

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

Coordination and Control Platform for Achieving S+3E and Creating Value through Coordination of Regional Resources

Kazuhiko Ogimoto

**Project Professor, Institute of Industrial Science,
The University of Tokyo**

25 January 2023

Data-driven study of achieving regional demand flexibility and value creation through energy coordination.

4th Forum (Dec. 2021)

■ **Proposed energy coordination and control platform to provide demand flexibility to bulk power systems and realize value creation in communities through smart use of energy.** Evaluated demand flexibility and creatable value, with focus on detached residential houses.

1. **Coordination and control platform:**
Energy coordination platform to create win-win for power suppliers and consumers in era of large-scale RE deployment.
2. **Value and demand flexibility created from detached houses:**
Everyone's participation is needed for CN. Evaluated benefits of in-home heat pumps and EVs whose operation does not cause inconvenience.
3. **Importance of transition in stages:**
Importance of social transition through creation of benefits to individuals and communities in stages

This presentation

■ **Expansion of scope of coordination and control platform to include entire residential sector, including apartment complexes, and with addition of business sector; evaluation of demand flexibility and value that can be created by regions.**

1. **Regional challenges in changing energy landscape:**
Energy price hikes and decarbonization in regions. Energy coordination & control platform is proposed as measure.
2. **Regions' potential for demand flexibility:**
Quantitative assessment of demand flexibility and value that can be created from regions, including residential and business sectors.
3. **Measures for smooth regional transitions:**
Importance of transition in stages for in homes, businesses, and industries linked to coordination & control PF

- (1) Are there win-win measures that advance regional decarbonization amid changing energy landscape?
- (2) Who is expected to take what actions? What measures should be prioritized, taking into account regional characteristics?



We will make recommendations based on our analysis and progress of peripheral technologies.

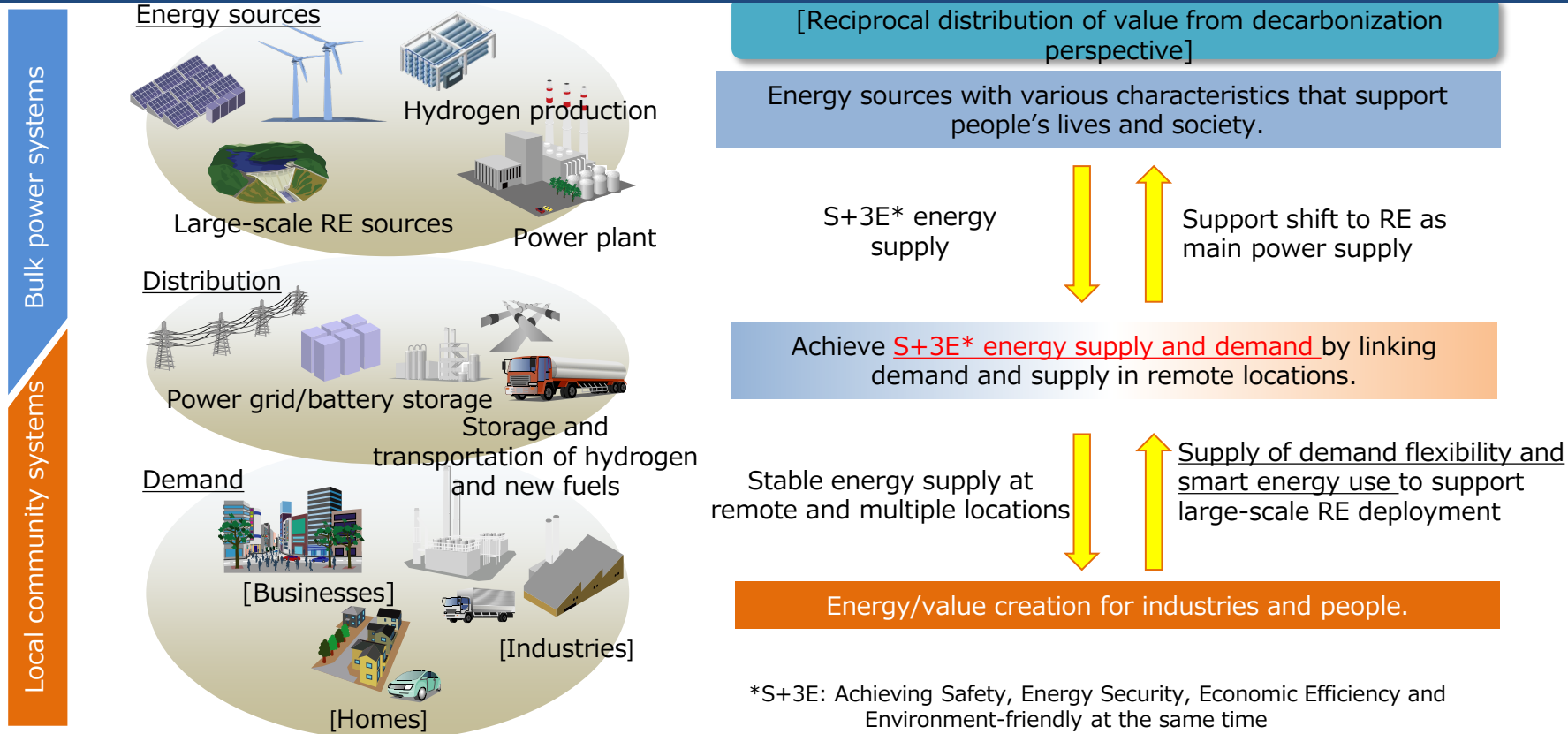
Contents

- 1. Changes in local communities and their energy situation.**
- 2. Local communities' challenges and coordination and control platform.**
- 3. Potential for regional stable supply and demand.**
- 4. Measures for smooth regional transitions.**
- 5. Conclusion**

1. Changes in local communities and their energy situation

1-1 Significance of local communities

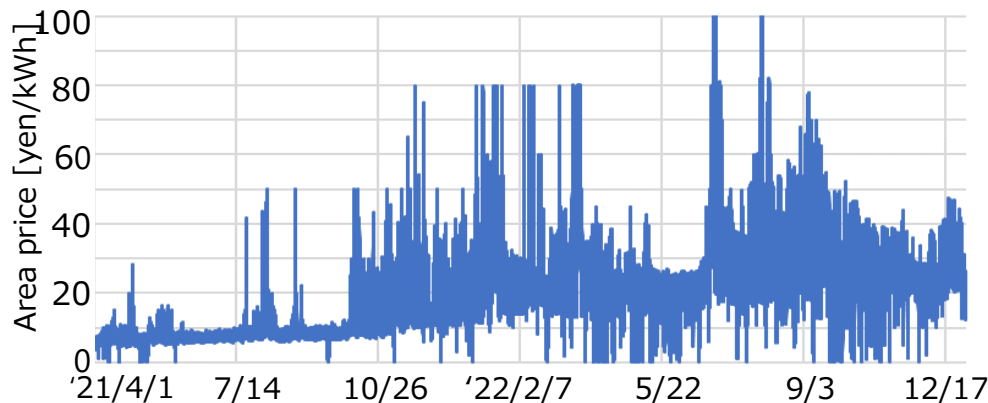
Social systems that encompass supply and use of energy that support lives of people and society. Create value through smart energy use.



1-2 Regional challenges in response to changing energy environment

With fuel price hikes and regional decarbonization, challenge is to overcome electricity price spikes and disincentives to decarbonization due to regional characteristics.

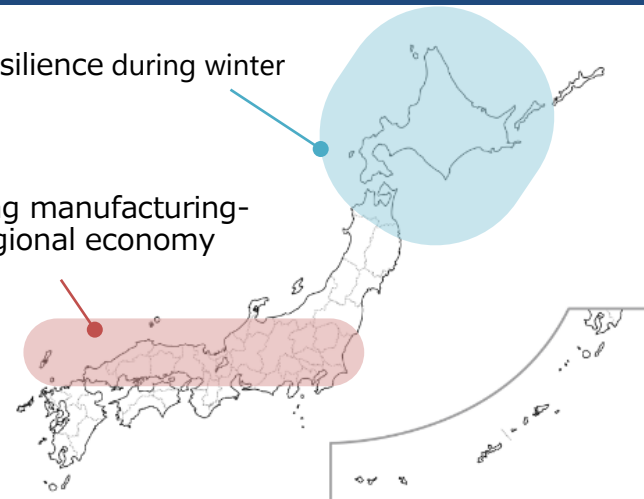
Changes in JEPX Tokyo area price¹⁾



Needed is accelerated expansion of RE and other decarbonized power supplies. Needed are low-cost supply-demand balance measures that keep down additional assets.

Ensuring resilience during winter

Maintaining manufacturing-centric regional economy



Needed is support for accelerated decarbonization tailored to regional characteristics without hurting people's livelihoods.

Accelerated mechanism to create demand flexibility* from wide range of demand, and support for transition based on priorities given to regional characteristics.

*Demand flexibility: (1) Demand flexibility traded in supply/demand adjustment markets + .
(2) Demand flexibility created through demand coordination in response to spot prices.

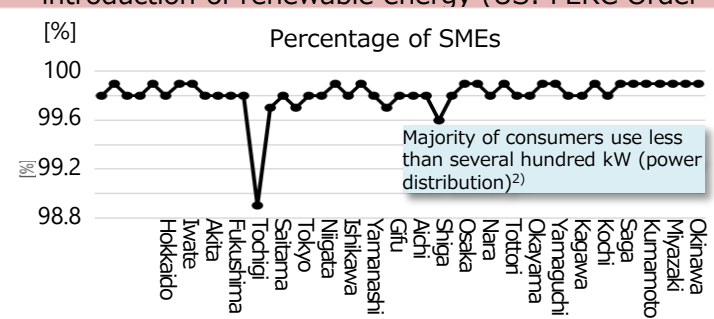
1) Created based on JEPX (Japan Electric Power Exchange)

2. Local communities' challenges and coordination and control platform

2-1 Government policy on energy supply/demand and additional discussion points

In addition to expansion of demand flexibility market and promotion of energy saving, we should inquire into causes of barriers to electrification in industrial sector and propose measures. We should also discuss measures to promote participation in energy coordination by small and medium-sized consumers. Their participation can achieve both demand

| | | Government policy ¹⁾ | Discussion points to be added |
|--------------|----------------------------|--|--|
| Power supply | | <ul style="list-style-type: none"> Maximization of nuclear power use and acceleration of renewable energy deployment. | <ul style="list-style-type: none"> Balanced deployment of nuclear power and RE. Promotion of RE with specific consideration of sites. |
| Grid | | <ul style="list-style-type: none"> Planned expansion of power grids. Installation of battery storage for power grids. | <ul style="list-style-type: none"> Appropriate demand-based deployment of additional assets. |
| Demand | Heavy-demand consumers | <ul style="list-style-type: none"> Establishment of electricity market for CN. Expansion of demand flexibility market. | <ul style="list-style-type: none"> Analysis of causes of slow electrification of heat sources and planning of measures. Creation of extensive demand flexibility to realize introduction of renewable energy (US: FERC Order |
| | Small/med-demand consumers | <ul style="list-style-type: none"> Reformation of buildings. Renovation of facilities. Promotion of behavioral changes among consumers through energy conservation programs, etc. Distributed power systems. | |

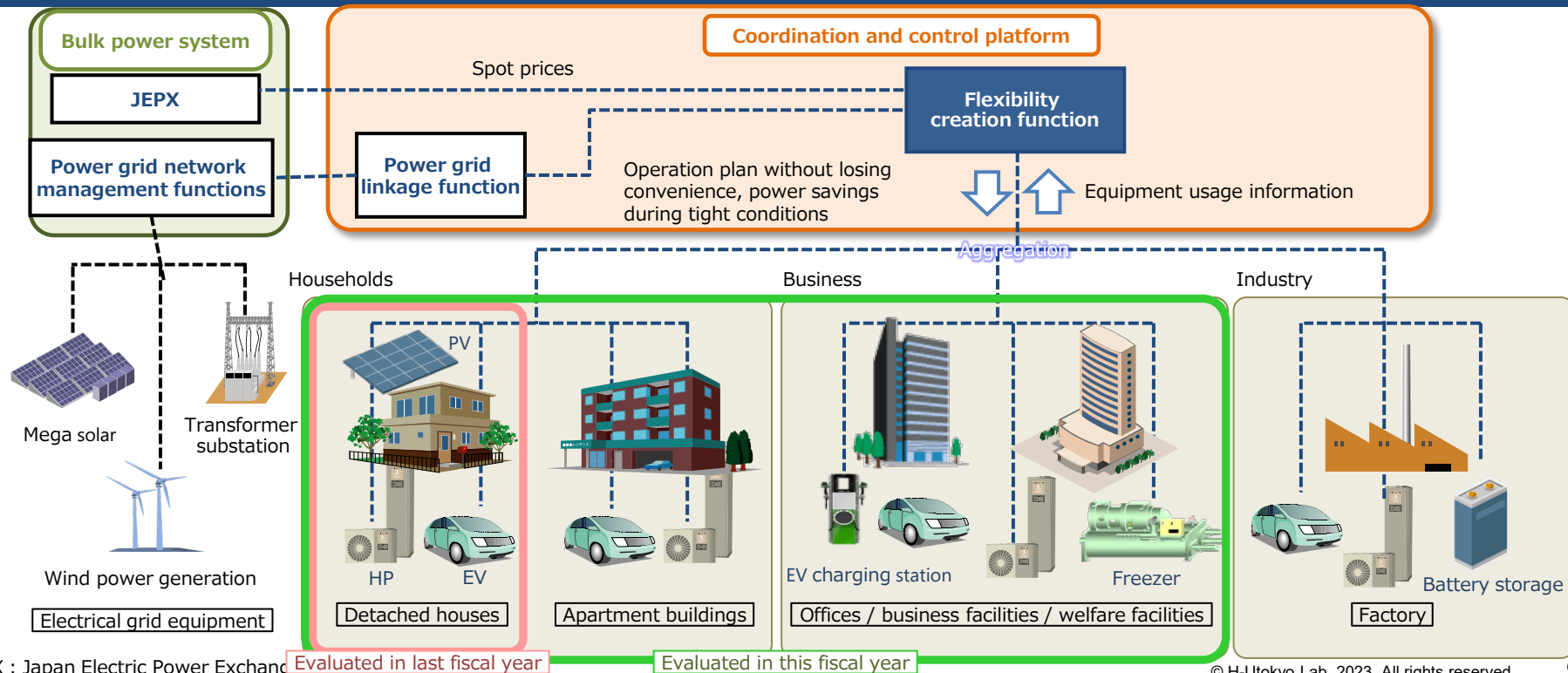


1) Created from Cabinet Secretariat, "Rebuilding Japan's stable energy supply," Document 1, August 24, 2022; GX Implementation Council, "Basic policy (Draft) for realizing GX - Roadmap for the next 10 years," December 2022; and other sources.

2) Created from Attached Statistical Data (Table 6) in "2021 White Paper on Small and Medium Enterprises in Japan," The Small and Medium Enterprise Agency.

2-2 Coordination and control platform

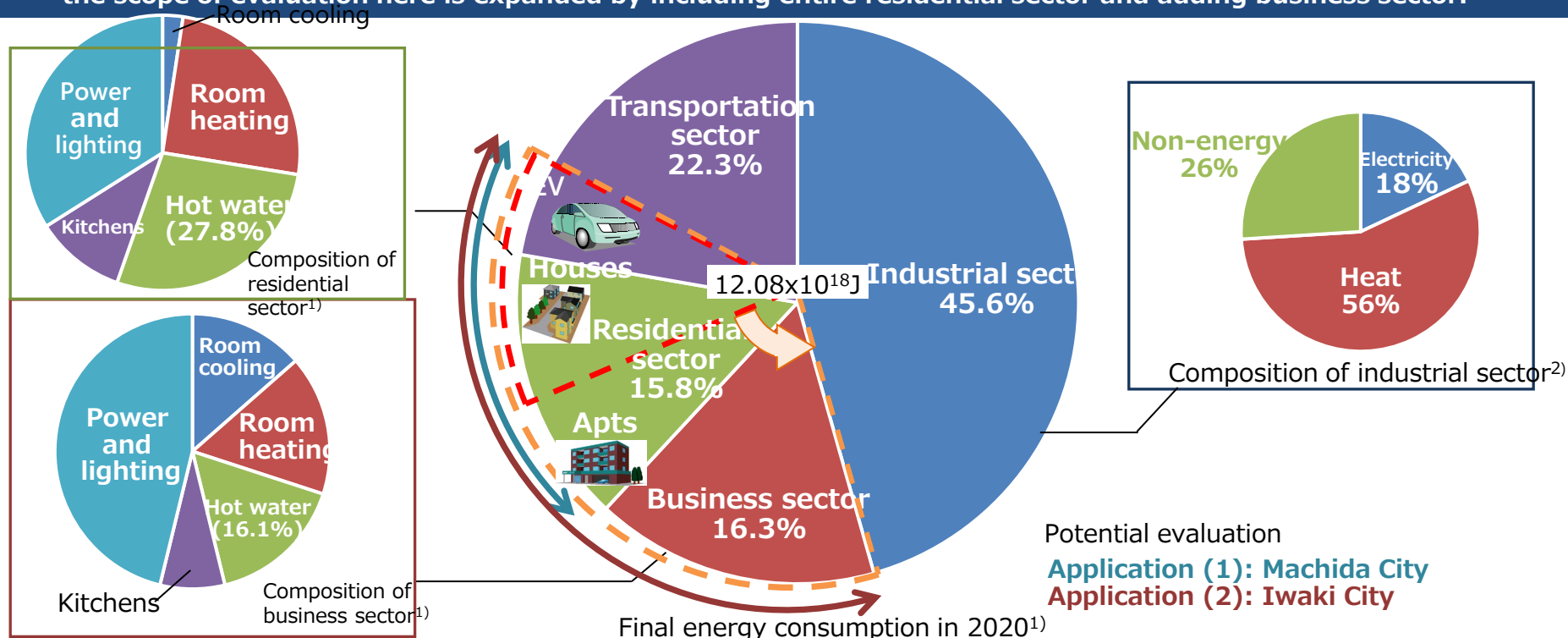
Platform that realizes cooperative mechanism in which everyone participates by creating data linkages between distributed energy resources and bulk power systems. Supports market price-based operational planning and demand time-shifting in response to supply-demand imbalances to create win-win for supply and demand sides.



3. Potential for regional stable supply and demand

3-1 Scope of evaluation of energy usage

In last year's evaluation, we confirmed the possibility of demand flexibility and value creation through energy coordination, mainly in form of heat pump water heater in detached houses. In anticipation of further increase in demand flexibility potential, the scope of evaluation here is expanded by including entire residential sector and adding business sector.



1) Created from "Energy White Paper 2022," Agency for Natural Resources and Energy
2) Created from "Effective use of heat" (2015), Agency for Natural Resources and Energy

3-2 Example of aggregation in household sector (1) H-UTokyo Lab.

Evaluation of scale of demand flexibility and coordination and control platform creatable with energy coordination with residential sector

Simulation of power grid supply/demand



Spot prices

Simulation of demand-side aggregation

Planning of electricity usage by HPs and EVs based on spot prices



Detached houses
Apt complexes

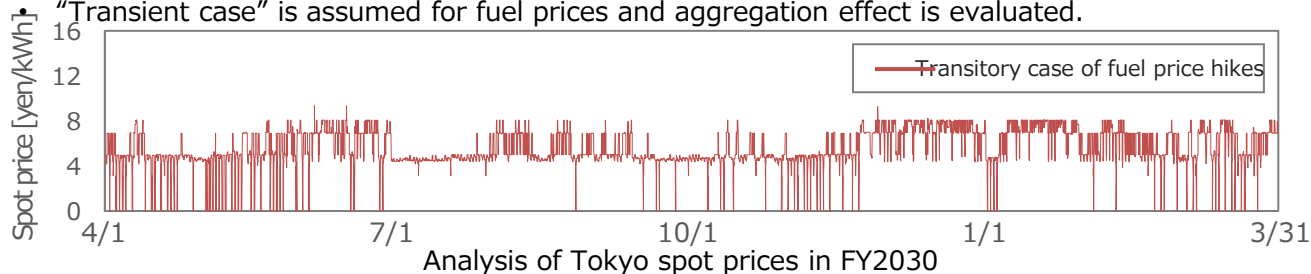
Municipality-scale demand flexibility

Estimation of nationwide demand flexibility

• Spot price estimation

- Calculated based on assumed prices of fuel and energy mix with reference to 6th Energy Basic Plan.

“Transient case” is assumed for fuel prices and aggregation effect is evaluated.



• Aggregation target

Number of households and distributed resource penetration rate in Machida City, Tokyo in 2030

| Residences | Number of households ¹⁾ | PV ²⁾ | HP ³⁾ | EV ⁴⁾ |
|-----------------|------------------------------------|------------------|------------------|------------------|
| Detached houses | 96,596 | 15.7% | 44.4% | 7.3% |
| Apartments | 102,572 | — | 15.2% | |

• Analysis conditions

Analyzed nighttime operation case and optimized case

| Case | Explanation |
|------------------------------|---|
| Case 1 (Nighttime operation) | HP hot water storage and EV charging mainly from midnight to 7 AM |
| Case 2 (Optimized) | Optimized HP hot water storage and EV charging/discharging based on hot water demand and driving demand |

1) Estimated based on “Projected Number of Households and Population” (Tokyo Metropolitan Government) and “Housing and Land Survey” (Ministry of Internal Affairs and Communications)

2) Calculated based on “Housing and Land Survey” (MIC), “Results of survey on actual conditions of carbon dioxide emissions from residential sector” (MOE) and “2020 housing market-based market survey of construction, equipment, and services” (Fuji Keizai Inc.)

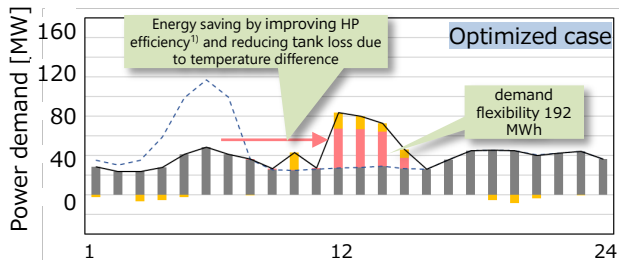
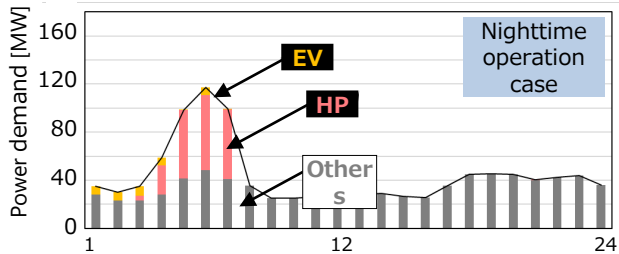
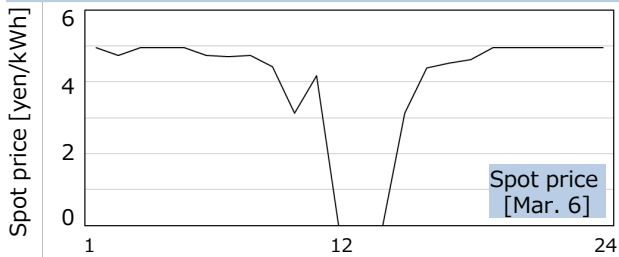
3) 3) Estimated based on “2020 Heat Pump Dissemination Outlook Survey,” Heat Pump and Thermal Storage Center of Japan.

4) Calculated based on “EV/PHEV Charging: Overview and Future Prospects in Japanese Market” by Automobile Inspection & Registration Information Association, Next Generation Vehicle Promotion Center, and Fuji Keizai Inc.

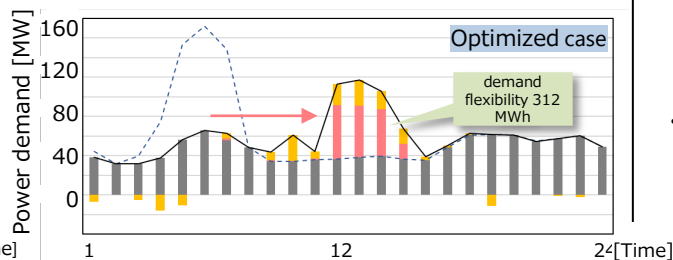
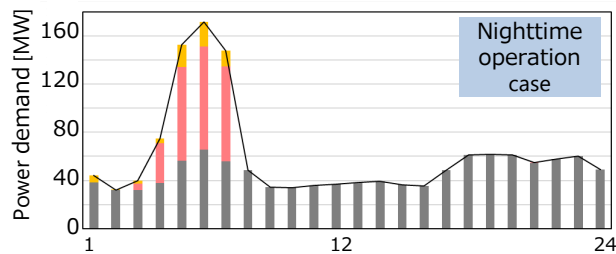
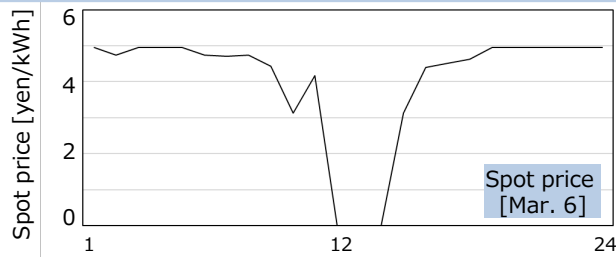
3-3 Example of aggregation in household sector (2) H-UTokyo Lab.

In Machida City, more than 1.5x demand flexibility in detached houses is possible by adding energy coordination with apartment complexes.

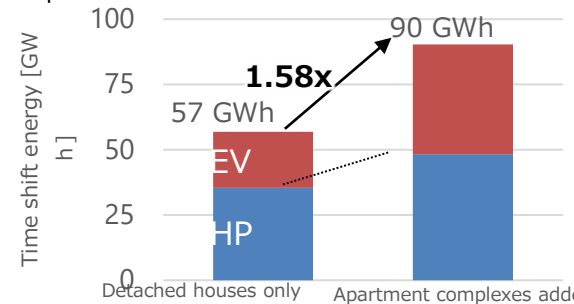
1. Detached houses only



2. Apartment complexes added



- In optimized case, HP operation and EV charging are concentrated during daytime when spot prices are low.
- Energy saving effect is confirmed by HP operation shift to daytime when temperatures are higher.
- Annual demand flexibility is increased to **1.58x** by including HPs and EVs in apartment complexes.



Annual power demand usable as demand flexibility ('30 Iwaki City)

- When converted to total number of households, demand flexibility generated by households is equivalent to 92.4 GWh/day nationwide.

1) "Use Case Analysis of Utilization of Residential PV-Generated Electricity after Feed-in Tariff Payment Period- Advantage of PV self-consumption by heat pump water heater and daytime heat storage -," Central Research Institute of Electric Power Industry Report No. C19001

3-4 Examples of aggregation in residential and business sectors

In Iwaki City, 1.35x demand flexibility is possible by adding business sector for water heating electrification.

Aggregation targets

Iwaki City: HPs and EVs in detached houses, apartment complexes; HPs in welfare facilities, hotels, and offices as business sector.

Number of households and penetration rate of distributed resources in Iwaki City ('30).

| Residence | Number of households | PV | HP | EV |
|-----------------|----------------------|-------|-------|------|
| Detached houses | 97,497 | 21.5% | 44.4% | 8.4% |
| Apartments | 47,503 | — | 15.2% | |

Iwaki City's business sector & HP info ('30)

| Businesses | Number of buildings | HP penetration rate ¹⁾ | HP output ²⁾ |
|--------------------|---------------------|-----------------------------------|-------------------------|
| Offices | 865 | 100% | 26.3MW |
| Hotels | 217 | 100% | 13.2MW |
| Welfare facilities | 526 | 100% | 50.1MW |

1) According to Reference [1], HP penetration rates in '30 are 2.4%, 3.0%, and 7.3%, respectively.

2) Calculated by H-UTokyo Lab based on business sector's annual demand of hot water according to Reference [2].

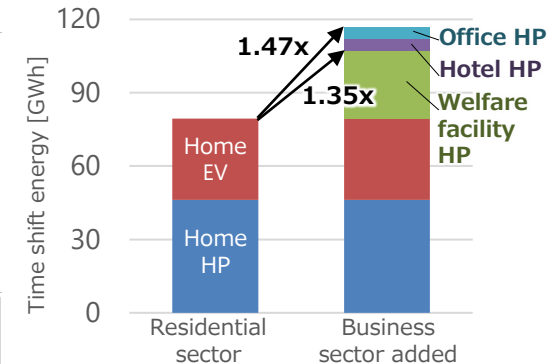
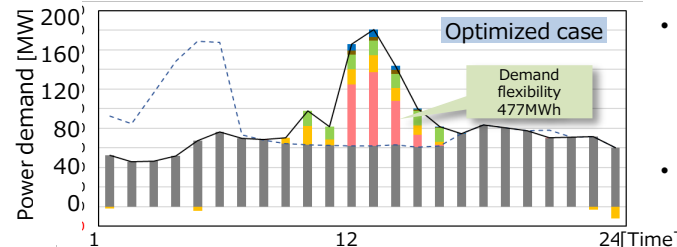
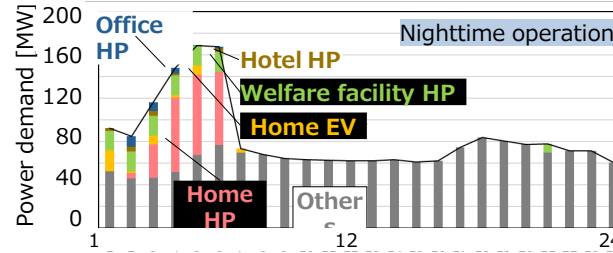
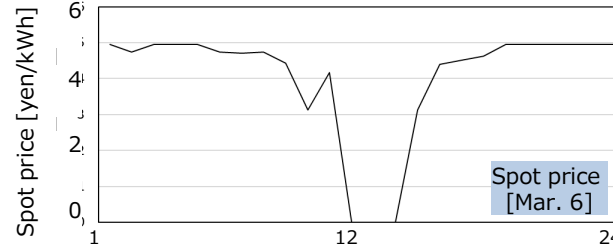
Analysis conditions

Nighttime operation case and optimized case (same as 3-2)

[1] Yohei Yamaguchi et al, Building stock energy modeling considering building system composition and long-term change for climate change mitigation of commercial building stocks (2022)

[2] Yohei Yamaguchi et al.: "Estimation of Electricity Demand Flexibility provided by Heat Pump Water Heater equipped in Commercial Buildings," presented at 38th meeting of Japan Society of Energy and Resources

Analysis results



Annual power demand usable as adjustment capacity ('30 Iwaki City)

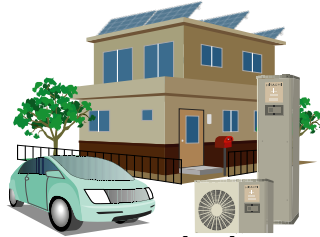
- Even assuming 100% HP penetration in business sector, time shift amount is only 1.47x of households.
- Local transition should be supported with targeted subsidies for welfare facilities, etc., where hot water demand is high and installation of storage tanks is relatively easy.
- Energy procurement costs are reduced by 6.1%.

3-5 Demand flexibility generated from regions in Japan

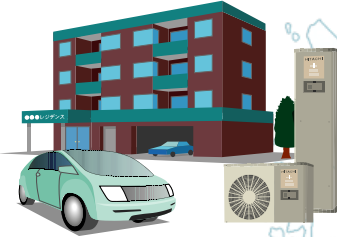
Estimate of annual demand flexibility producible in 2030 nationwide based on number of households and total floor space.

Demand flexibility that is beyond storage systems and pumped storage power generation is anticipated.

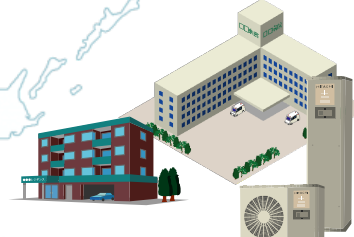
Type



Detached houses
HP: 4.44 %
EV: 7.3 %



Apartment complexes
HP: 15.2 %
EV: 7.3 %



Welfare facilities

Size of demand flexibility nationwide¹⁾

14.1 TWh/year²⁾ + 9.7 TWh/year²⁾ + 9.4 TWh/year³⁾

Total
33.2 TWh/year

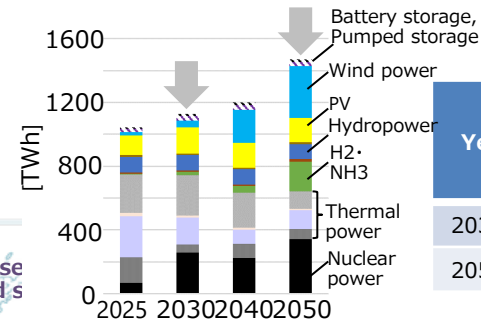
Energy saving effect of nationwide HP use

2.4 TWh/year²⁾ 1.0 TWh/year²⁾
(21.1%)

Nationwide energy procurement costs

49.3 billion yen/year Reduction
(8.16%)

Note: Calculation based on assumption of increase daytime spot price by 1 yen/kWh due to demands



Equivalent to 230 TWh/year if HP and EV penetration is 100%

| Year | Battery storage [TWh] | Pumped storage [TWh] |
|------|-----------------------|----------------------|
| 2030 | 14.2 | 27.8 |
| 2050 | 16.7 | 24.1 |

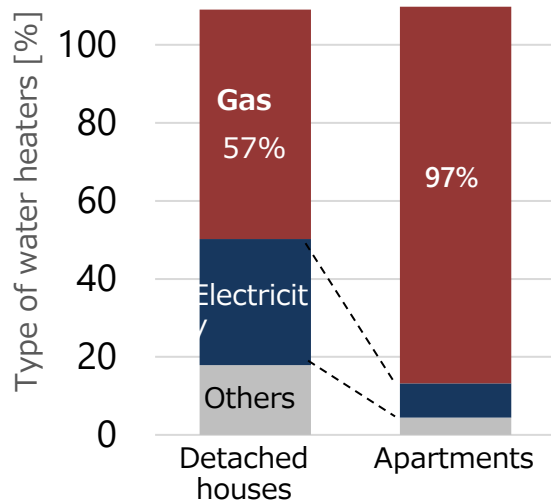
Nuclear power use scenario

- Calculations based on analysis of Machida City for detached houses and apartment complexes and Iwaki City for welfare facilities.
- Created based on base transition values in "Estimates of household types by municipality, based on consideration of population change, housing type selection, residential energy saving technologies, and electrification; and of CO2 emissions by region," Center for Low Carbon Society Strategy.
- From "Energy and Economic Statistics Handbook (2022)" (Quantitative Analysis Unit, Institute of Energy Economics) data of total floor space by business sector and industry, assuming 100% HP penetration rate

3-5 Current state and challenges of energy use related to expansion of regional adjustment capacity (1)

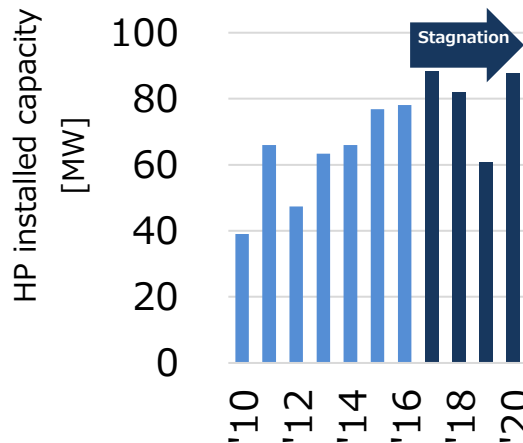
Challenge is to break through stagnation in installation of heat pump water heaters and industrial heat pumps in slow-to-change apartment buildings.

High percentage of apartment buildings have gas water heaters.



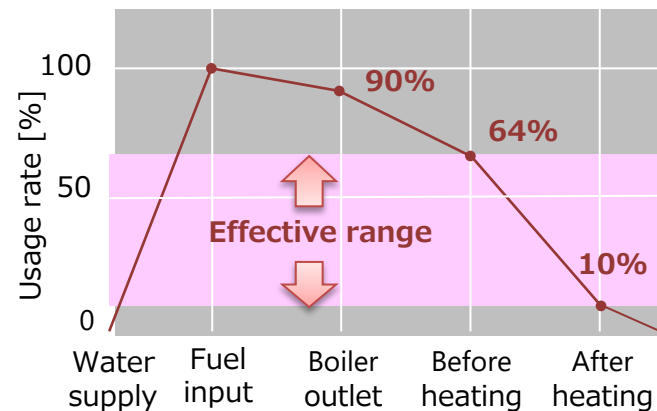
Percentage of water heater type in homes (multiple responses allowed)¹⁾

Stagnant deployment of industrial HPs.



Industrial HP installed capacity by year²⁾

Large loss in piping heat in steam heating process.



Measured effective steam utilization rate³⁾

Necessary to visualize energy usage status and provide engineering support to promote electrification in stages that does not interfere with main business of companies. (From interviews).

1) Created based on "2019 - Understanding the current energy situation in Japan," Ministry of the Environment

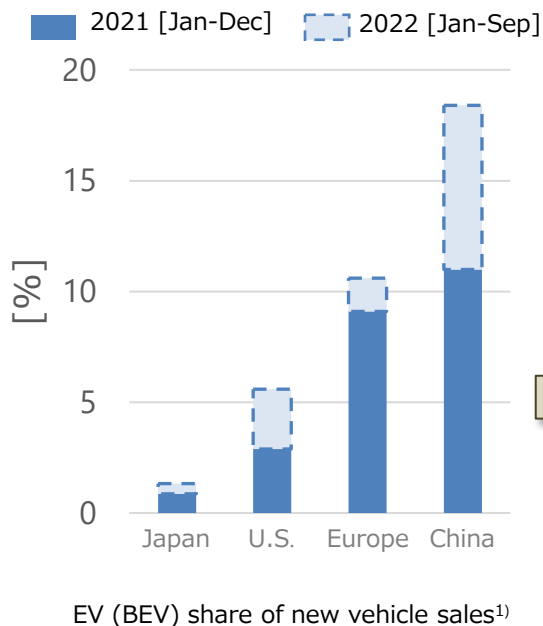
2) "FY2020 results of survey on amount of industrial heat Pumps installed," Japan Electro-Heat Center

3) Created based on "Industrial heat pump usage guide," Japan Electro-Heat Center

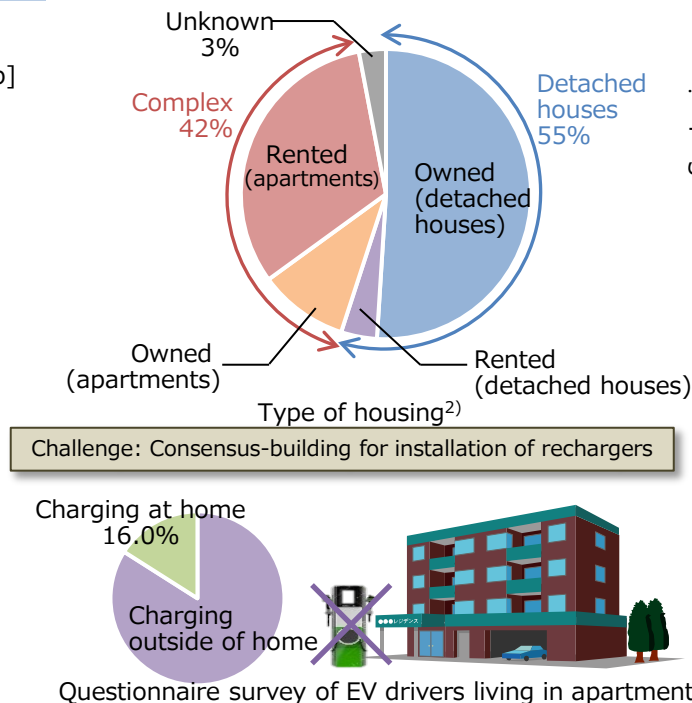
3-5 Current state and challenges of energy use related to expansion of regional adjustment capacity (2)

Acceleration of EV penetration in Japan is a challenge. In addition to subsidies, it is important to share successful examples of installation of charging facilities in apartment complexes and to build service systems to improve attractiveness of EVs.

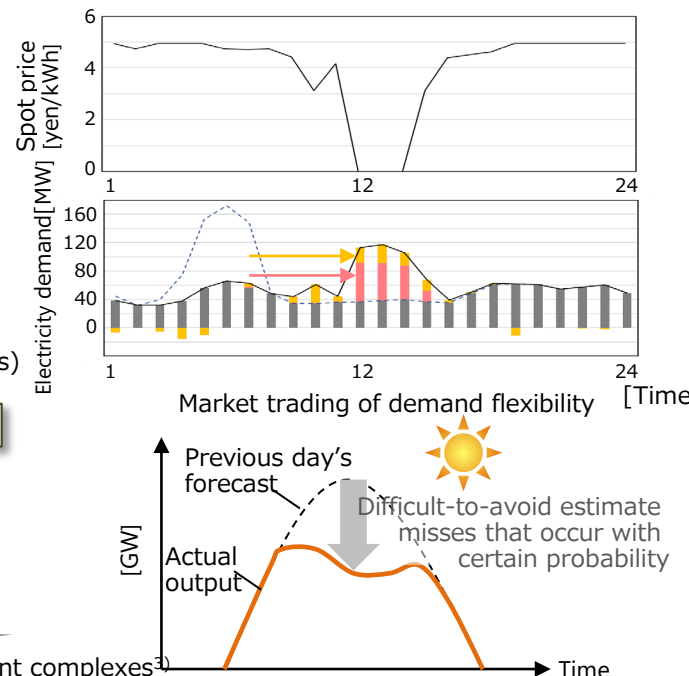
Sluggish growth of EV share



Spread of EV to apartment complex residents



Increasing attractiveness of EVs



Reserve capacity/demand flexibility when estimate is missed

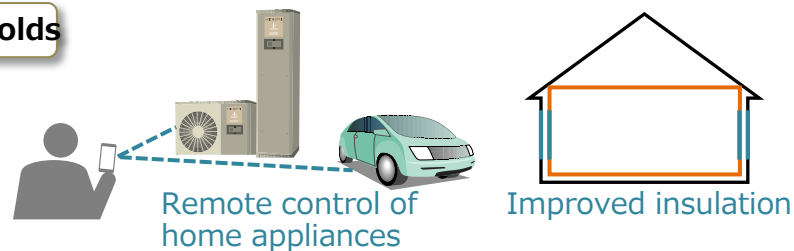
- 1) Created based on "EV-DAYS" (November 2022), TEPCO Energy Partner
- 2) Created based on "Material 4 Residential status by household type," MLIT
- 3) Created based on "Is EV charger necessary for condominiums and apartment complexes? We explain the benefits of installation!", ENECHANGE

4. Measures for smooth regional transitions

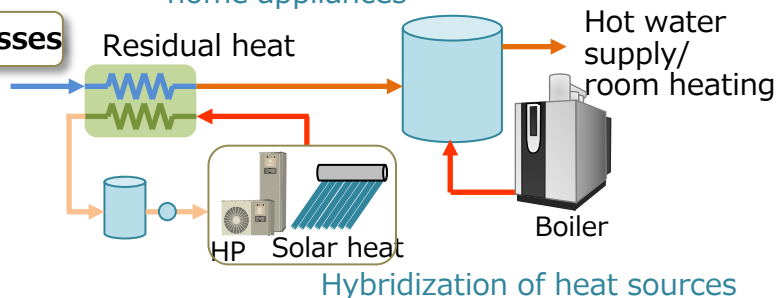
4-1 Social implementation of platform in stages

Acceleration of smooth social transition with decarbonization methods in stages and platform collaboration.

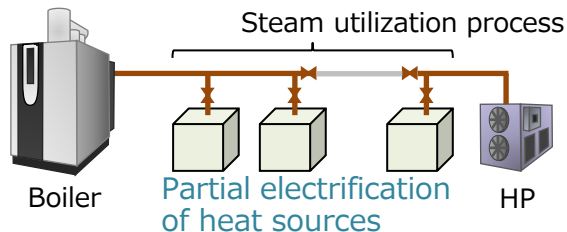
Households



Businesses



Industries



Decarbonization and upgrades in stages based on regional characteristics

2023 2030 2035 Year

Equipment with energy storage functionality

Accelerate with multiple options

Coordination and control platform

Field testing Implementation Spread

Edge technologies

Separate functions Linkage

Individual

Convenience Energy cost containment Demand flexibility compensation

Community

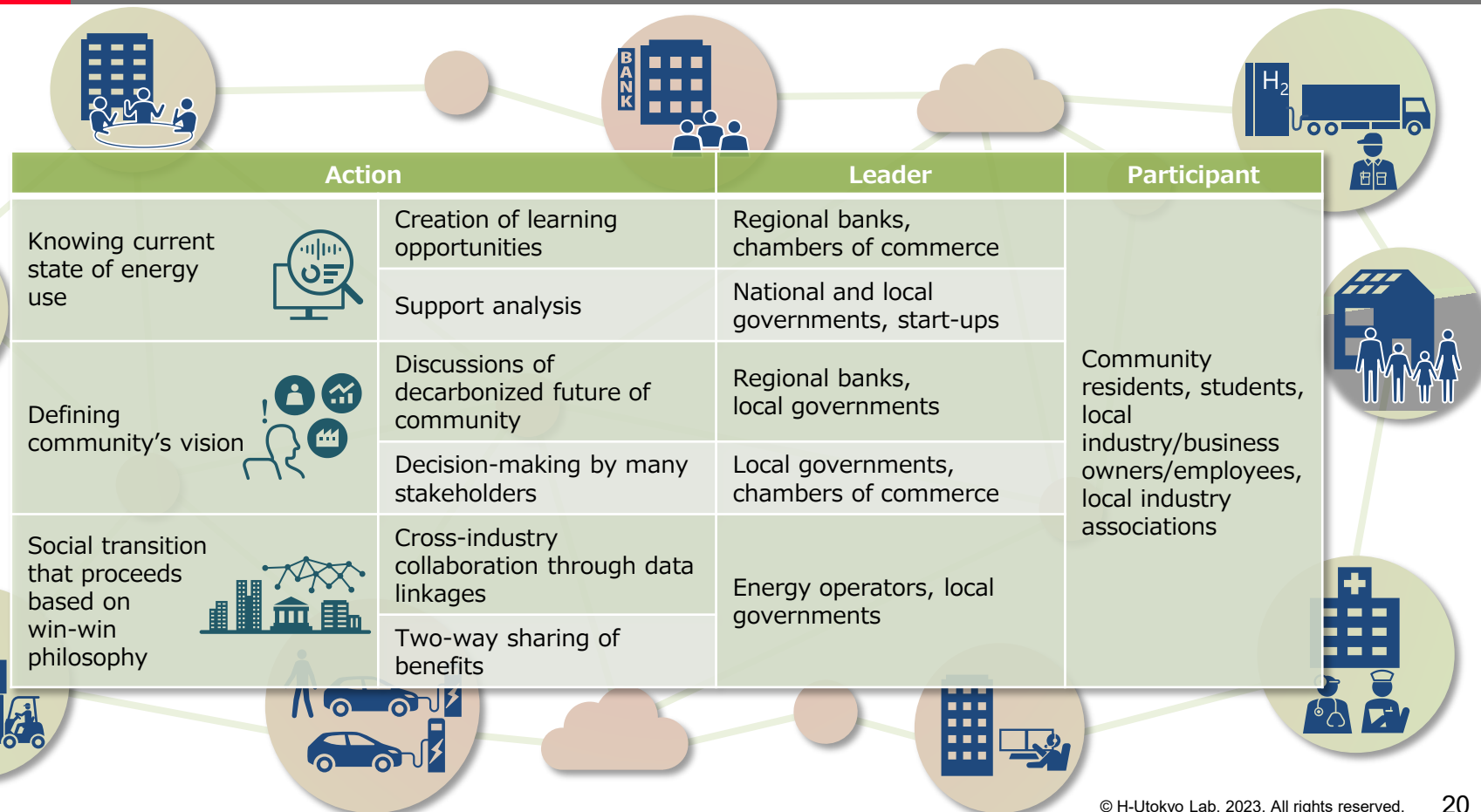
Energy value creation Resilience Attractiveness of cities

W/W

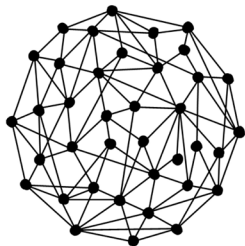
Sharing of case studies

Social implementation of platform in stages

4-2 Actions for smooth transitions



- In local communities, challenges are **securing S+3E of energy**, including dealing with fuel price hikes and energy shortages, and transition to **decarbonization based on local characteristics**.
- Important steps are accelerating deployment of decarbonized power supplies and **reducing emissions**—measures include electrification of heat sources in residential, business, and industrial sectors. In addition, **creating demand flexibility from regional power demand** will contribute to reducing costs and accelerating transition to decarbonization.
- Based on win-win philosophy, it is necessary to **create demand flexibility from local residents and transportation sector** through use of HP water heater and EVs. The time shift amount by 2030 is **33.2 TWh/year**. To realize this goal, it is necessary to promote **widespread use of equipment and facilities with necessary functions and to implement coordination and control platform** in society at early stage.
- For introduction of industrial decarbonization equipment and facilities, it is important to **establish engineering service system for planning and design, and to discuss in advance mechanisms for ensuring best practices**, in addition to providing economic support for deployment of such equipment and facilities.
- In CN of local communities, what will accelerate future is **providing means to support transition in stages**, clarifying roles and participation of all, and having **collaboration among different industries through data linkages**.



H-UTokyo Lab.