# Innovation in Energy Storage for Renewables Integration

Deepdive Session: Energy Storage & Electric Vehicles

IRENA Innovation Week

"The Age of Renewable Power"

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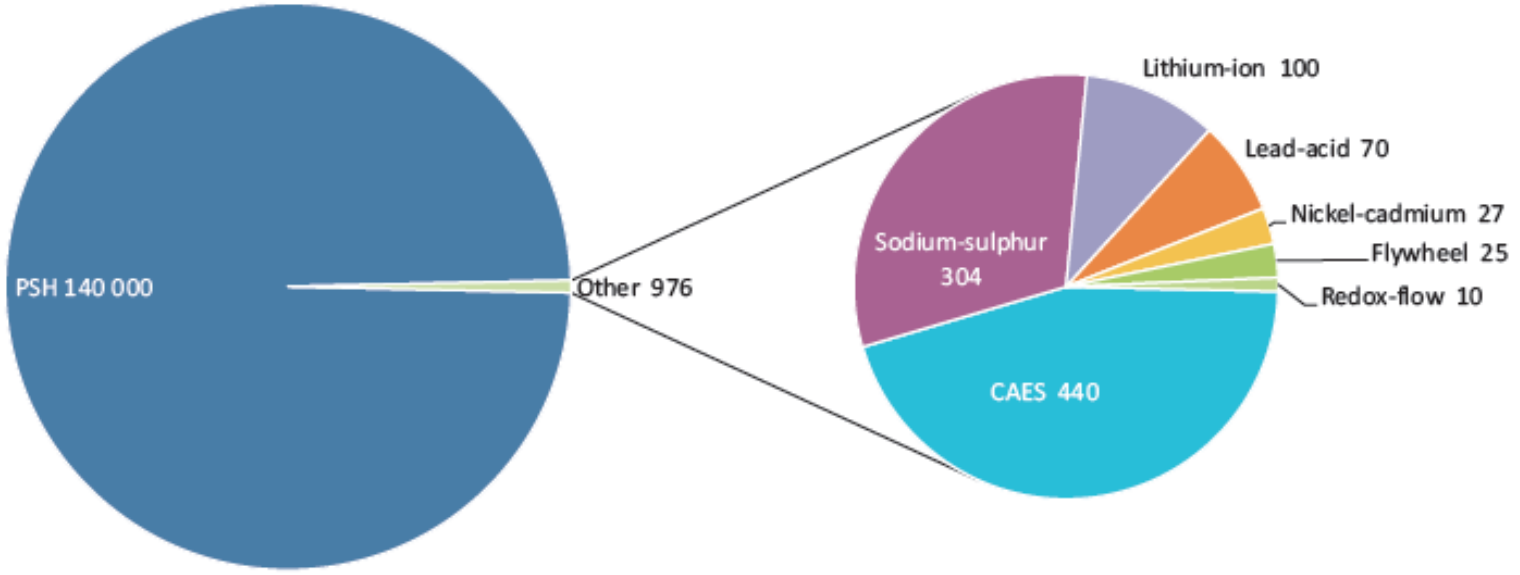
# Features of Grid Integration Measures

| Measures | Features and Challenges |
|---|---|
| Dispatchable generation | ✓Necessary in any case<br>✓Incentive to keep dispatchable generation |
| Strengthening transmission lines | ✓Huge investment cost<br>✓Long lead time, land expropriation |
| Curtailment | ✓Reasonable only if small amount is curtailed<br>✓Control technology, protocol, compensation |
| Energy storage | ✓Pumped hydro is a candidate<br>✓Battery is still expensive<br>✓Thermal storage is also expected |
| Demand side measures<br>*(that uses storage technologies)* | ✓Low cost (?)<br>✓Feasibility and potential should be evaluated |
| Power to Gas (hydrogen, SNG)<br>*(that has storage characteristics)* | ✓High cost presently<br>✓Long period storage<br>✓Gas can be used for multiple purpose<br>✓Long term perspective |

# World Energy Storage Technologies Today

- CAES is largest other than pumped hydro. However, only two (Germany and the USA) are operating.
- Japan is pumped hydro rich country, 27GW out of 140GW world total.

## Share of Electricity Storage (grid-installed)

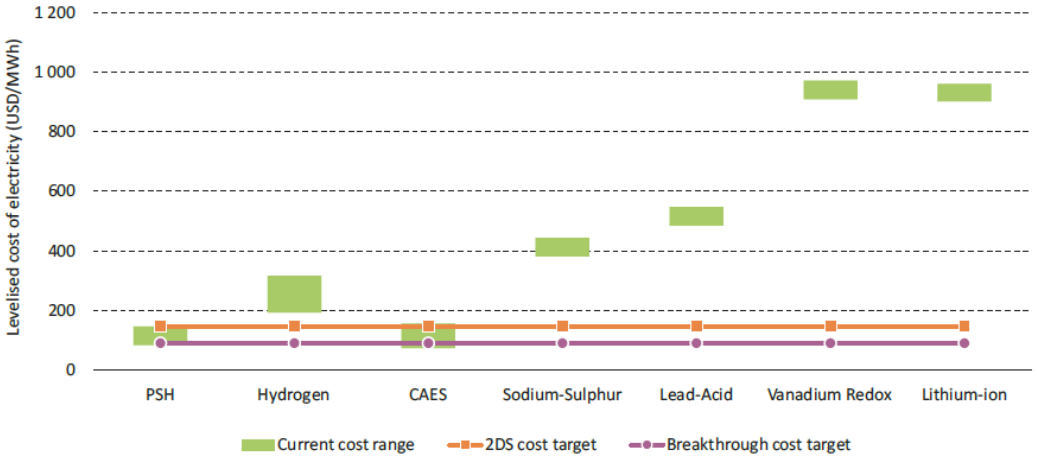



Source: ”Technology Roadmap, Energy storage”, IEA

# Cost of Battery

- The cost of batteries still needs to be reduced substantially, compared with other technologies.

## Current Cost and Cost Target



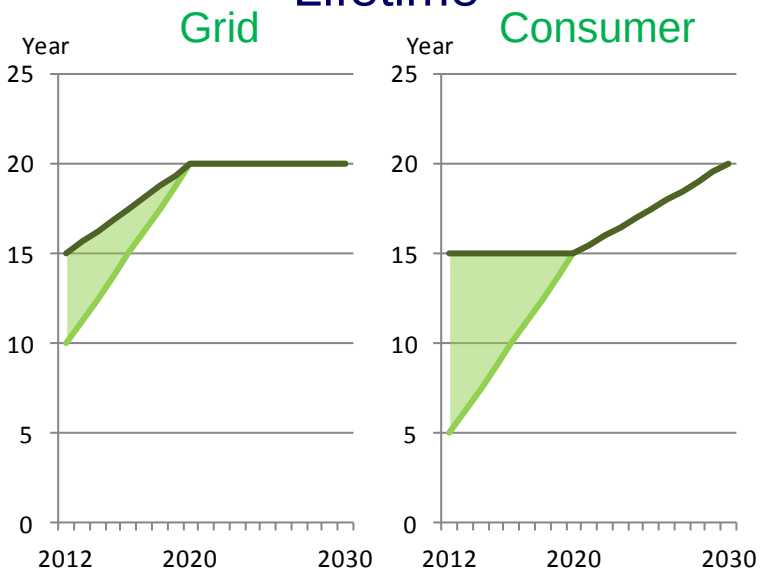

Source: ”Technology Roadmap, Energy storage”, IEA

## Japan’s Roadmap

Cost:

0.05~0.6millionJPY/kWh➔0.02~0.08

Lifetime




Source: ”Battery Technology Roadmap 2013”, NEDO

# Battery for Grid Stability

- The world largest NAS battery has started operation in Japan (March 2016).
- One of the “pilot projects for improvement in electric power balancing by large capacity battery” funded by METI through New Energy Promotion Council.
- Installed in Kyushu region (southern part of Japan), where solar PV penetration is much higher than other regions.

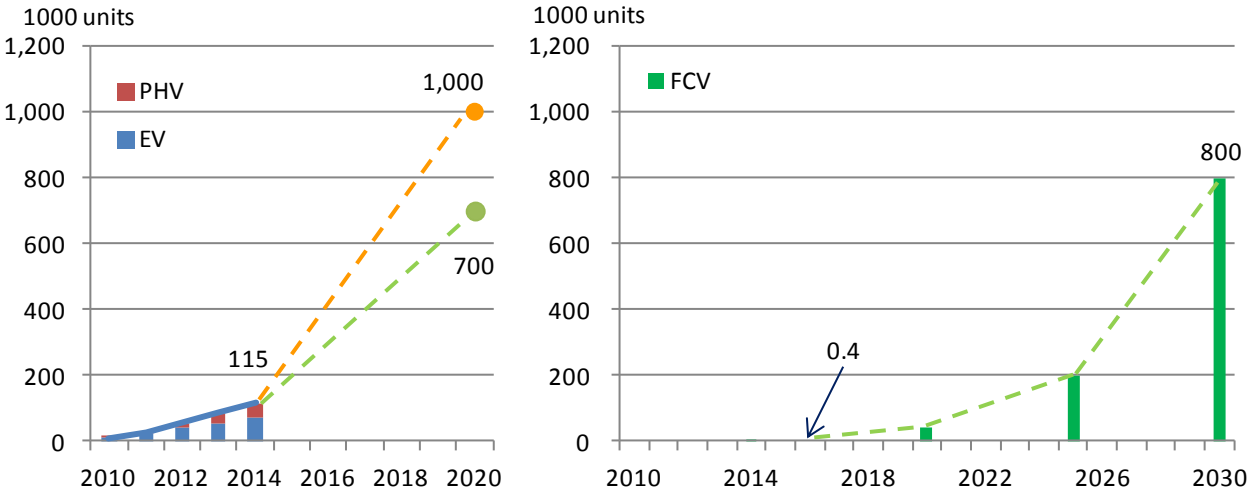
- ✓ Output: 50MW
- ✓ Storage capacity: 300MWh
- ✓ Number of units: 252
- ✓ Installed at a transformer station.

Source: NGK Insulators, LTD. (http://www.ngk.co.jp/news/2016/20160303_01.html)

# EV, PHV and FCV

- EVs for renewables: Incentives are needed for consumers.
- Aggregated management is required, individual EV has limited potential for renewable energy grid integration.
- Japan's Roadmap for EV & PHV (March 2016): 1 million EV&PHV (2020 high case)
  ➔20 million kWh of battery capacity (20kWh/vehicle)
- Japan's Roadmap for FCV (March 2016): 800,000 of FCV(2030)
  ➔130 million kWh of storage capacity (5kg-$H_2$/vehicle)

## EV, PHV and FCV Deployment Target of Japan

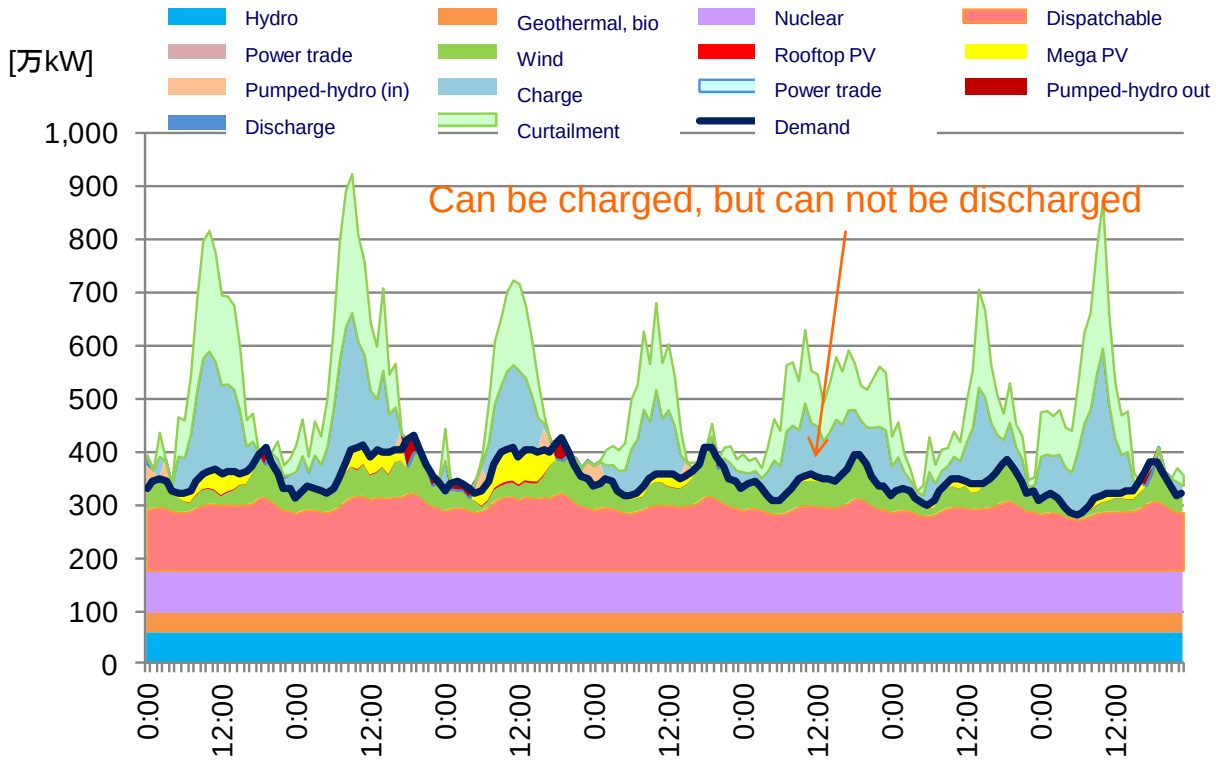



Source: EV and PHV: " EV・PHV Roadmap Report", March 2016, METI
FCV: Hydrogen and Fuel Cell Strategic Roadmap, March 2016, METI

# Energy Storage Operation

- Battery is still expensive, though effective for variability absorption for the short cycle.
- Control of "power⇔power (PtoP)" can be complicated.
- "power to heat/hydrogen" can be used also for non-electricity use.

## Barrier of Electricity Storage (EtoE)

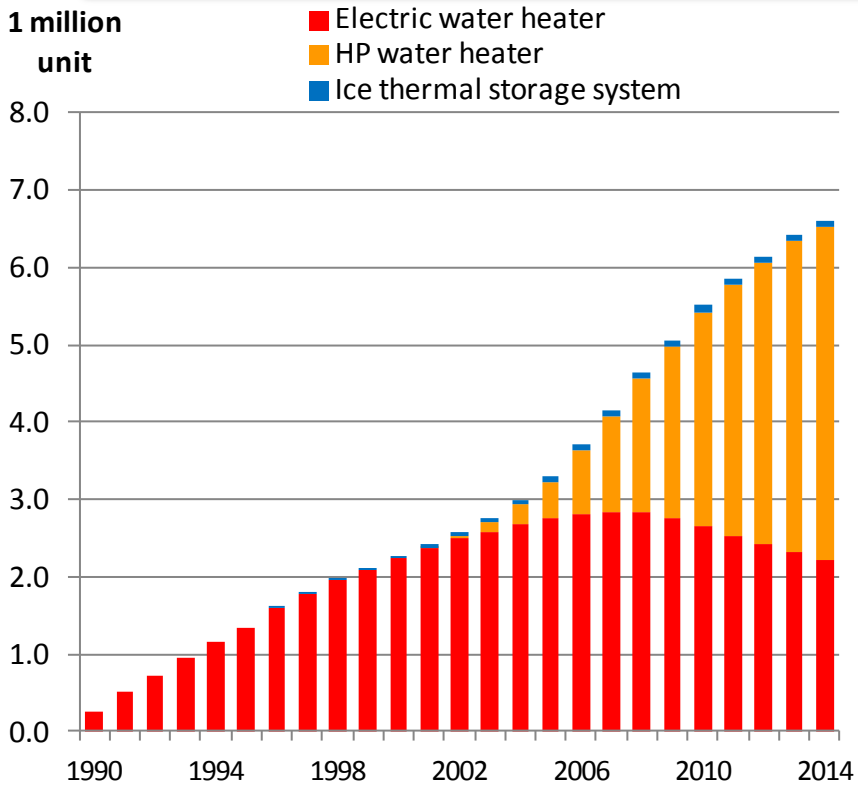


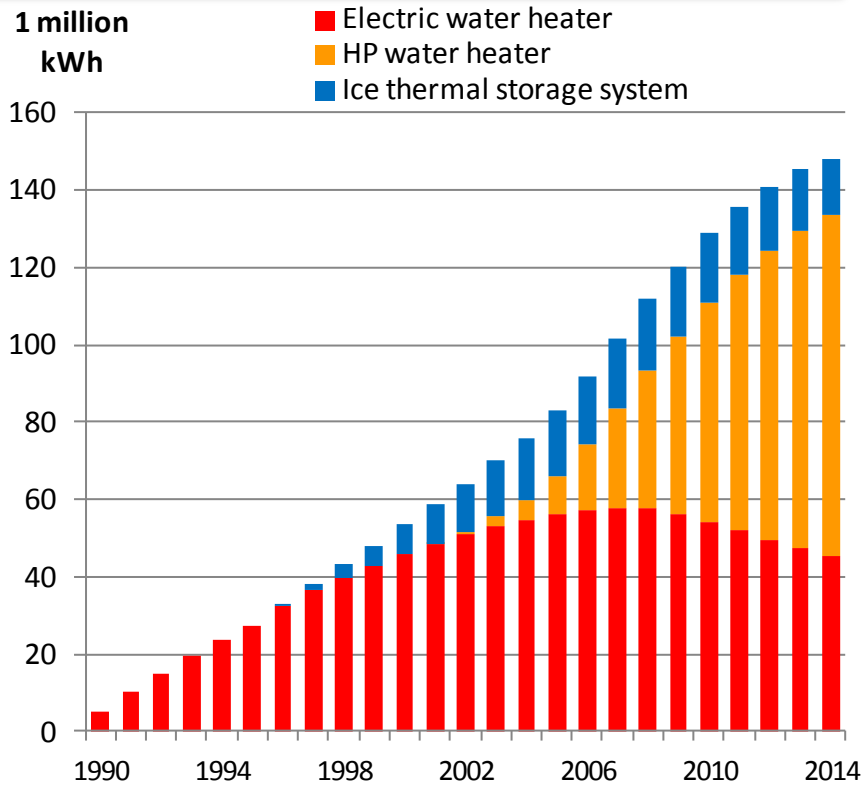

**TES, PtG**

# Thermal Energy Storage (Japan)

- Thermal energy storage is a proven technology and already widely used in Japan.
- The total storage capacity in Japan reaches up to 160 million kWh in 2014, majorly residential water heater (either electric heater or heat pump) equipped with tank.➔ Huge potential for variable renewables grid integration.

## Thermal Energy Storage in Japan

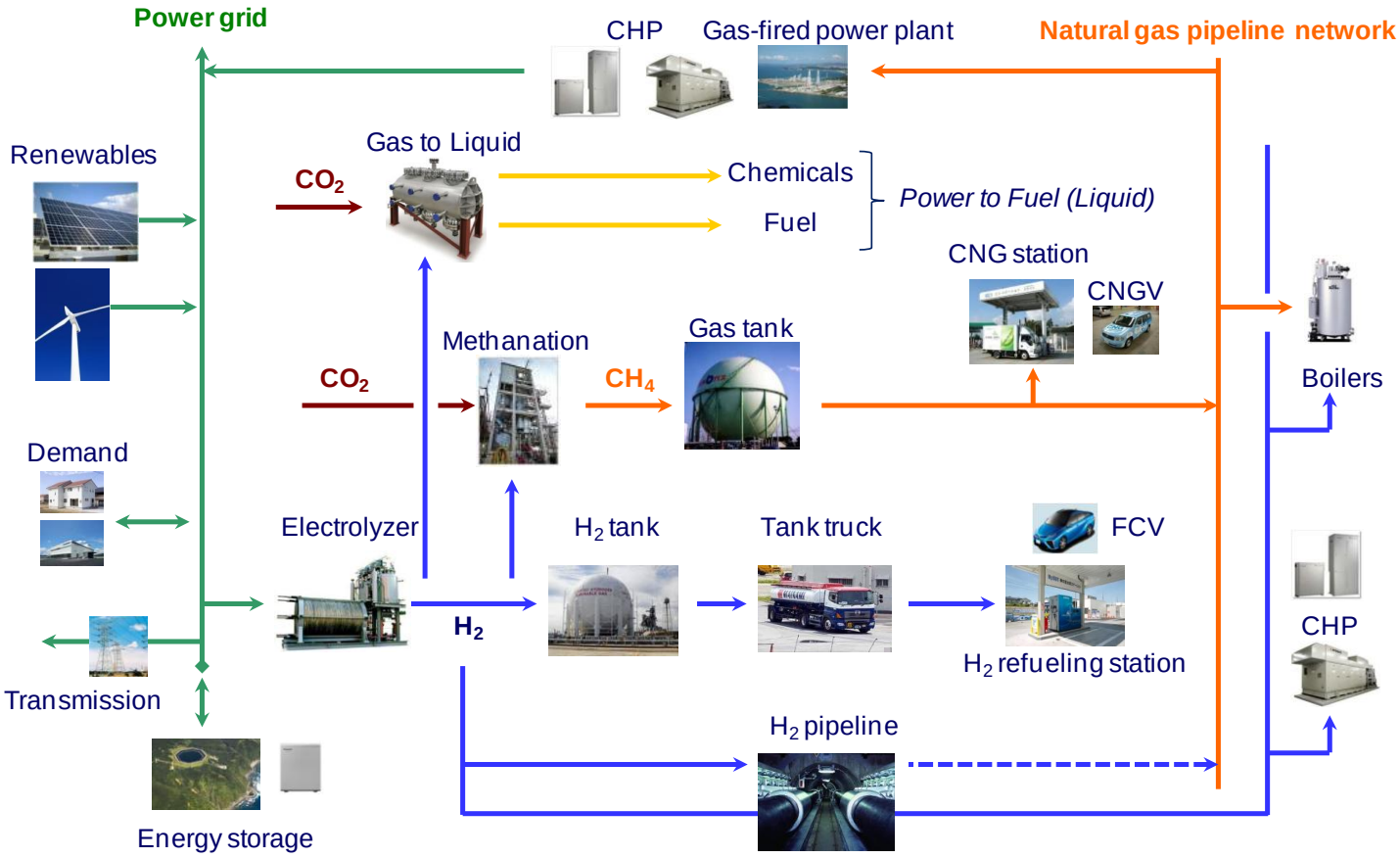



Note: Estimated from on the statistic data of "The Japan Refrigeration and Air Conditioning Industry Association" and "Heat Pump & Thermal Storage Technology Center of Japan". The annual shipment from this two data resources are used to estimate the penetration.

# Power to Gas

- Renewable electricity used to produce hydrogen/synthesis natural gas
- PtG concept gets the power grid and the natural gas network work together.
- If the existing gas infrastructure can be used, the investment cost can be curtailed considerably.



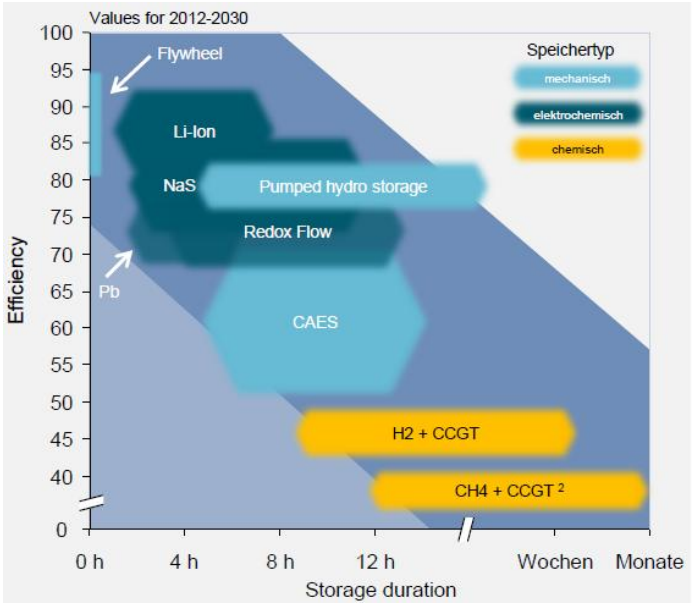

Source: Shibata, " Is Power to Gas Feasible in Japan?", IEEJ, 2016

# Types and Roles of Energy Storage Technologies

- Battery is suitable for shorter period of storage.
- PtG is able to store energy for the long period, though the round-trip efficiency is low.

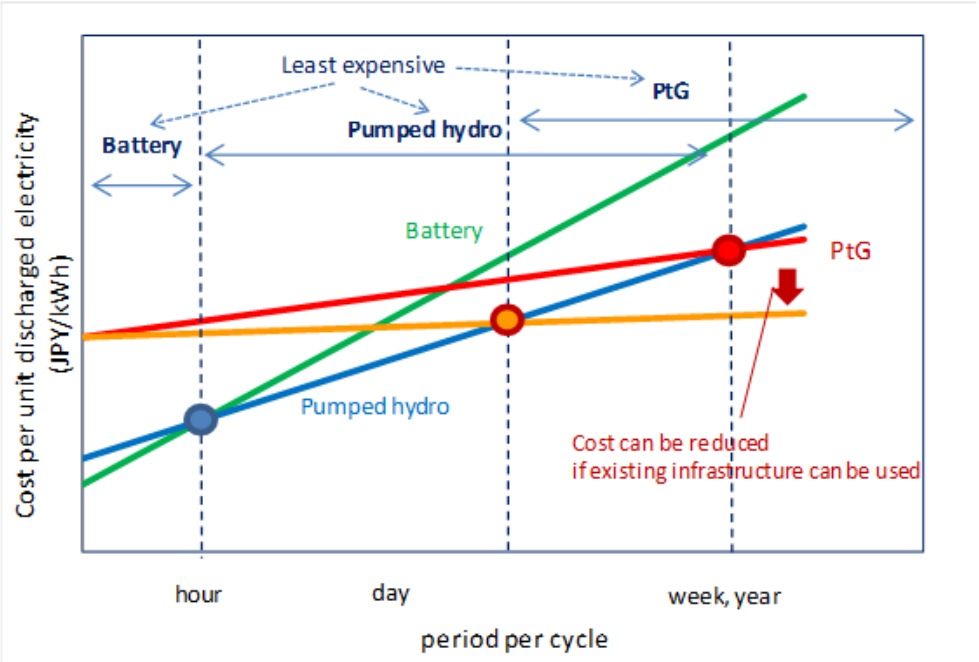
➔Right technology in the right place

## Round-trip efficiency and Storage period




Source: "ETOGAS smart energy conversion", ETOGAS GmbH, 2013

## Different Role of Energy Storage



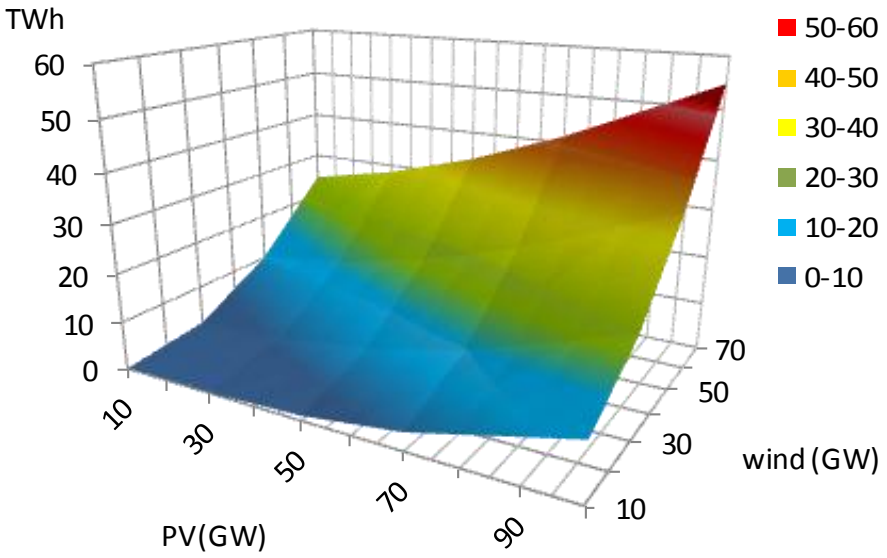

Source: Shibata, " Is Power to Gas Feasible in Japan?", IEEJ, 2016

# Grid Integration Measures and Surplus Electricity

- Amount of surplus electricity largely varies depending on which and how deeply the grid integration measures are taken.
- In case of "Long-term Energy Supply-Demand Outlook of Japan" (*), the surplus electricity will be ranging from 4TWh (≒4%) to 22TWh (≒24%).

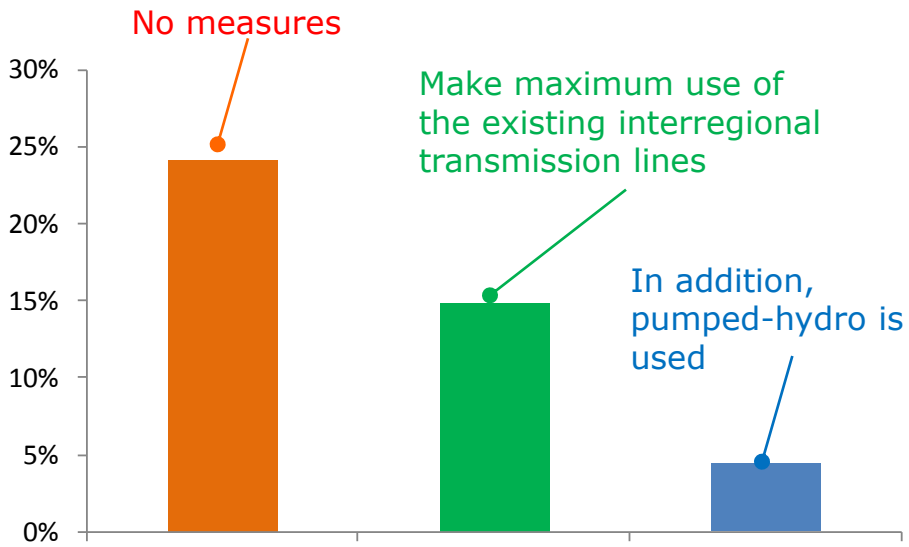
*: 64GW of PV and 10GW of wind power in 2030 (24GW of PV and 3GW of wind as of march 2015).

## Surplus Electricity from VRE




## Surplus Ratio

- Surplus ratio=Surplus VRE/ Power generation from VRE
- VRE = Solar PV + Wind power

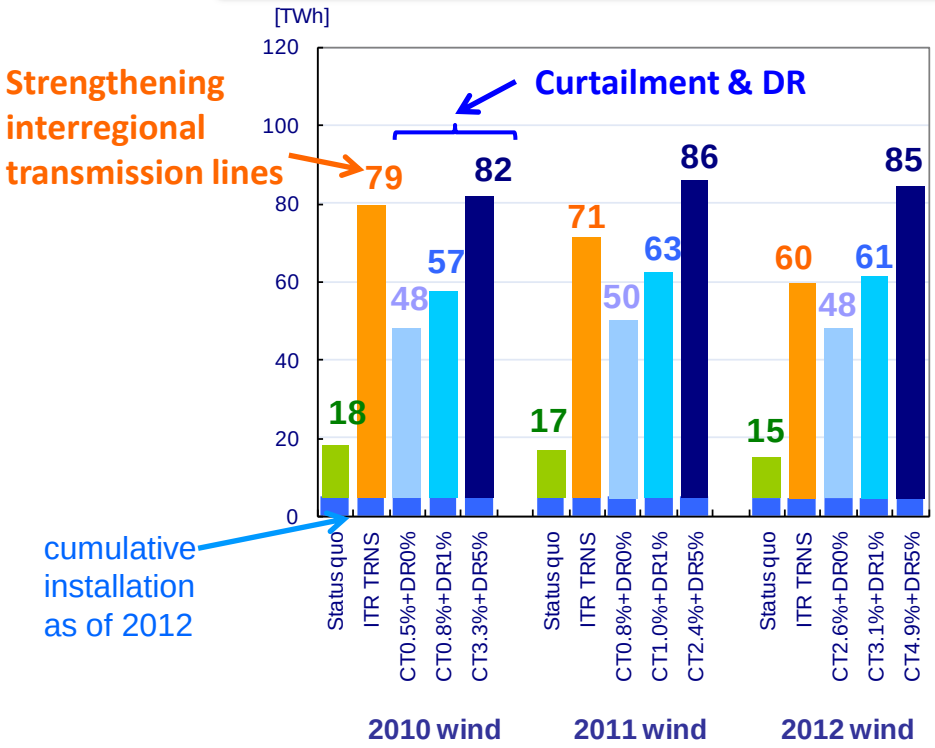



Source: Shibata, "Economic Analysis of Hydrogen Production from Variable Renewables", IEEJ Energy Journal, Vol.10, No.2, 2015

# Wind Power Integration Potential in Japan by Curtailment & DR

- Fractional curtailment & DR can yield large increase in wind power integration potential, which equals the impact of strengthening interregional transmission lines in Japan.
- Demand response for renewable integration is not yet widely used. Should be verified its feasibility (energy demand with inertia➔ energy storage) and needs incentives.

## Wind Power Integration Potential



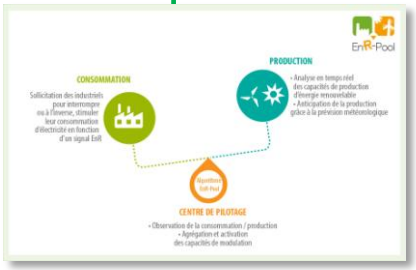

## Required DR Scale

| No. of DR events | DR rate |
|---|---|
| 2~3 times/year | 0.8%~2.5% |

## Curtailment Rate

1%~5% (annual kWh)

## Demand response

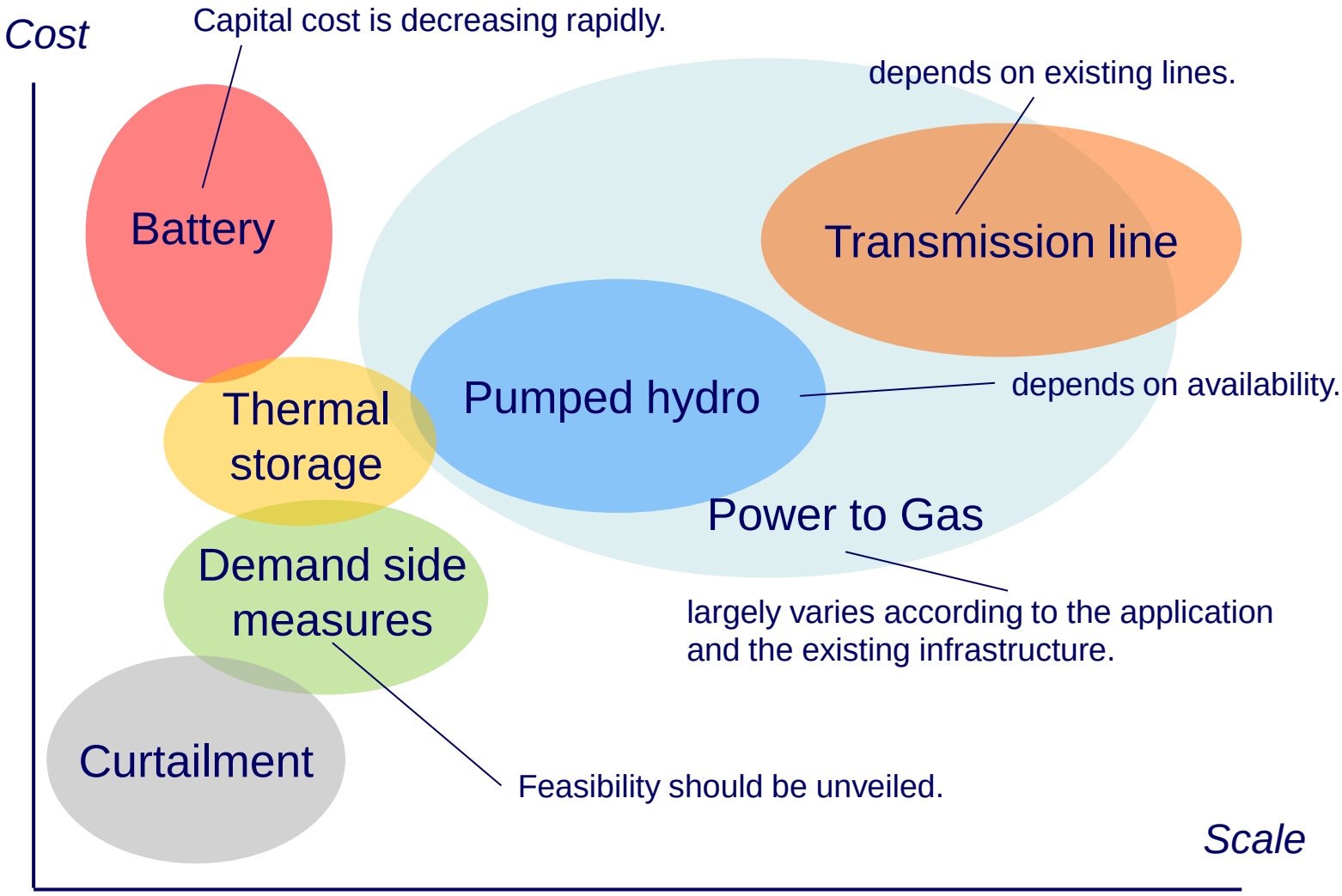



Source: http://www.enr-pool.pemaco.fr/

Note: ITR TRANS: Strengthening interregional transmission lines, CT: Wind power curtailment, DR: Demand response

Source: Shibata, "Potentiality of Demand Response and Curtailment for Wind Power Integration - Implications for Demand Response Designing -", IEEJ Energy Journal, Vol.9, No.2, 2014

# Cost vs. Applicable Scale of Integration Measures



# Discussion

- There is a wide variety of grid integration measures, according to the purpose and type of use.
- Combination of grid integration measures should be selected based on the cost and lead time for development and commercialization.
- Energy storage, playing an important role, has also a variety of technologies, though still expensive.
- Energy storage technologies should also taken into account how to use the stored energy; PtP, PtM, PtH, PtGtP, PtGtM, PtGtH, etc..

➔ Right technology in the right place

➔Best–mix of the grid integration measures

➔ How to transform the “energy” system (not only power grid)

Thank you

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