2017 IERE-TNB Putraja Workshop :Technologies Shaping the Electric Supply Industry

Decentralization and Cooperative Management in Electric Energy System

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November 22, 2017

Advanced Research Organization for Smart Society

Waseda University

Change in the electric energy policy through “3.11”

March 11, 2011

After “3.11”

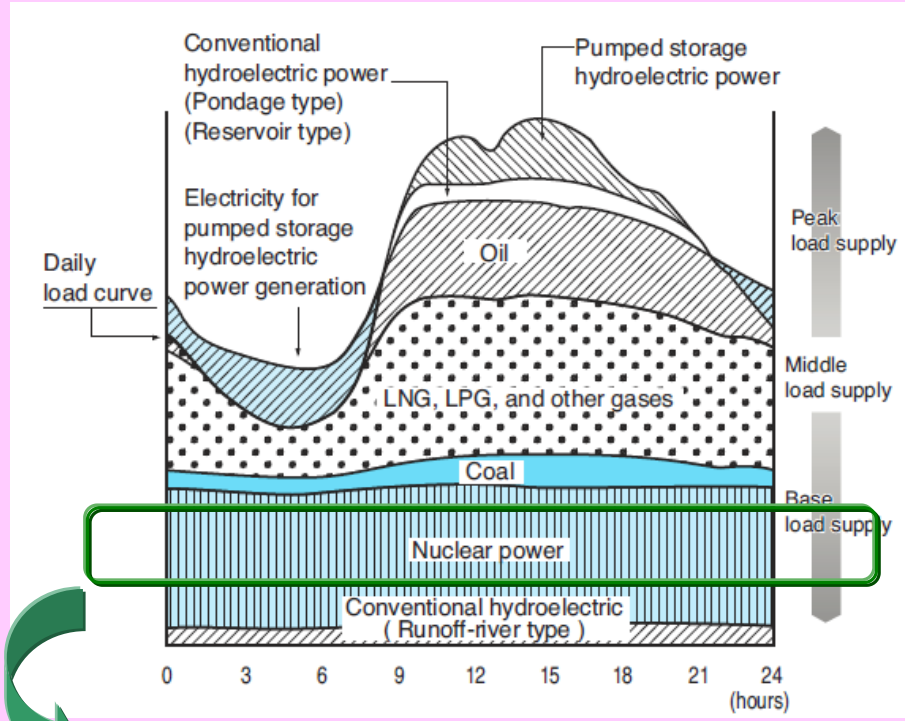
Before “3.11”

Realization of Low Carbon Society by deploying energy management system

- ✓Installation of high-efficiency equipments & appliances
- ✓Integration of renewable energy
- ✓Integration of EV/PHV
- ✓Balancing demand-supply for electricity & gas

etc.

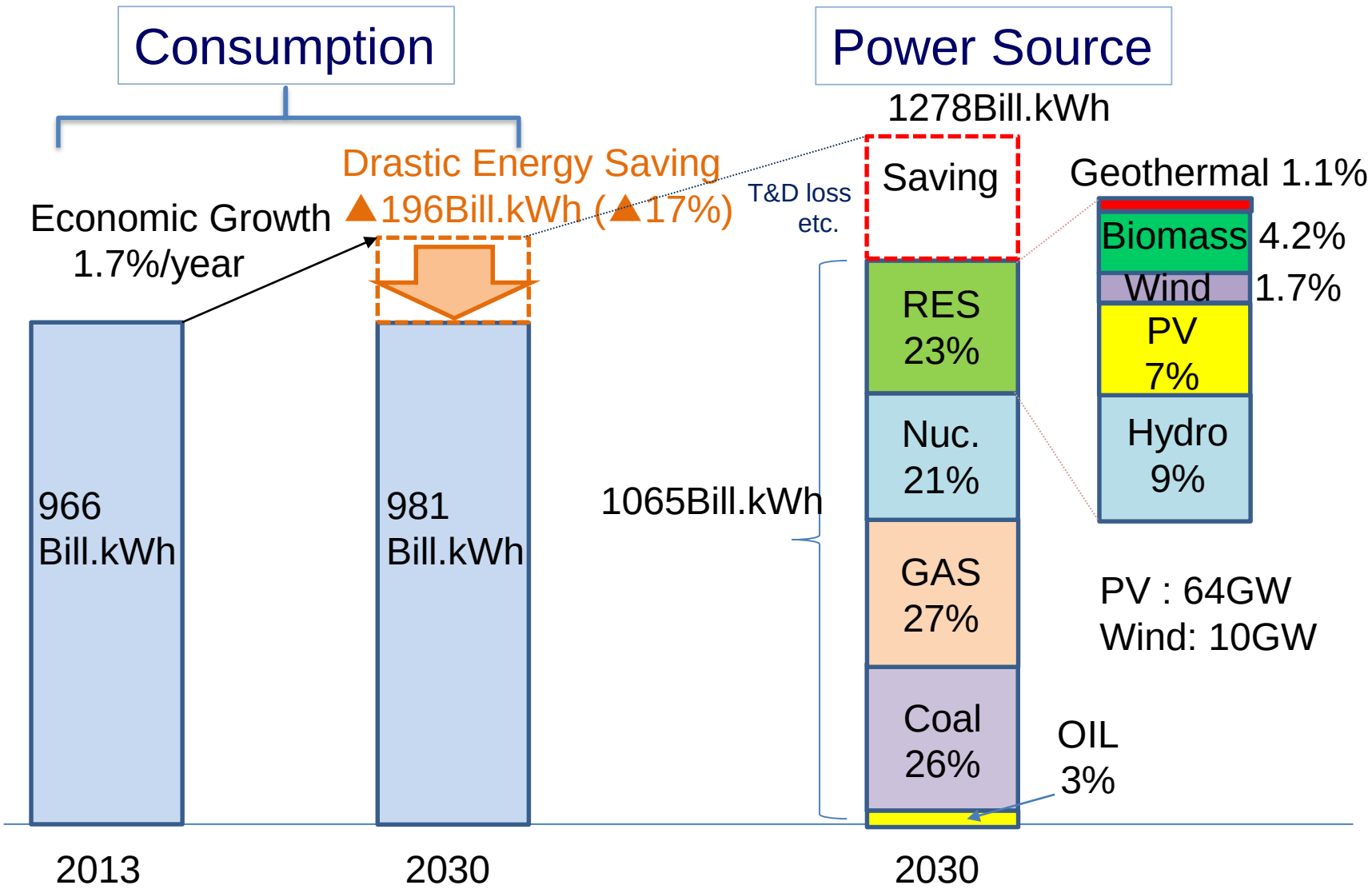
\+ Electricity saving
Peak cut in electricity demand



Lost significant amount of base load supply

Long term perspective of electricity demand & supply

COP21 Paris Agreement : GHG deduction by 26% from 2013



Energy Policy & Innovation on Demand side

Foundation of the Policy

- Elevating Energy Self-Sufficiency : 6% → 25%
- Reducing Energy Cost : lower than present
- Reducing GHG Emission : ▲26% (base : 2013)

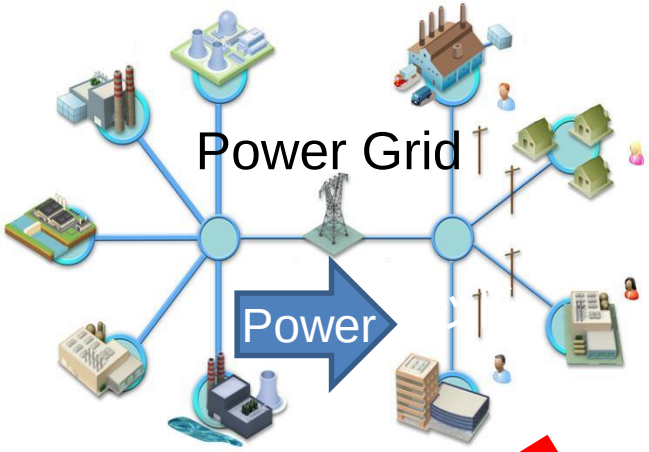
Supply Side

- Electric Power System Reform
- Mixed use of various resources while increasing RES

Demand Side

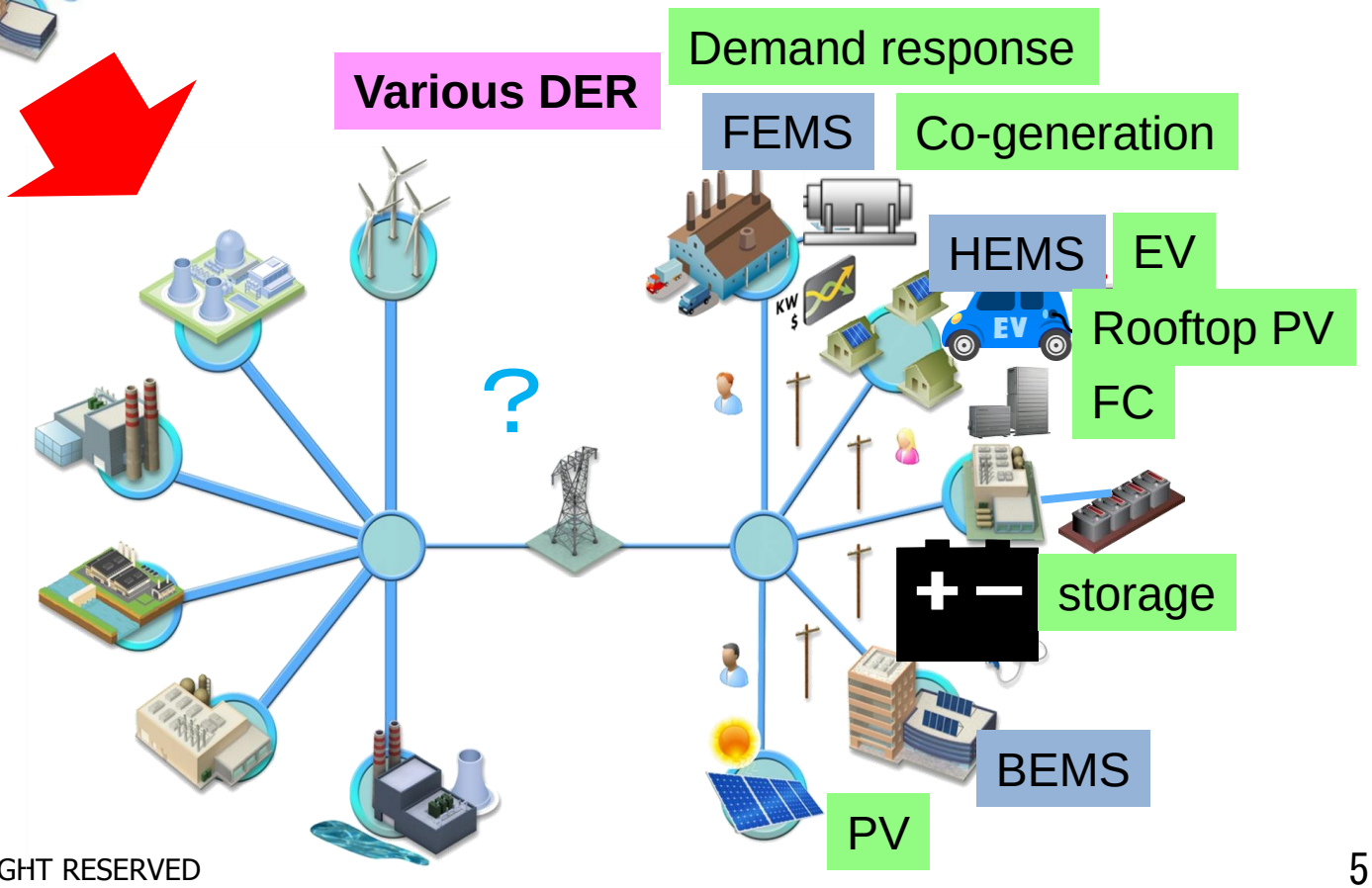
- Smart Energy Saving : Energy Management / FEMS, BEMS, HEMS
  → NET Zero Energy House / Building (ZEH / ZEB)
- Smart Demand : Demand Response
- Co-Generation, FC
- EV / PHV
- Battery, Storage

Transition of Electric Energy System



Bulk Generation

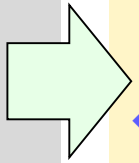
- New DERs at the end of the Grid
  - ✓ low visibility, uncontrollable
  - ✓ Accommodate these “disruptive” technologies



Paradigm Change in Electric Energy System

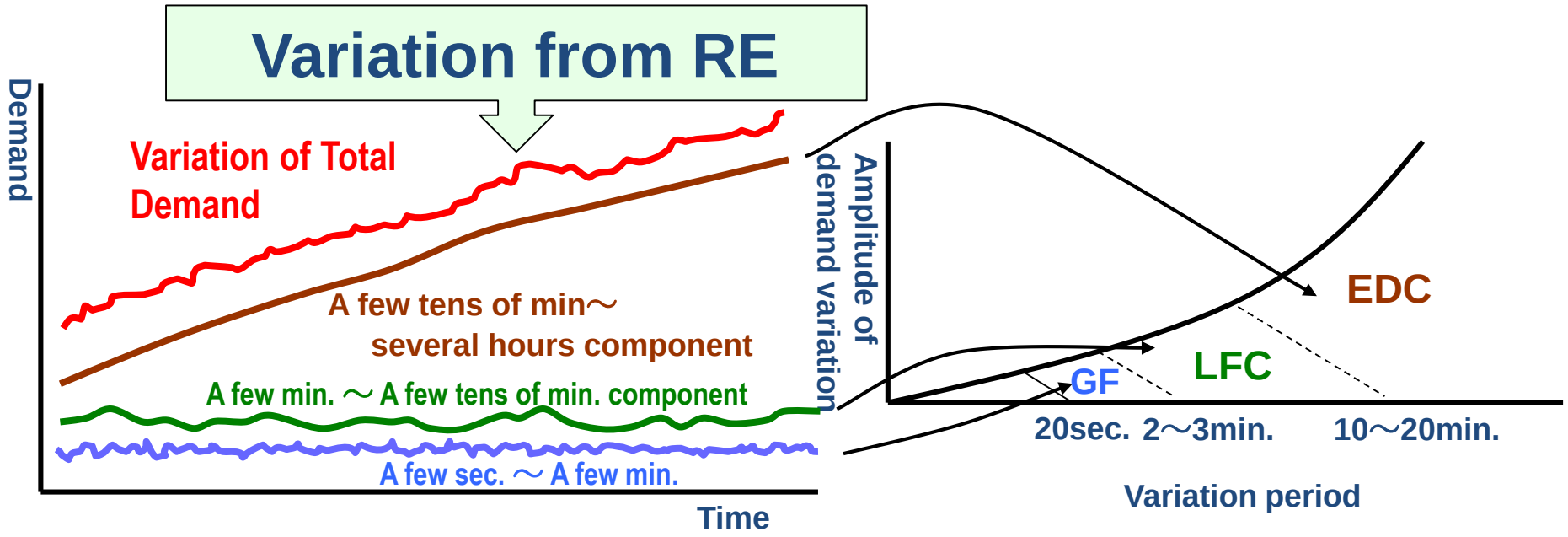
✓ Electric Power System Reform
✓ Large scale RE installation

- Large Power Plants + Bulk Grid
- Demand : Given (Forecast)
- Vertically Integrated
- Power Flow : one way
- Basically Dispatchable Generation



- Cooperation with Distributed System
  - Various Resources: e.g. EV, Battery
  - Integration vs Local Optimum
- Demand : Control
  - DR, Nega-watt Trading
- Horizontally Divided
  - New Rules, e.g. Simultaneous Equivalence
- Power Flow : bi-directional
- Intermittent (Renewable)

Supply-Demand Balance Control



- **EDC（economic load dispatching control）**
  Forward control based on demand prediction
- **LFC（Load Frequency Control）**
  For unpredictable demand variation (1～2% of total demand)
- **GF（Governor-Free）**
  For fast demand variation which can not be covered by LFC

Challenges in New Paradigm

New Electric Energy System

- ✓ Two-way power flow
- ✓ Combination of central & distributed control
- ✓ Co-existence of different optimization : supply-demand balance & new values
  - maximum use of renewable energy recourses
  - efficient use of energy including heat, transportation, etc.
- ✓ Resiliency : preparation for emergency

New kind of Control for Grid Operator

Demand Response and PV Generation

- ✓ Not necessarily owned by grid operators
- ✓ Various sizes
- ✓ The smaller, the larger the number

RIANT Overview

RIANT : Research Institute for Advanced Network Technology

Director
Prof. Y. Hayashi

+

11 Faculty Members

+

Research Associate
Dr. S. Yoshizawa

<Research Member>

Prof.
H. Ishii

+

Assoc. Prof.
Y. Fujimoto

Assoc. Prof.
M. Ito

+

4 Regular Researchers

12 Adjunct Researchers

Research Area

- Distribution network operation methodologies and algorism
  - voltage regulation
  - loss minimization
- Home Energy Management and Human Comfort
- Data analysis and application
  - Forecast : demand, RE generation

National Project

- Distributed cooperative EMS (CREST)
- Home Energy Management + Demand Response & Standardization
- WP & PV variation mitigation in power grid + Smart Inverters
- International Standardization of Communication connecting Grid and Customers

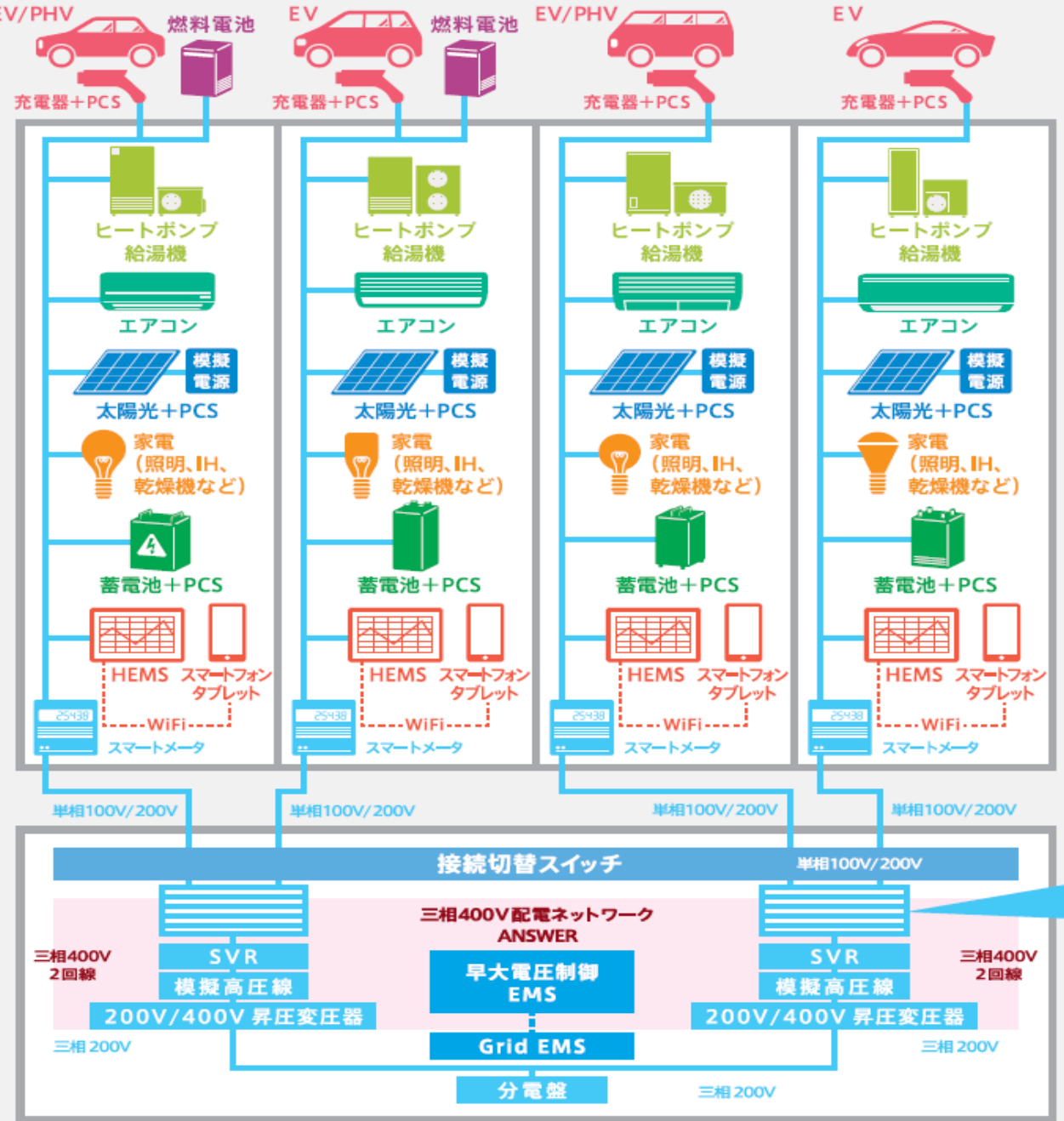
Shinjuku Demonstration Center Layout

スマートハウス

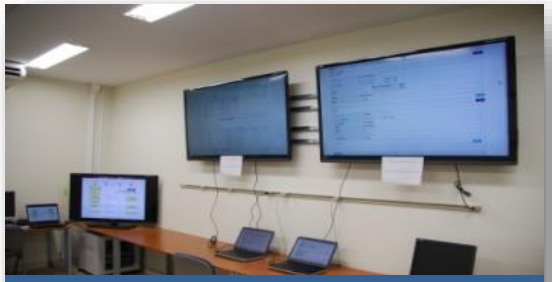
棟内写真（2012年９月撮影）

配電系統制御模擬システム（ANSWER）

イメージ写真



Devices and Appliances in Shinjuku Demo. Center



DRAS

Smart Houses

Smart Meters

Smart GAS Meter

Analog Grid Simulator (ANSWER)

HEMS

Air Cond.

PHV/EV

Charger

Fuel Cells

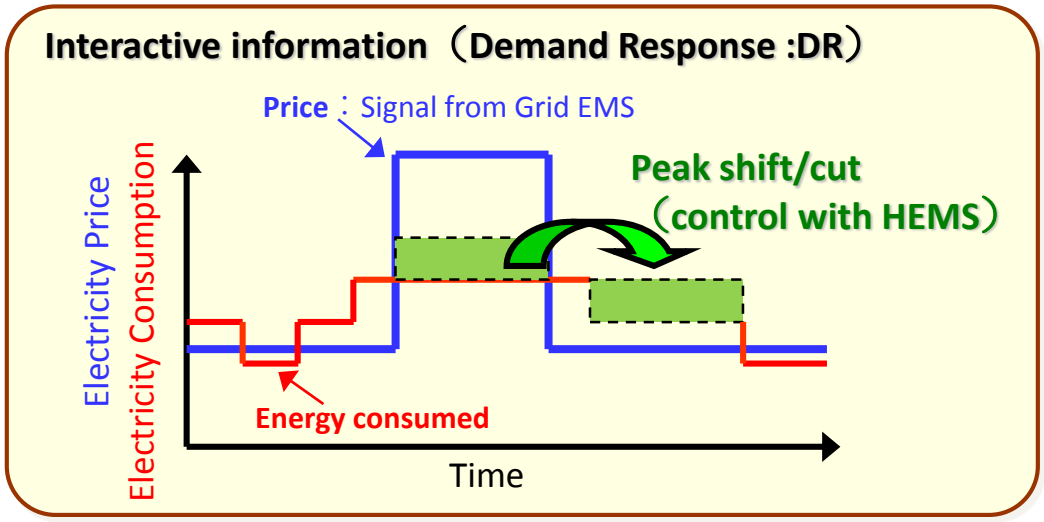
Heat Pump Water Heater

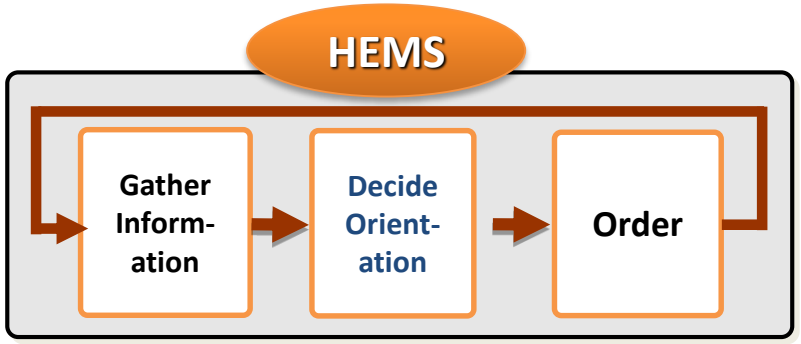
Battery

Distribution Boad

PCS for PV

Demand Response Test with Demand Side Equipment





Distribution Network Simulation System
（ANSWER）
- Voltage control
- Current control

Smart Meter

Route A

Route B

DR Signal →

← Evaluation

HEMS

Smart control
Peak Shift/cut

International Standard Protocol

EV/PHV

PV

Fuel Cell

Charge/ Discharge Control

Output control

DRAS and Head End System
- meter reading
- DR Signal output
  - TOU
  - Change of contract capacity
  - Load control

Internet

Route C

Current Control

Current Control

Air Conditioner

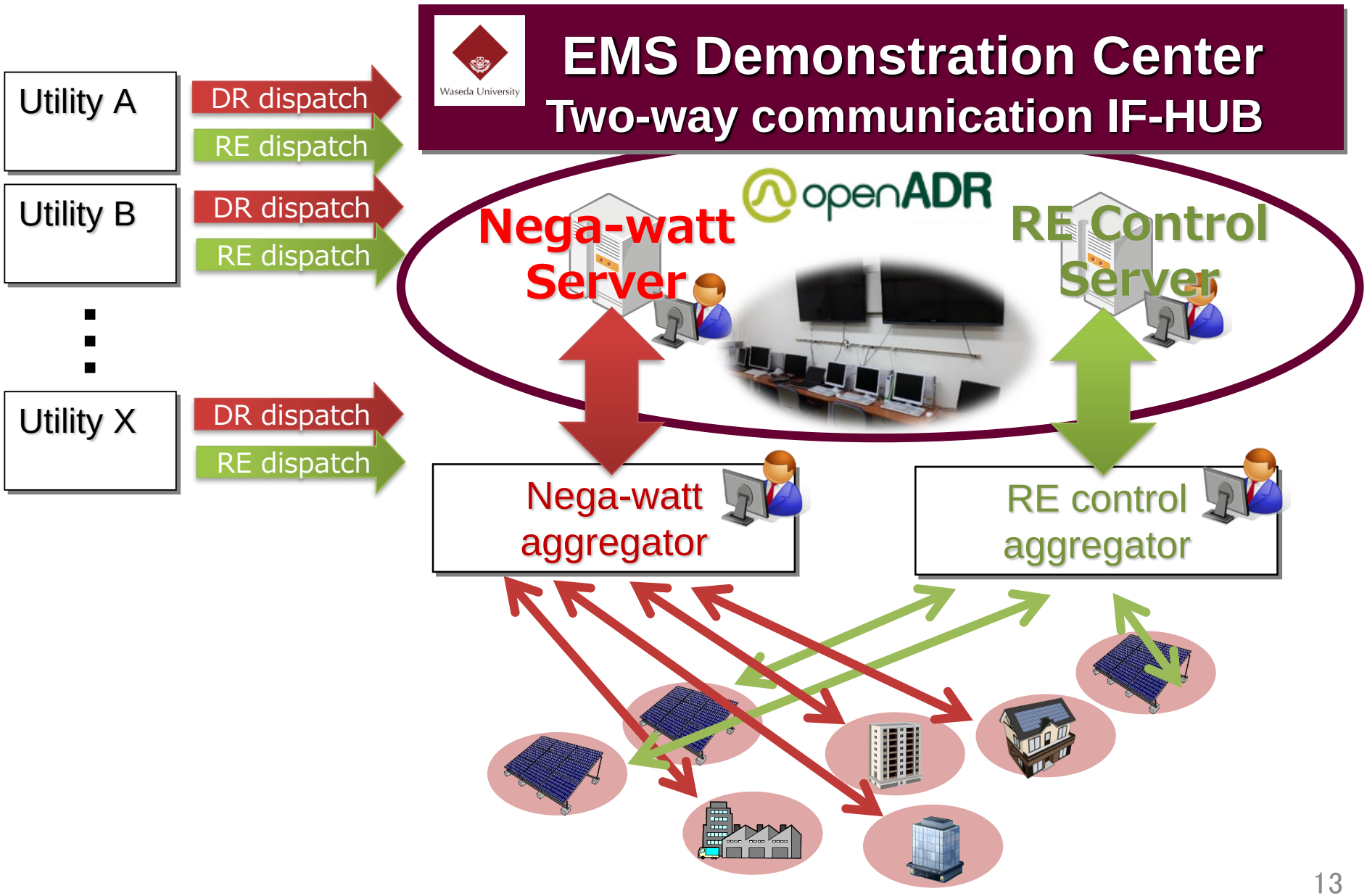
Light

Heat Pump Water Heater

Battery+PCS

wire
Current
Information

DR & RES Dispatch Center



Research Perspective

Distribution line voltage control

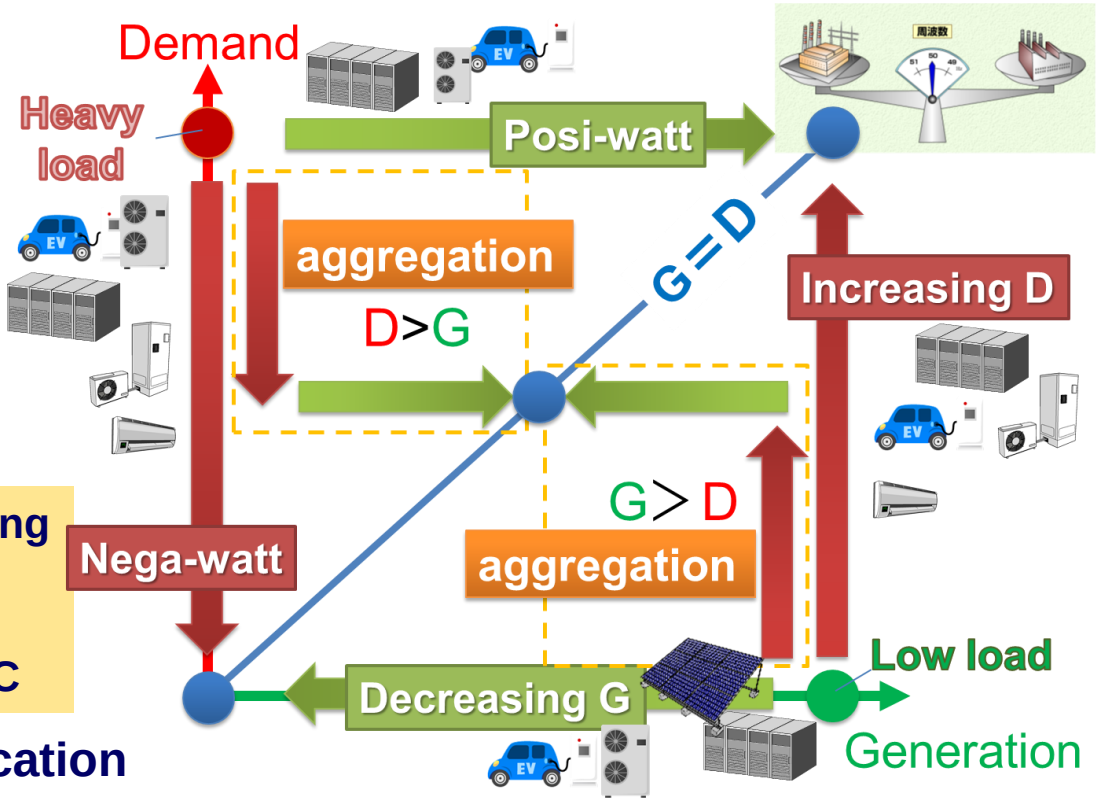
- Sensing : voltage / current
- Utilizing AMI
- Autonomous / Central control of voltage regulators (SVR, LTC, etc.)
- Forecast : Demand, PV generation
- Smart Inverters

Energy Resource Aggregation

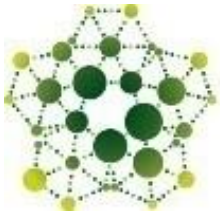
- Cooperative Management & Integration of various energy resources by "aggregation"

✓ Load : Air conditioner, Lighting Water Heater
✓ Storage : Battery, EV/PHV
✓ Generation : PV, Generator, FC

- Architecture, Function Allocation & Standard Communication



Academic Collaboration : CREST (JST)



EMS
ENERGY
Management
SYSTEM

Japan Science & Technology Agency
CREST
Core Research for Evolutionary Science and Technology

"Development of distributed cooperative EMS methodologies for multiple scenarios by using versatile demonstration platform"

WASEDA University

THE UNIVERSITY OF TOKYO

TOKYO TECH Pursuing Excellence

NAGOYA UNIVERSITY

HOKKAIDO UNIVERSITY

TOKAI UNIVERSITY EUROPEAN CENTER

OSAKA UNIVERSITY

Targets of EMS Project

1. Propose integrated cooperative EMS methods for multiple scenarios

G/H/B/MEMS method

Forecast → Plan → Control

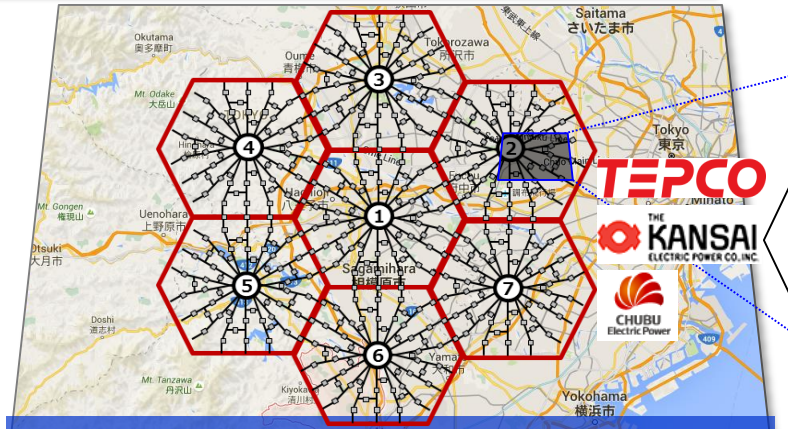
Loss minimization scheme for DS

+

Computer science Economics
Cyber security Satellite data

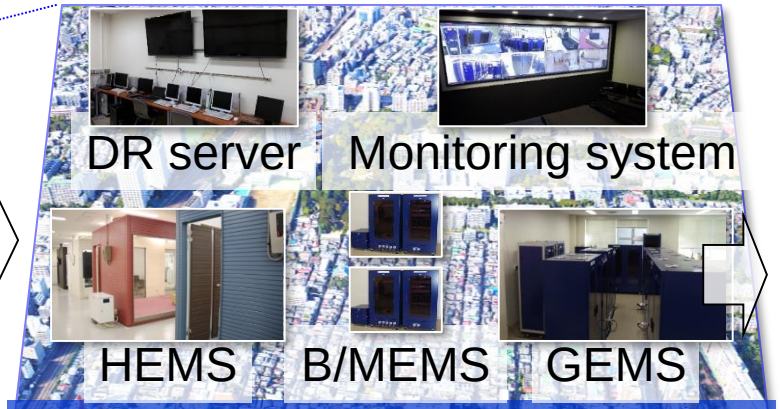
2. Construct EMS platform

Implement



EMS Simulation Model
(Energy cyber field)

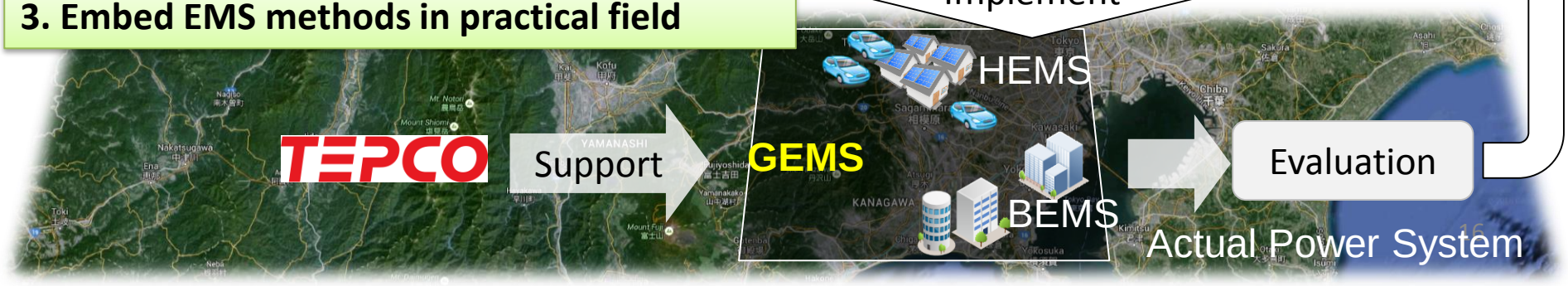
System Link



EMS experimental platforms
@Waseda U (Energy physical

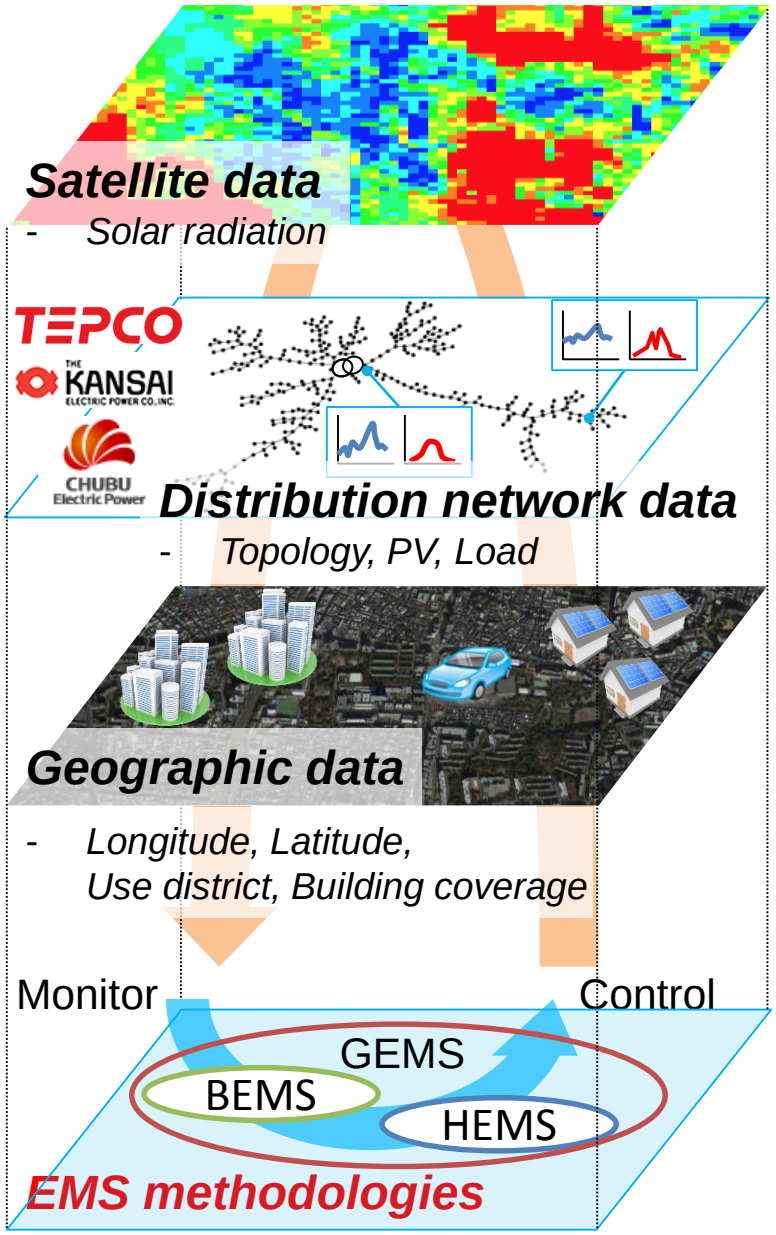
Implement

3. Embed EMS methods in practical field



Concept of EMS Platform for Designing Sustainable Smart City

EMSP for designing smart city

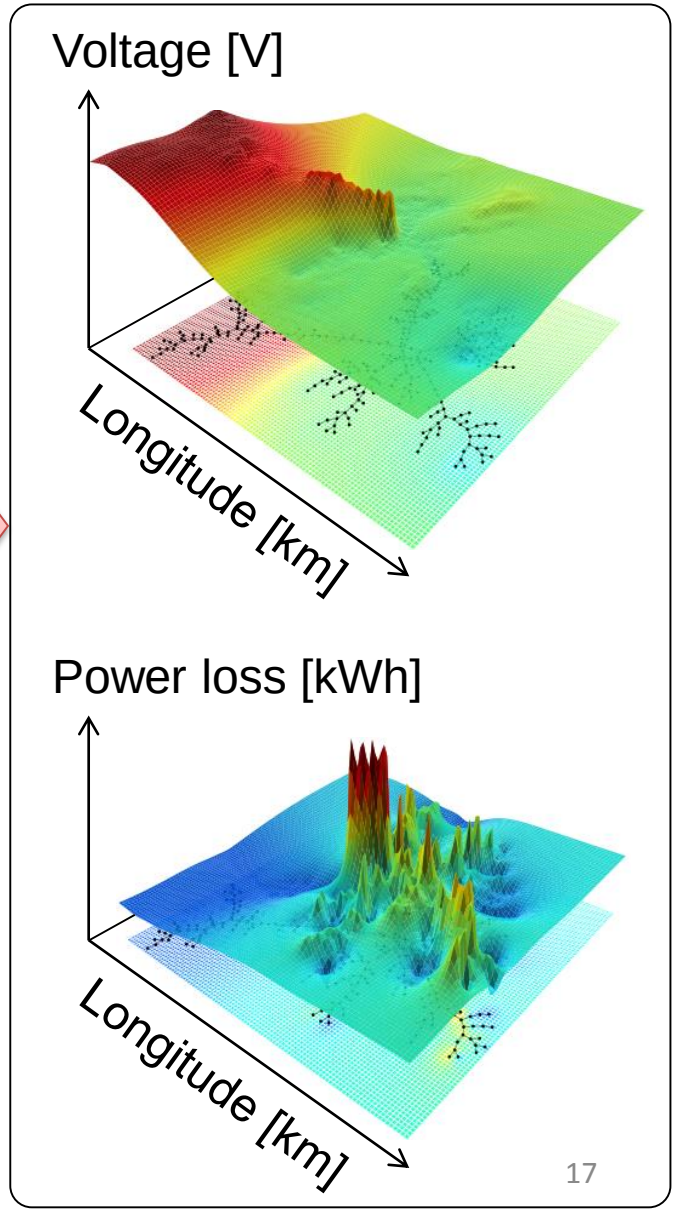


Evaluation

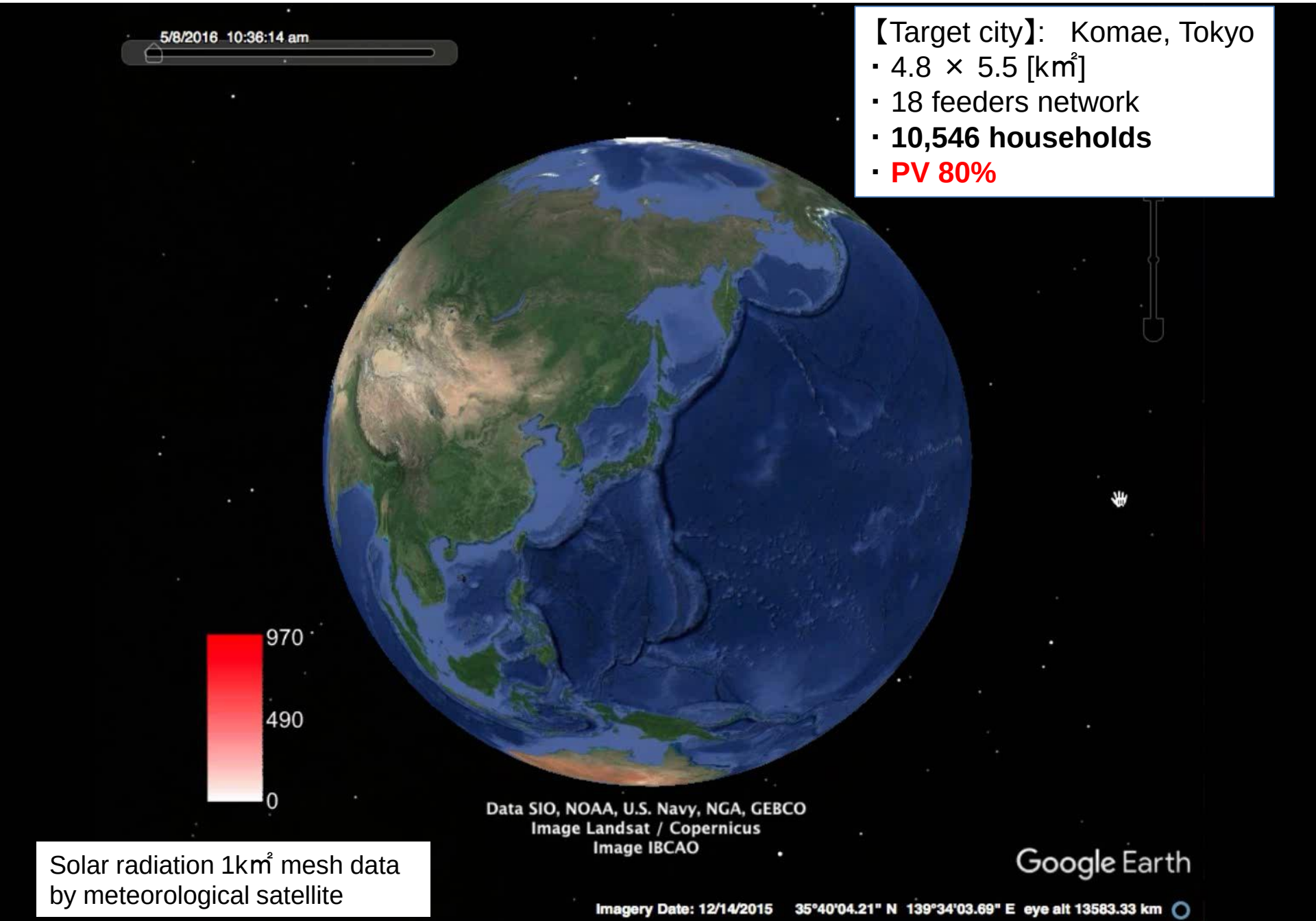
- Voltage deviation
- Distribution NW loss
- PV curtailment
- CO2 emission
- Line capacity margin
- Consumers cost
- Energy self-sufficiency

etc.

Sustainable indices of smart city



Spatiotemporal Modeling of City in EMS Platform

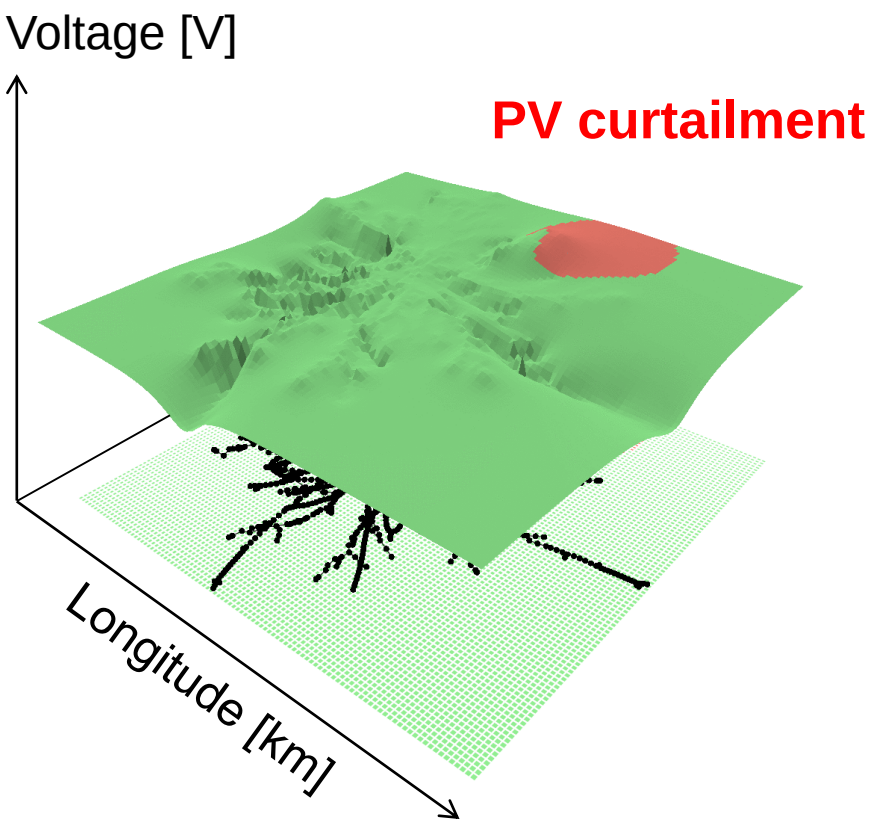


【Target city】: Komae, Tokyo
- 4.8 × 5.5 [km²]
- 18 feeders network
- **10,546 households**
- **PV 80%**

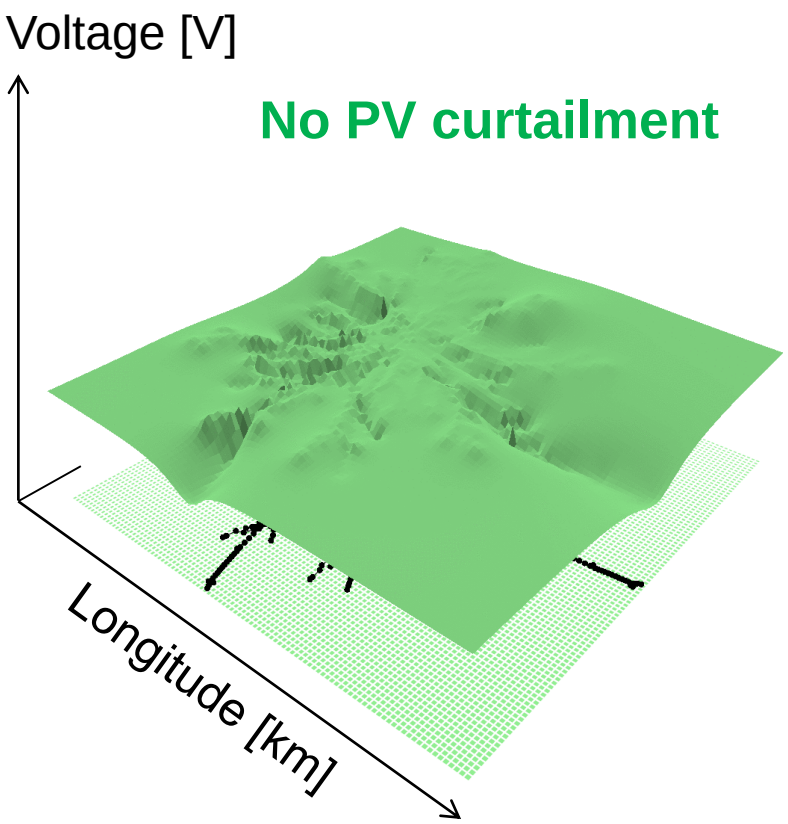
Solar radiation 1km² mesh data by meteorological satellite

Evaluation Result of PV Curtailment in Target City

Conventional GEMS



Advanced GEMS

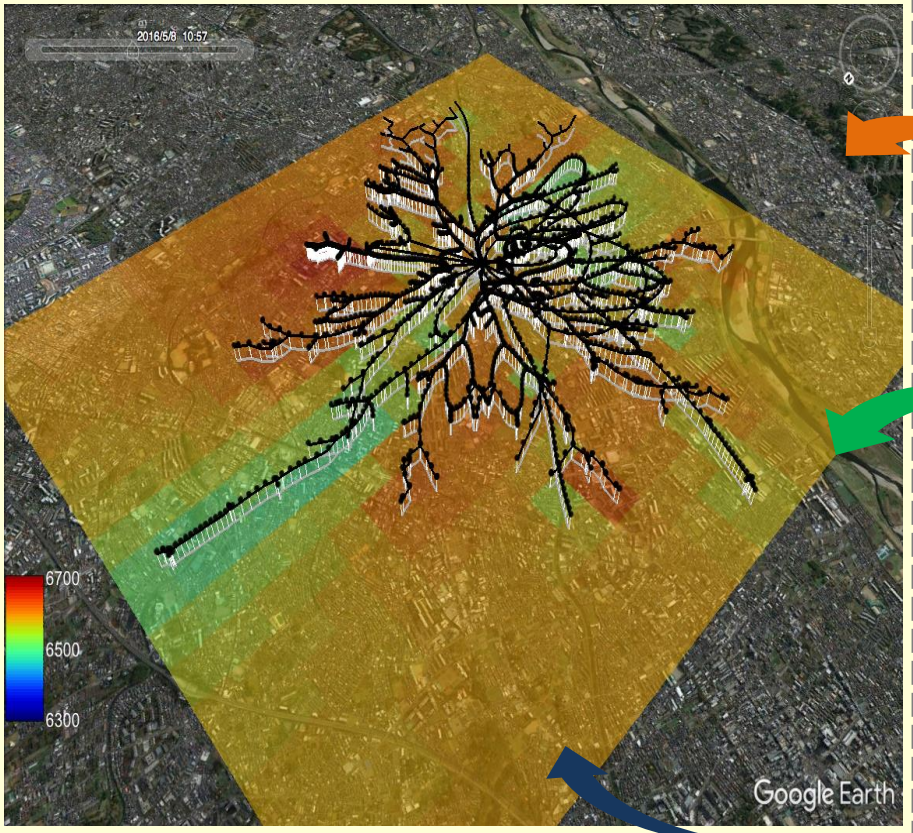


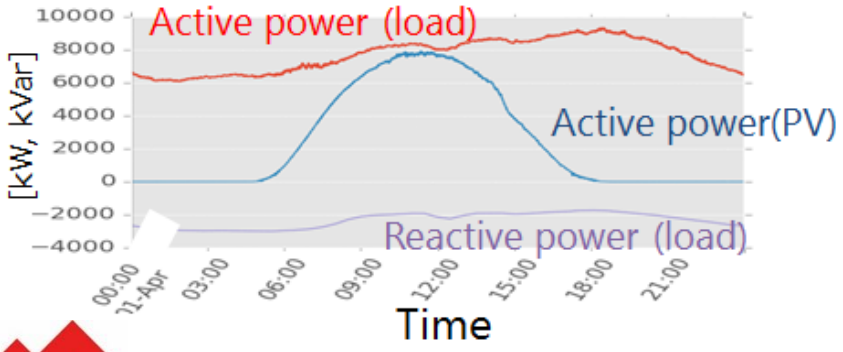
【Target city】10,546 households , PV 80%, 18 feeders

Open DATA based on actual distribution grid

【 18 Feeders Test Model 】

1 substations, **18** feeders, **100** switches,
,total line length **155** km



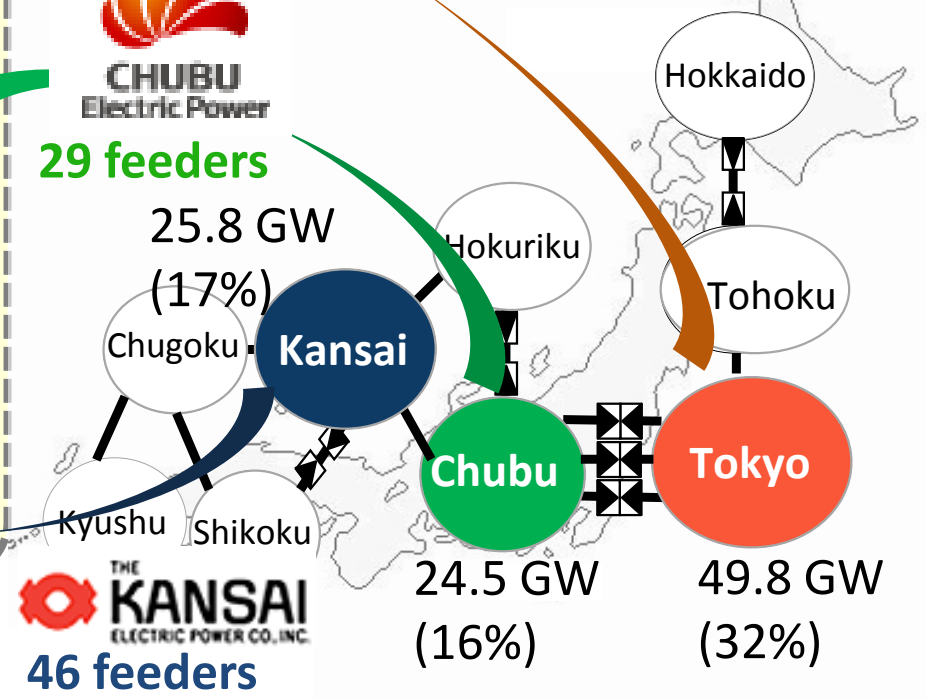


48 feeders

CHUBU Electric Power

29 feeders

Peak load: 152 GW, 2014



THE KANSAI ELECTRIC POWER CO., INC.

46 feeders

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