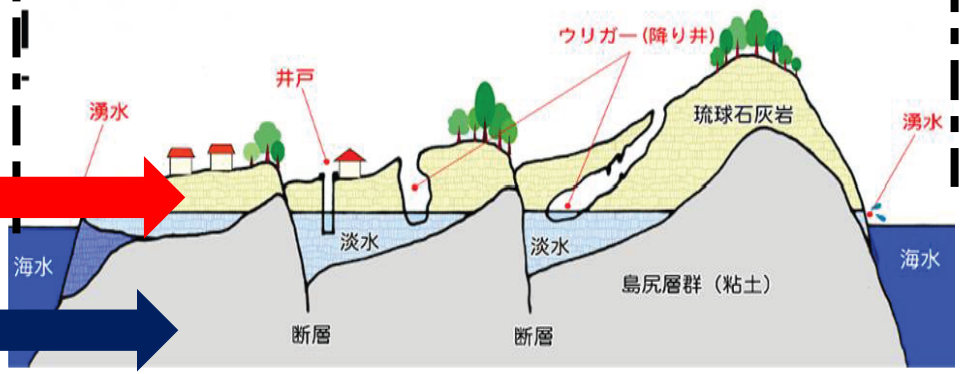
Shimoji Island

Kuruma Island

Miyakojima

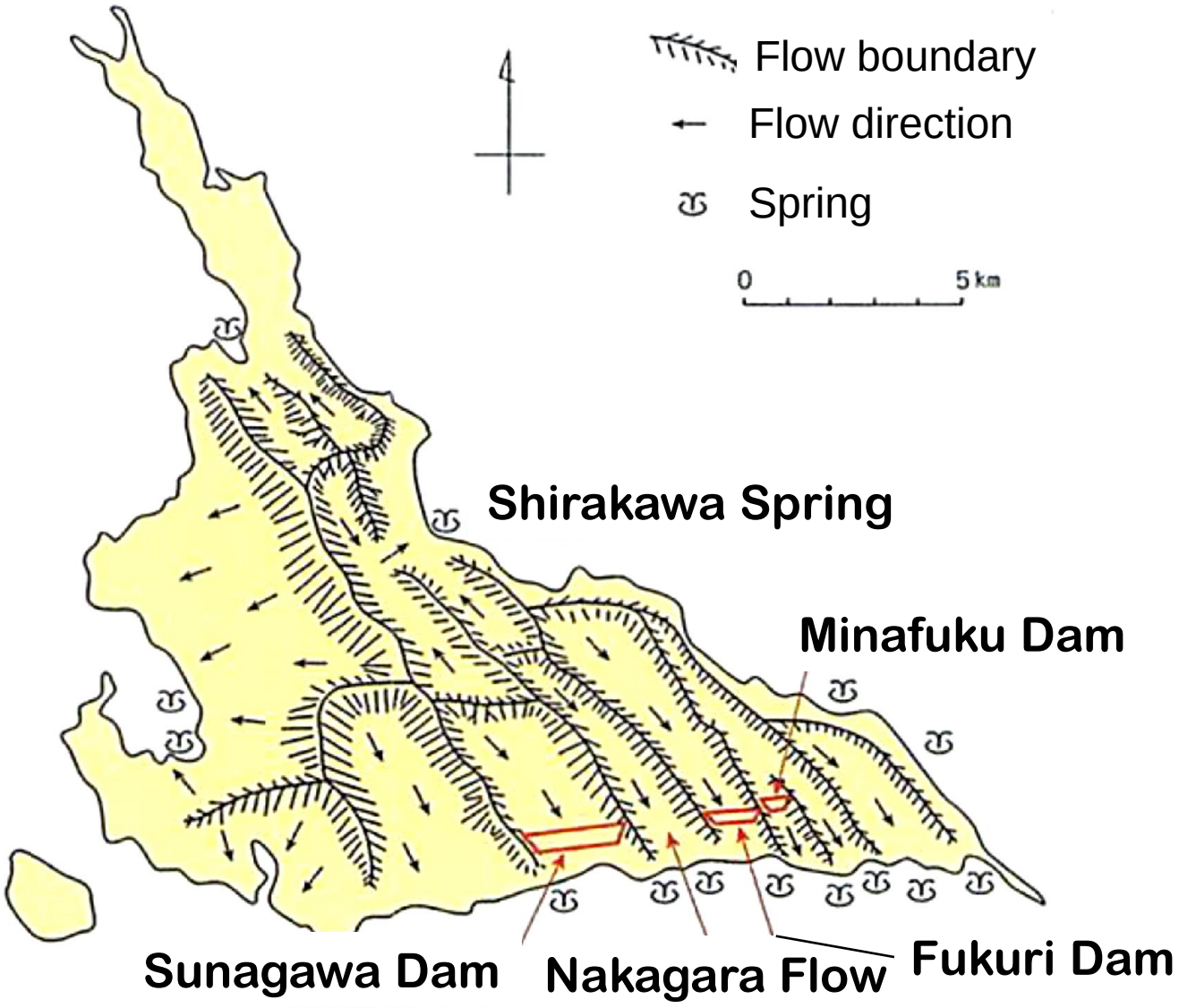
Porous Limestone Layer

Clay Layer



Eco-Island Miyakojima

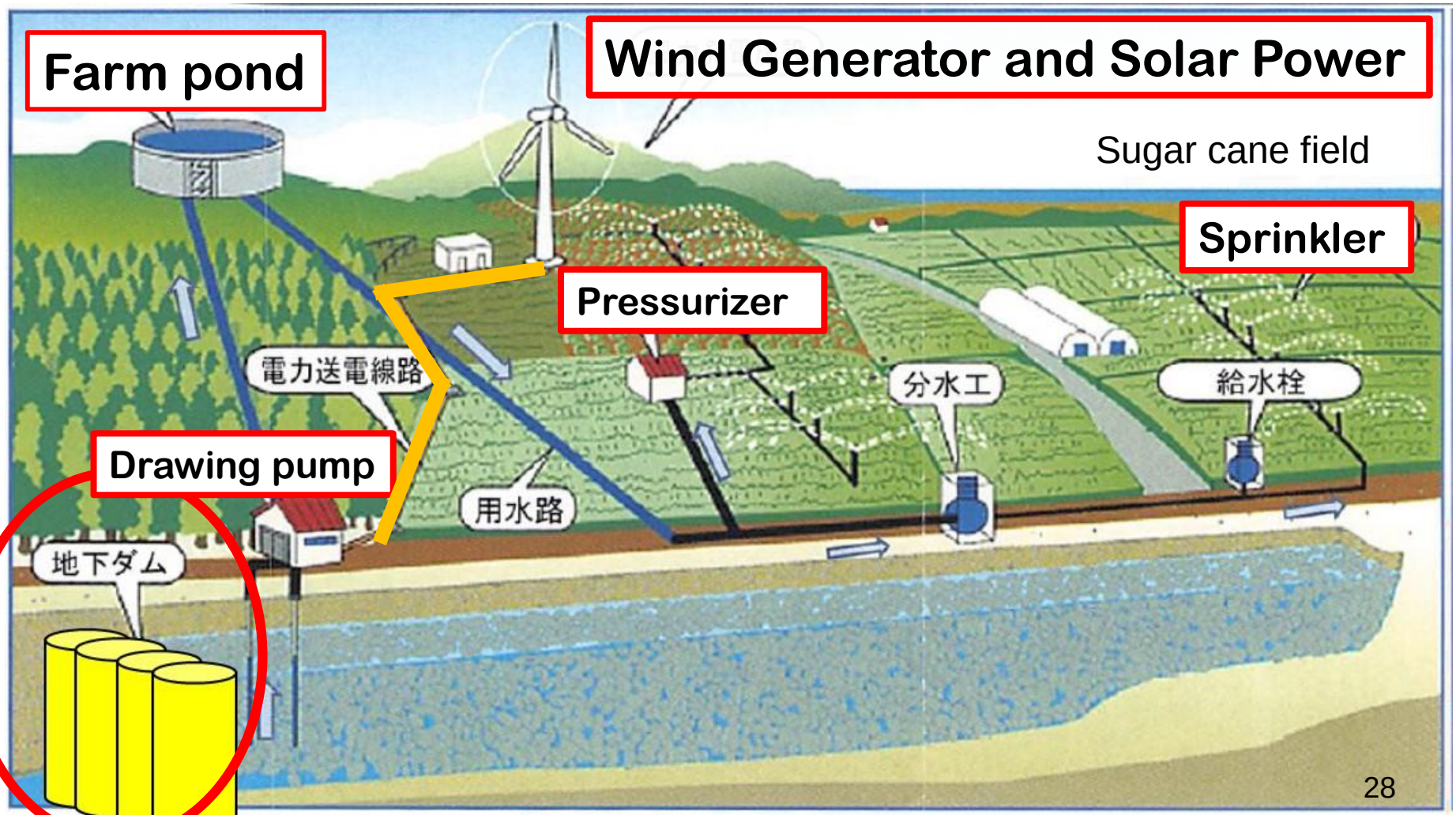
Underground Water Dam



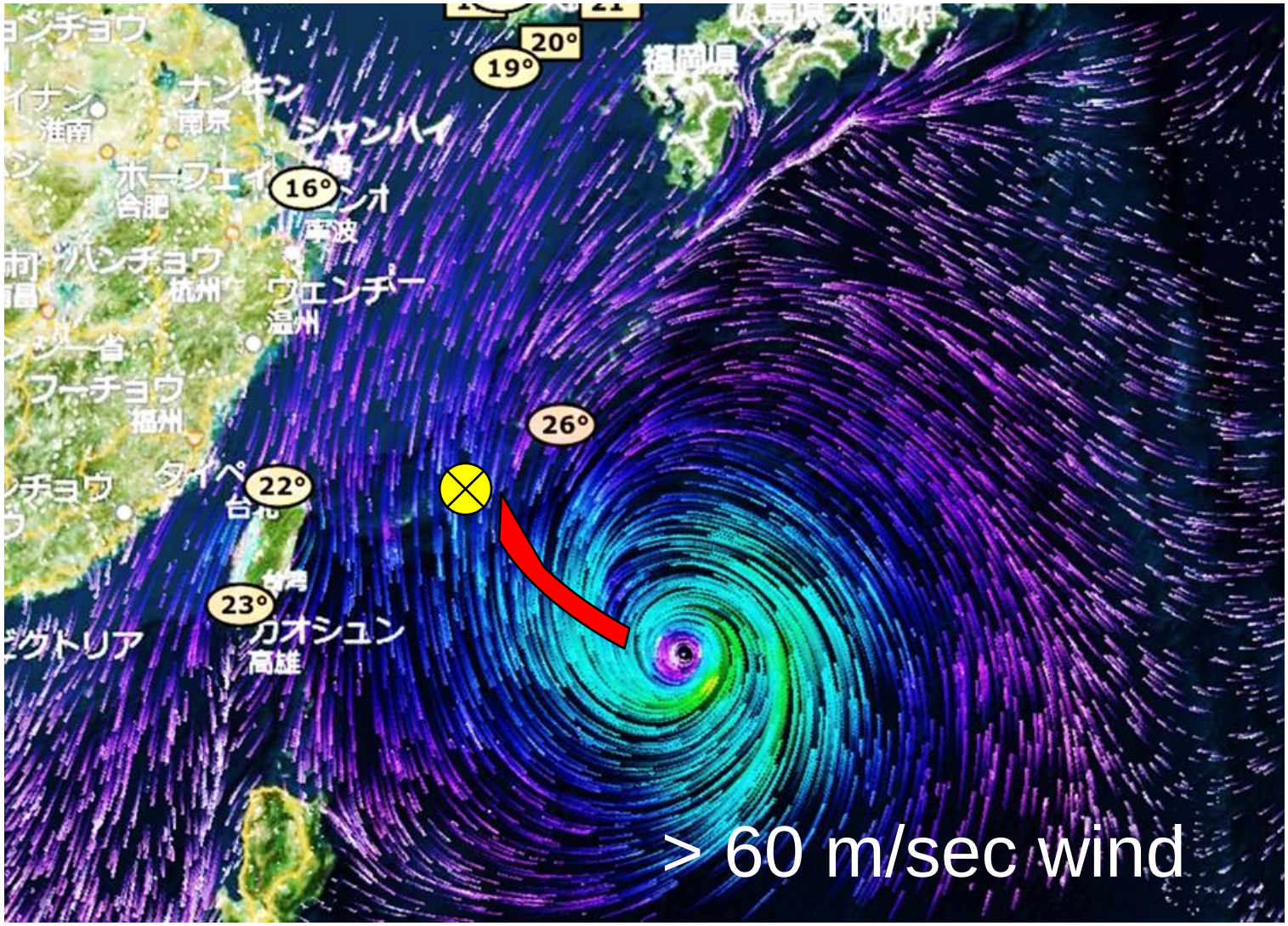
Eco-Island Miyakojima

1. Renewable energy system in Miyakojima

Linkage of underground dam



Renewable Energy in Disaster



Eco-Island Miyakojima

After passing typhon
15. Sep. 2017
Miyakojima

Eco-Island Miyakojima

Next step of Renewable Energy

Renewable Energy

Low Energy Density

Unstable

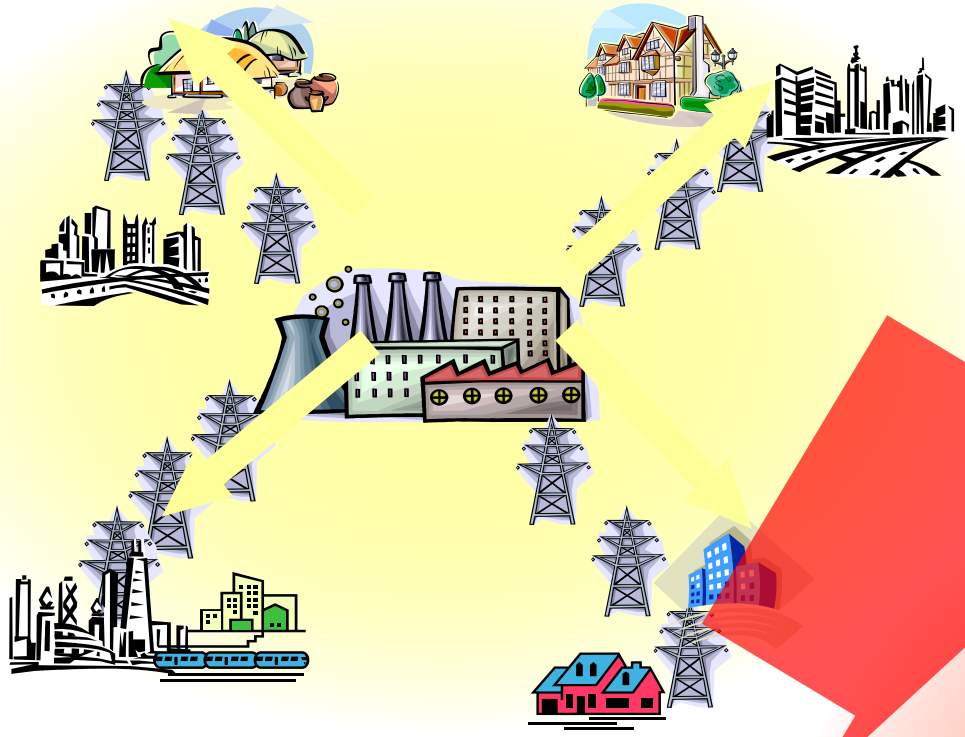
Huge Amount of Energy

Environment Friendly

Problems in Connecting Grid System

Necessity of Ideas and challenging mind

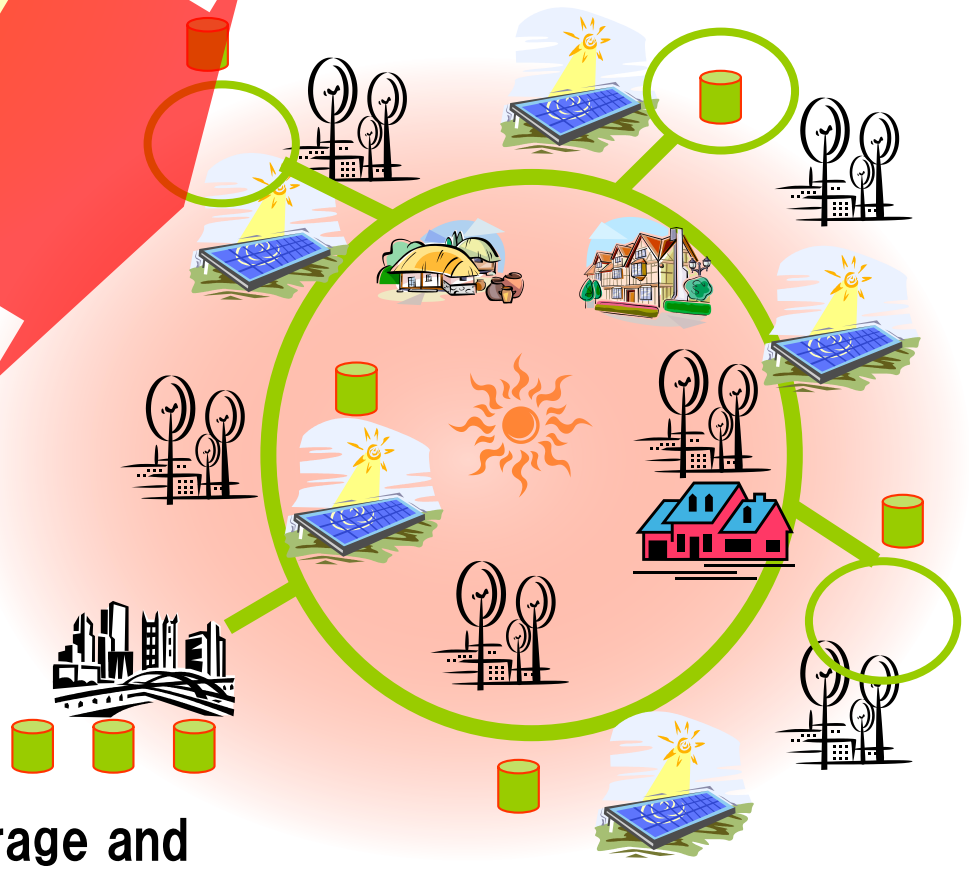
Next step of Renewable Energy



High power generating plant
Distribution through grids

Expectation to the renewable enrgy

Distributed generation
Adaptability and flexibility



Storage and

Concept of **Smart Grid**

Importance of Creativity Education

- Tokai Univ. – Intellectual Property Education:

"IP Education as Education in Creativity"

To foster humanistic people who are creative and able to contribute to building a more affluent and peaceful society.

- Creative, entrepreneurial, and a respective spirit
- Promoting IP culture
- Fostering talented people for coming new society

IP Education TOKAI Model

Kind.Garden Elem.Sch. J.H.Sch. H.School U.Grad. Graduate

Entrepreneurship Education (Vaassa Model)

Group working, Products thinking, Ideas, Venture Company

Intellectual Property Education (TOKAI Model)

(Copy Right) (Patent, Trade Mark) (IP law)
(Patent writing)

(Specialist at Law-School
(Fostering research fellows)

Creativity Education

Story telling Arts, Creative activity Discovering Engineering

Energy Transition & Energy Technologies:
Moving towards sustainable future in Denmark and Japan
22 November 2017 (Wed.)

Conclusions

- SCW may be used for H_2 generation from water including organic substances.
- Renewable energy should be utilized and increased under considering and using the natural future of the area.
- There, the system should be designed and constructed with also considering disasters.
- For the next step to the sustainability, plenty of new ideas and challenging mind are important for all.