

**Hitachi-UTokyo Lab. 5th Industry-Academia Collaboration Forum
Toward Realizing Energy Systems to Support Society 5.0**

Sustainable Energy Innovation with Local Communities

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25 January 2023

Contents

- 1. Keywords derived from WG1 and WG2 discussions.**
- 2. Demand coordination: Changes in demand and contributions expected from energy coordination.**
- 3. Regional characteristics: Smart energy use based on regional characteristics.**
- 4. Large-scale introduction of inverter power supply: Emerging new issues and countermeasures.**
- 5. Conclusion**

1. Keywords derived from WG1 and WG2 discussions H-UTokyo Lab.

[Part 2, Report 1]
Bulk power system
S+3E for a carbon-
neutral society

- **Maintaining system stability, inertia, and frequency retention capacity** designed for decarbonized power sources is a key issue for bulk power systems.
- **Sophistication of inverter power supplies and use of distributed resources in the region** are effective in maintaining inertia and frequency retention.
- Maintaining the robustness of power supply in response to weather conditions requires use of **storage energy** such as nuclear power and hydrogen.

[Part 2, Report 2]
Energy coordination
control platform that
enables stable
energy supply
through coordination
of regional resources

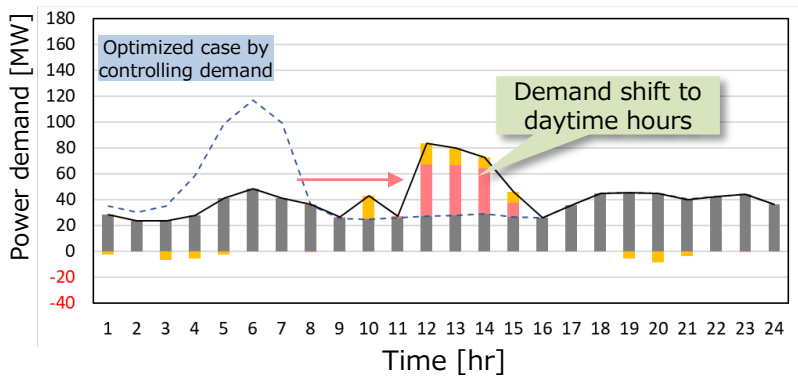
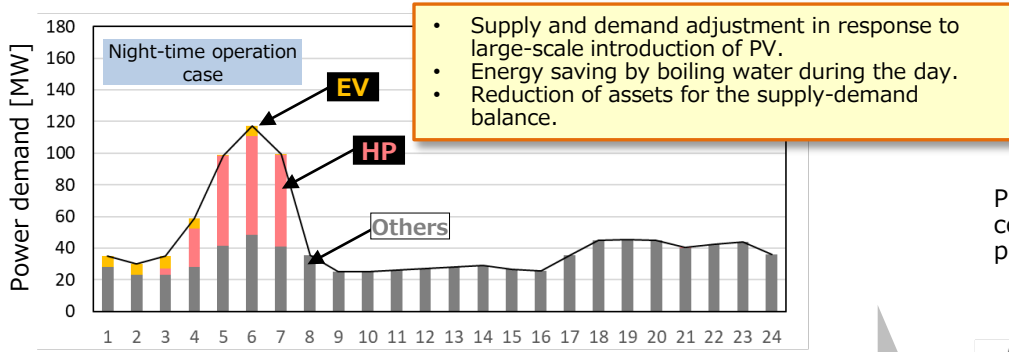
- Soaring electricity rates and **decarbonization based on regional characteristics** are the issues to address. Smooth **introduction of renewable energy** and measures tailored to the characteristics are necessary.
- There is potential in the region to generate a win-win **adjustment capacity**. This will likely be generated through the coordination control PF.
- There is a need to share awareness, make decisions with participation by all, provide means for gradual transition, and **collaborate across industries through data linkage**.

Three keywords to be considered for the realization of sustainable energy systems:

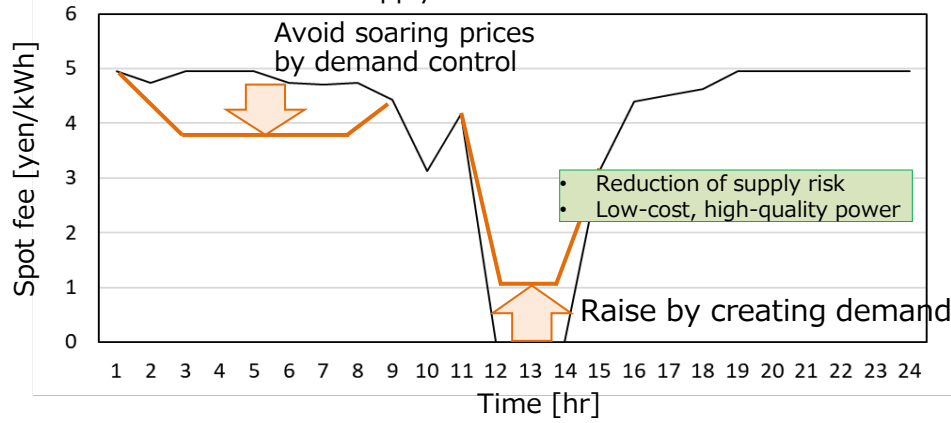
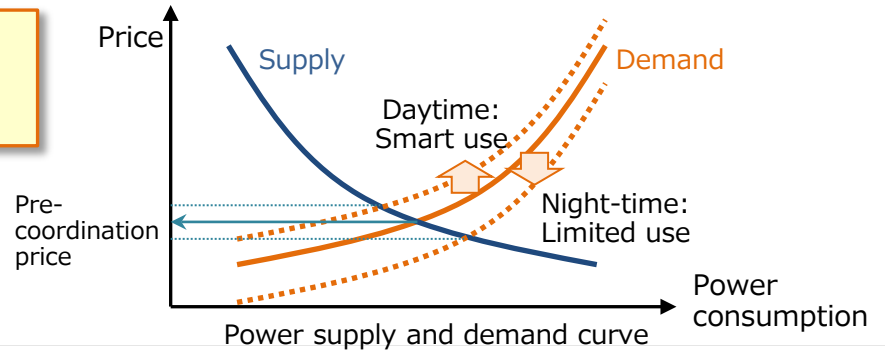
- ① **Demand coordination**
 - **Energy resources**
 - **All stakeholders**
- ② **Smart energy use based on regional characteristics**
 - **Electrification and decarbonization of heat sources and gradual transition.**
- ③ **Large-scale introduction of inverter power supply**
 - **Hidden issues and countermeasures other than the balance between supply and demand.**

2. Demand coordination: Changes in demand and contributions expected from energy coordination

Realizing innovation that contributes to the stabilization of the electric power market with energy coordination through smart energy use.



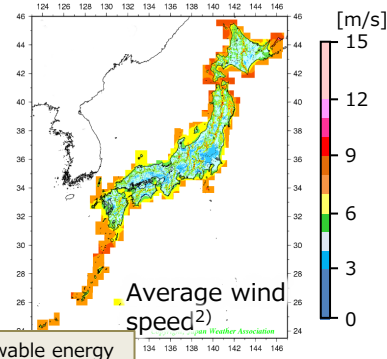
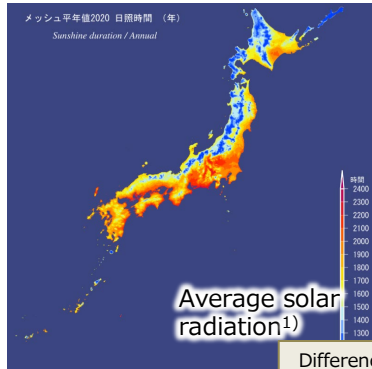
Results of coordinated aggregation analysis for Machida City in 2030 (repost)



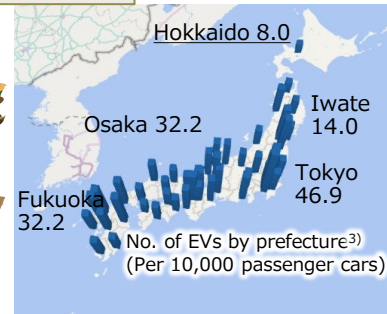
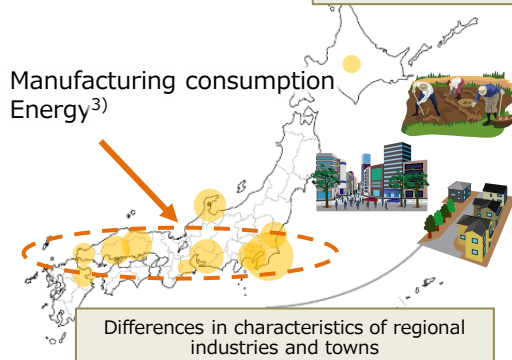
Effect of stabilizing electricity market prices (simulation)

3. Regional characteristics: Smart energy use based on regional characteristics

Issues differ by industry, renewable energy resource, and regional classification. Need for a framework that supports decarbonization measures tailored to the characteristics.



Differences in renewable energy resources



Differences in electrification progress due to climate

[Adjustment capacity]

- Support for the targeted introduction of CO₂ control equipment (housing complexes and facilities)
- Demand coordination for data utilization including industry to effectively utilize renewable energy.

[Use of heat/refrigeration heat in conjunction with electrification]

- Summer air conditioning by storage of ice and snow.
- Utilization of residual heat from solar heat industrial heat source, commercial air conditioning.

Buildings, stores, Data centers

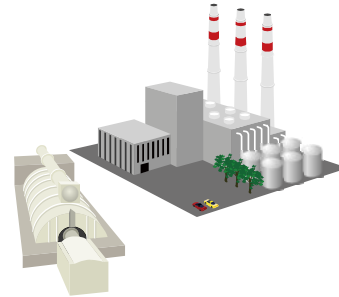
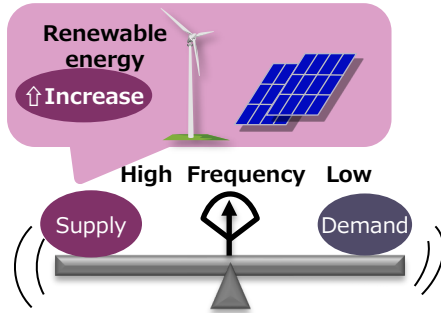
[Hydrogen and new fuels]

- New fuel generation at CO₂ recovery destination with exhaust heat.
- Hydrogen production based on the location of offshore wind power (geographic and temporal fusion).

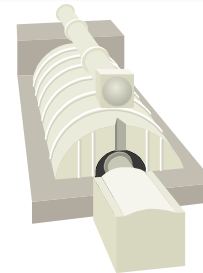
1) Prepared from "Past Meteorological Data" by the Japan Meteorological Agency, <https://www.data.jma.go.jp/obd/stats/etrn/index.php>
 2) Prepared from "New National Wind Map" by the Ministry of Land, Infrastructure, Transport and Tourism, https://www.mlit.go.jp/kowan/kaihatuka/wind_hp/huukyuo-map/wind_map.html
 3) Prepared from FY2019 figures in "Energy Consumption Statistics by Prefecture" by the Agency for Natural Resources and Energy
 4) Prepared from "Survey and Statistics: Subsidy Status for Electric Vehicles by Prefecture" by the Next Generation Vehicle Promotion Center and "Number of Vehicles Owned" by the Automobile Inspection & Registration Information Association

4. Large-scale introduction of inverter power supply: Emerging new issues and countermeasures

Further challenges other than the supply-demand balance. Importance of motivation to maintain rotary generators and improve functionality of inverters.



Maintenance of rotary generators with low operating rates



- Value generation and market creation for reactive power supply and inertia provision.
- Improving economic efficiency of coal-fired thermal power through collaboration with the CO₂ material industry.
- Utilization of pumped water power stations in adjustment capacity market.

Increase in output fluctuations due to renewable energy
Rotary generator parallel-off

Supply and demand mismatch
Loss of inertia

Frequency loss of retention capacity

① Expanded voltage drop range during grid fault

Increased power interruptions

② Abnormal noise and burnout caused by inverter operation

Increased power outages

Filter Circuit

Reduced quality

③ Instability of renewable energy due to decrease in number of rotary generators

Reference voltage

Controller

Reduced quality

Grid contribution and stabilization through upgrade of inverters

- Provision of grid stabilization functions to wind and solar power generation and energy storage systems.
- Robust control for stable operation in highly fluctuating grids and generating value from it.



BESS¹⁾ with grid-forming function

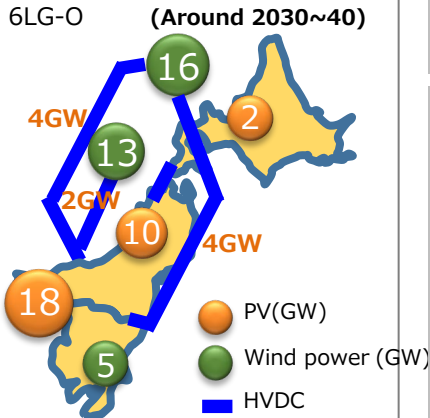
1) Hitachi Energy, "Grid forming energy storage provides virtual inertia, interconnects renewables and unlocks revenue"

4-1. Voltage drop during accidents due to the presence or absence of rotary generator

Rotary generator mitigates the voltage drop during lightning strikes. Operational decisions should be discussed, including maintenance of power quality and support for innovation.

Criteria for consideration

- Grid: System analysis model created from public information from electric power companies.¹⁾
- Demand, renewable energy, and grid (DC/AC) conditions are set in the OCCTO Master Plan uneven power distribution scenario (45GW).
- Fault condition: Miyagi - Nishi Sendai.



HVDC: High Voltage Direct Current (DC transmission)

Results summary

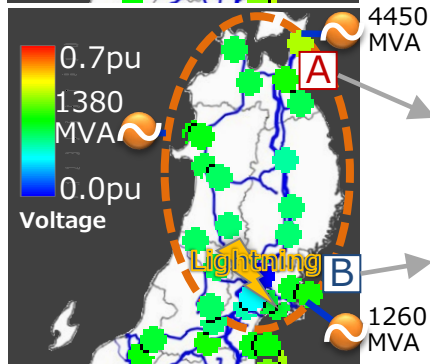
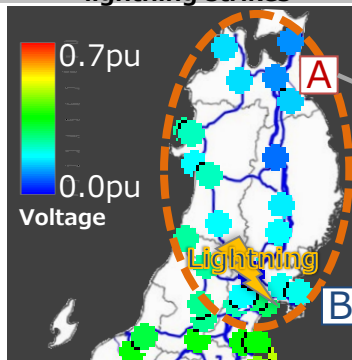
No rotary generator

Significant voltage drop north of the lightning strike point (Miyagi Prefecture).
 → May affect a wide range of industrial and office equipment.
 (Variable speed motors, electromagnetic switches, PCs, etc.²⁾)

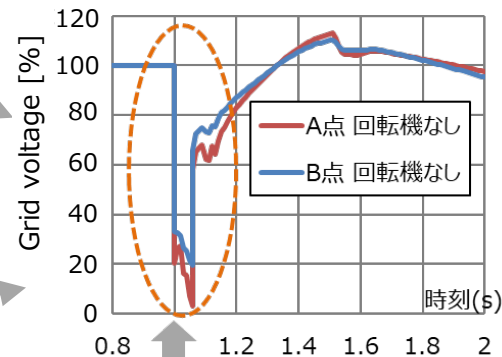
With rotary generator

Reduced voltage drop north of the lightning strike point

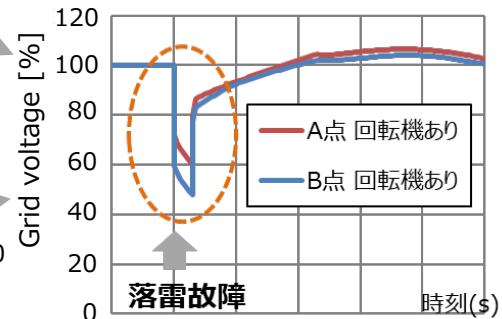
Voltage distribution during lightning strikes



Voltage fluctuation



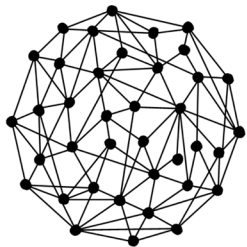
落雷故障



落雷故障

1) Prepared by Hitachi-UTokyo Lab with reference to OCCTO "Master Plan Interim Reorganization."
https://www.occto.or.jp/iinkai/masutapuram/2021/210524_masutapuram_chukanseiri.html
 2) Hokuriku Electric Power "Measures to prevent instantaneous voltage drops in customer facilities" <https://www.rikuden.co.jp/tairai/taisaku.html>

- **Three keywords to be considered for the realization of sustainable energy systems:**
① **Demand coordination** ② **Energy use based on regional characteristics** ③ **Large-scale introduction of inverter power supply.**
- Demand coordination is expected to **stabilize electricity market prices**. It has an economic innovation aspect that broadly benefits not only electricity suppliers and energy coordination participants.
- Regional issues differ depending on local industry, renewable energy resources, and climate. **In addition to prioritized support for coordinated energy use, energy conservation using heat/refrigeration heat, and the spatio-temporal fusion of hydrogen, new fuels and renewable energy** by optimizing location and utilizing data should be accelerated. There is a need to support and establish systems for these measures.
- In addition to the supply-demand balance, new issues have emerged in the large-scale introduction of renewable energy sources. Maintaining power quality and reliability requires institutional innovation that will **stimulate grid contribution and improvement of robustness of inverters** through **maintenance and advancement of control of rotary generators with low operating rates**.



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