System Architecture & OpenADR Applicability in the Japanese Integrated Grid

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Change in the electric energy policy through “3.11”

March 11, 2011

After “3.11”

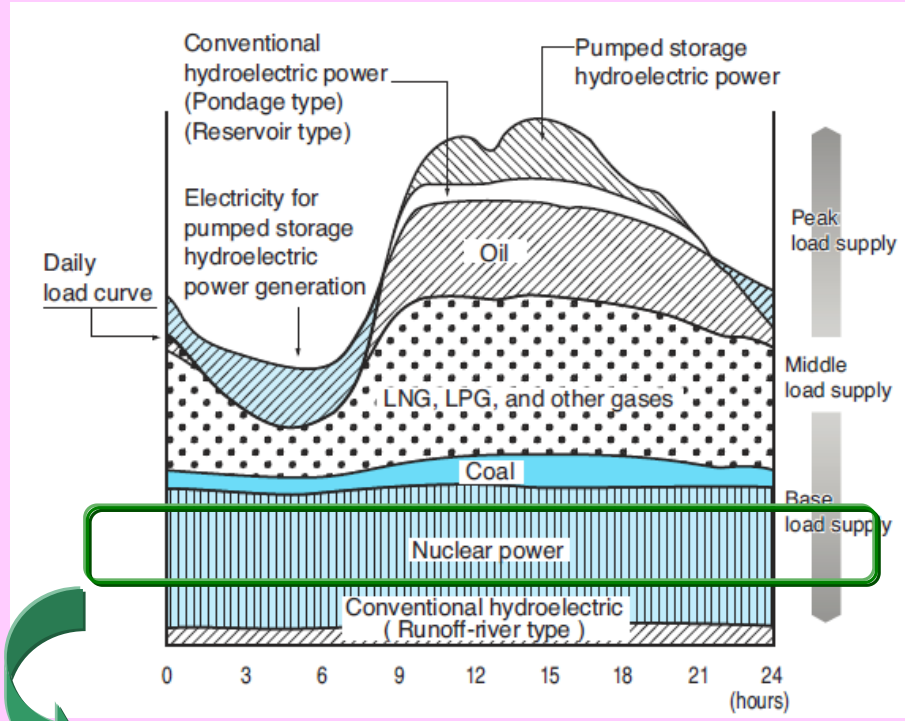
Before “3.11”

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

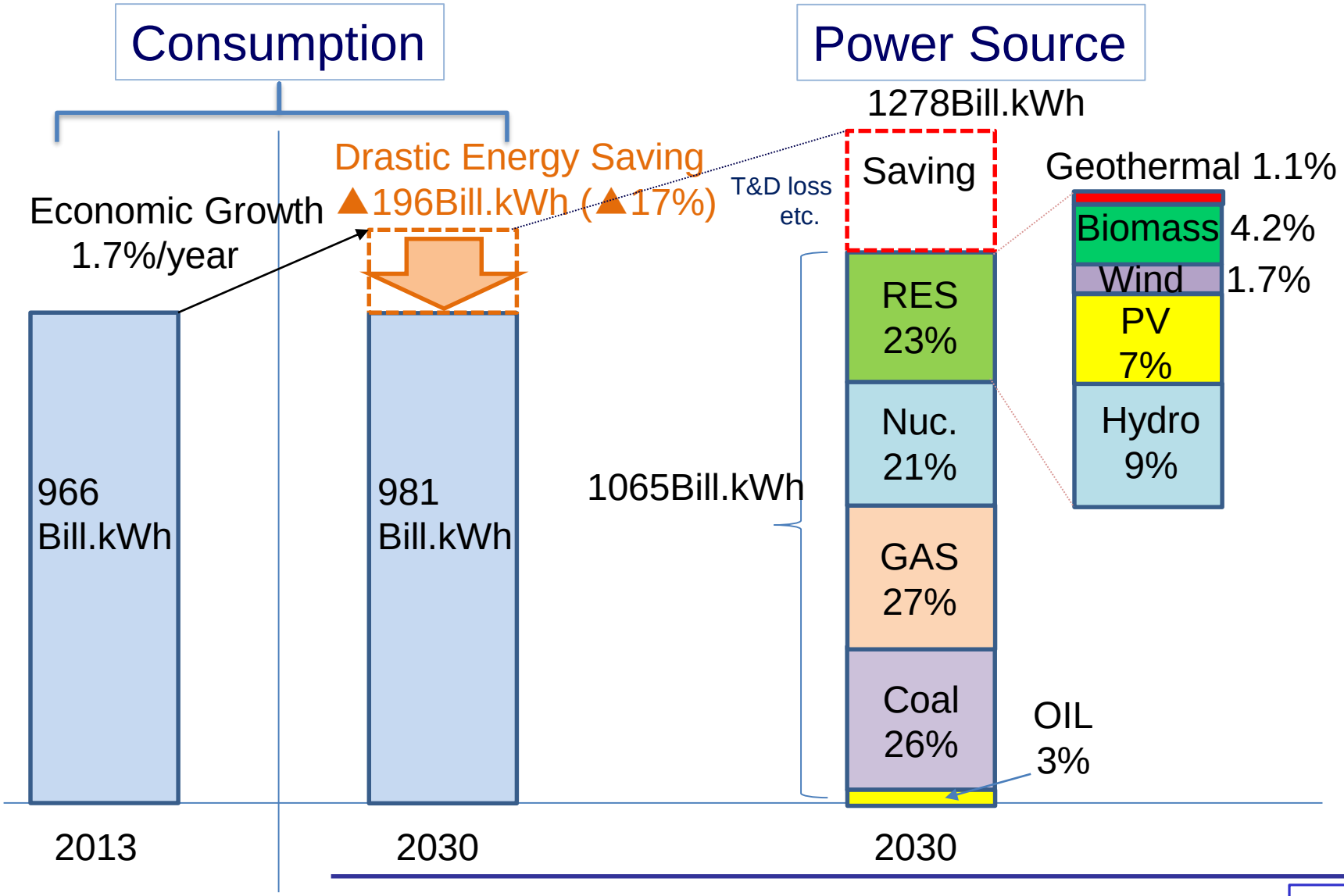


Lost significant amount of base load supply

Long term perspective of electricity demand & supply

The Agency of Natural Resources and Energy, April 2015

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

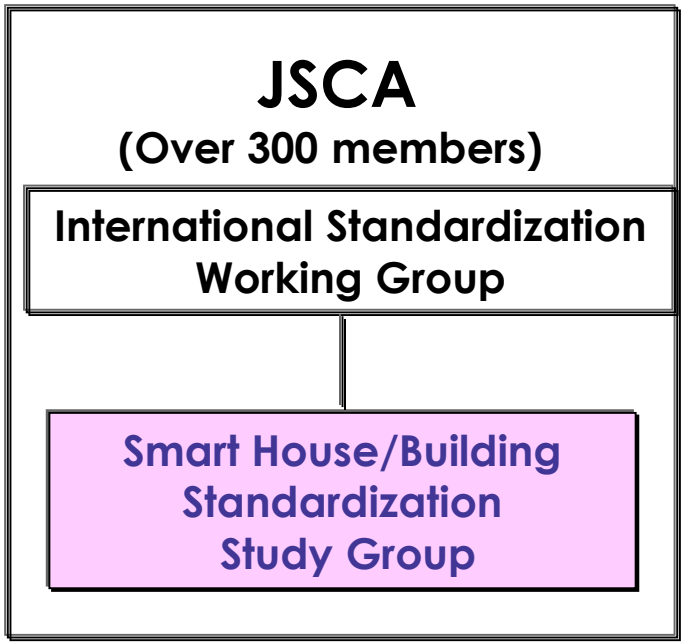
Demand Side

- 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

Smart House and Building Standardization Committee

The Ministry of Economy, Trade and Industry (METI) started the specialized committee under the Japan Smart Community Alliance (JSCA) in June 2012.

- **Purpose**
  - ✓ Standardization of communication interfaces for smart houses and buildings
  - ✓ Development of standards for demand response (DR)



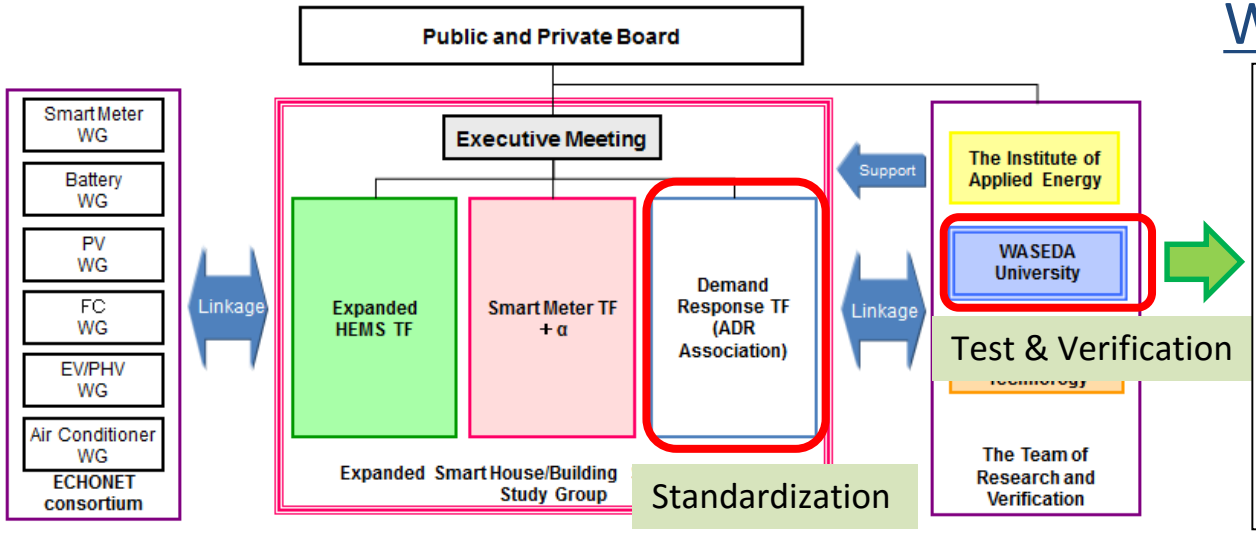
Chairman : Prof. Hayashi, Waseda University

Vice-chairman: Prof. Issiki, Kanagawa Inst. Tech.
Prof. Umejima, Keio University

Members : electronics manufacturers,
home-builder,
automobile manufacturers,
gas and electric utilities,
telecommunication utilities, etc

Secretariat : METI

The Study Group and Demo. Project



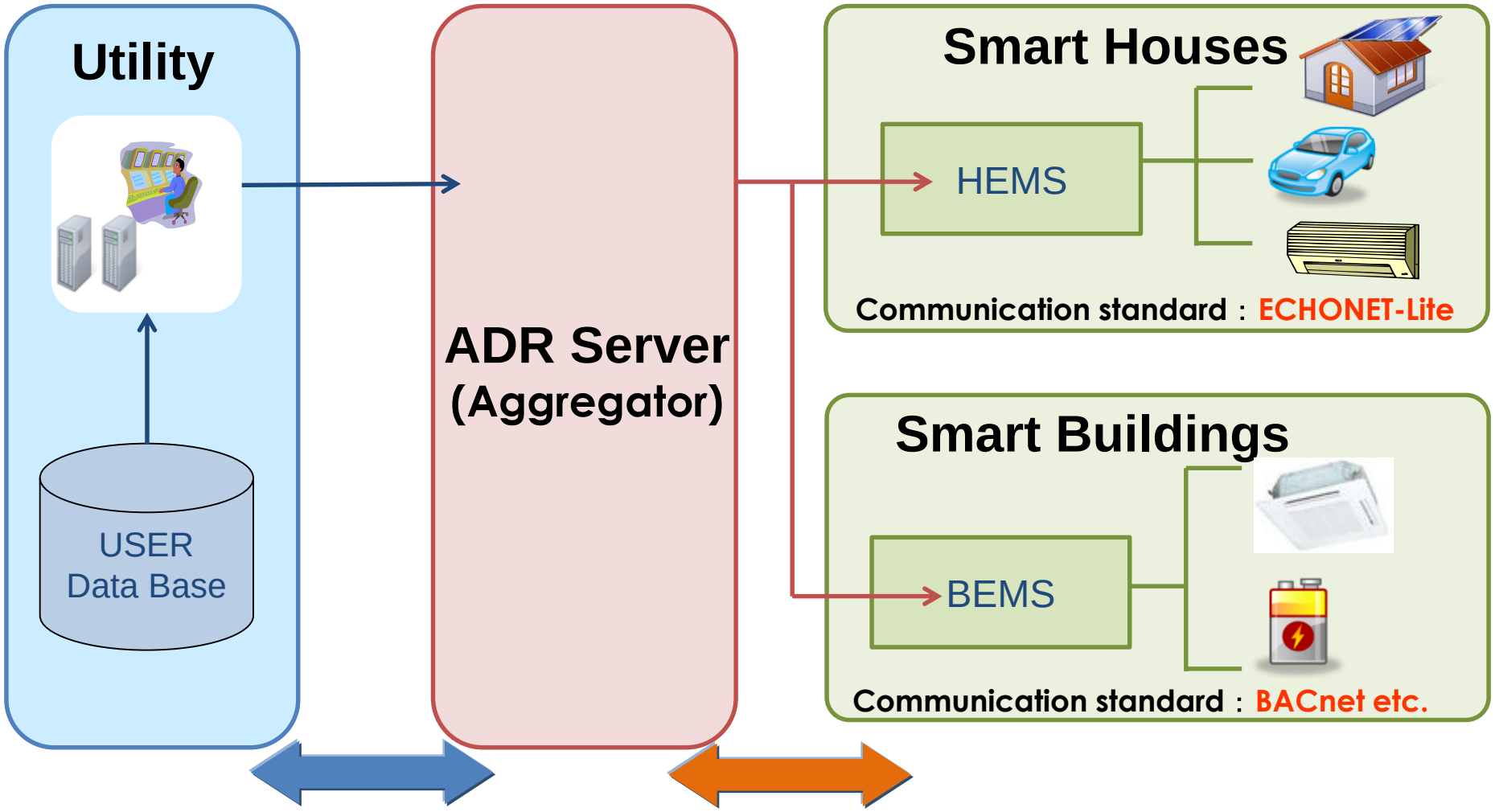
Waseda Project Member

WASEDA University
経済産業省
AsahiKASEI
Ad-Sol Nissin
大阪ガス
OMRON
関西電力
KDDI
九州電力
SHARP
住友電工
DAIKIN
中部電力
DENSO
東京電力
TOKYO GAS
TOSHIBA
TOYOTA
NISSAN
NTT
NEC
Panasonic
HITACHI Inspire the Next
FUJITSU
MRI
MITSUBISHI

Waseda Project Mission

- Research and evaluation of national & international standards
  - ✓National standard : ECHONET-Lite
  - ✓Overseas standards : SEP2.0, KNX, etc.
- Research for technology and standardization regarding DR
  - ✓Test use case and validate Open ADR

Standardization of Communication Interface for DR (2012-)



EMS Shinjuku Demonstration Center

Smart House

Photo taken 2012 Sep

ECHONET Lite

SEP

EV/PHV FC EVSE+PCS

EV FC EVSE+PCS

EV/PHV EVSE+PCS

EV EVSE+PCS

Heat Pump Water Heater

Air Conditioner

PV simulator + PCS (模擬電源)

Home Appliance (IH etc)

Battery + PCS

HEMS Smart Phone

WiFi

Smart meter

1Φ 100V/200V

Power Distribution Simulation System (ANSWER)

Image Photo

Switch

1Φ 100V/200V

3Φ 400V Power Distribution Network

3Φ 400V 2 line

SVR

HV Line

Voltage Control EMS

200V/400V Boost Trans

Grid EMS

Distribution Panel

3Φ 200V

単相負荷

模擬低圧線

変圧器 模擬柱上

三相負荷

模擬高圧線

Apparatus at EMS Shinjuku Demonstration Center

DRAS

Smart Houses

Smart Meters

Smart GAS Meter

Analog NW Simulator ANSWER

HEMS

Air Cond.

PHV/EV

Charger

Fuel Cells

Heat Pump Water Heater

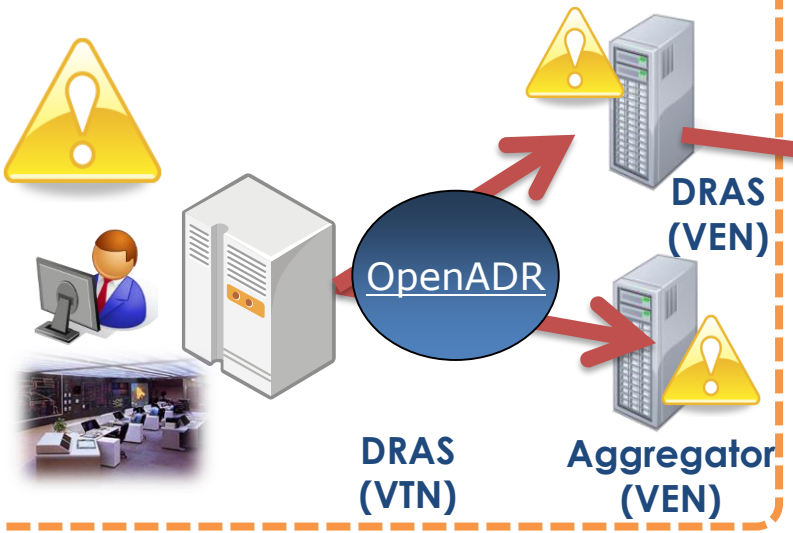
Battery

Distribution Boad

PCS for PV

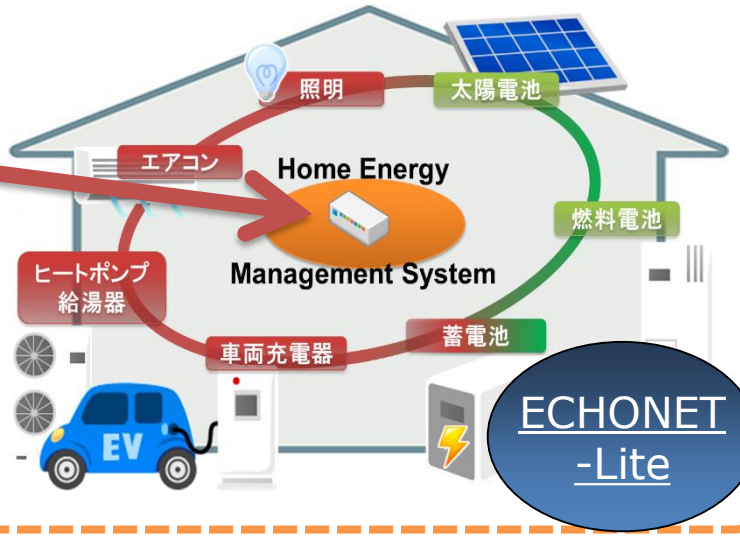
Function & Role of EMS Shinjuku Demonstration Center

Supply Side System
Utility and Aggregator
- Open ADR -



DR

Demand Side System
HEMS
- ECHONET-Lite -



- Establish Open ADR2.0 base multi-vender DRAS Test Site
- Connect with Utilities, Aggregator and CEMS
- Test DR TF use cases and validate Open ADR2.0 specification for Japan

- Establish ECHONET-Lite base multi-vender Demand side Test Site (Smart House)
- Validate ECHONET-Lite for Demand Side Energy Management and DR (DLC, Pricing etc)
- Compare ECHONET-Lite with SEP2.0 base Energy Management

FIT System for PV (July, 2012~)

Purchase Price (eventually lowered in every FY)

<10kW :

- 42JPY/kWh (initial)
- reverse power only (surplus)
- fixed over 10 years

>10kW :

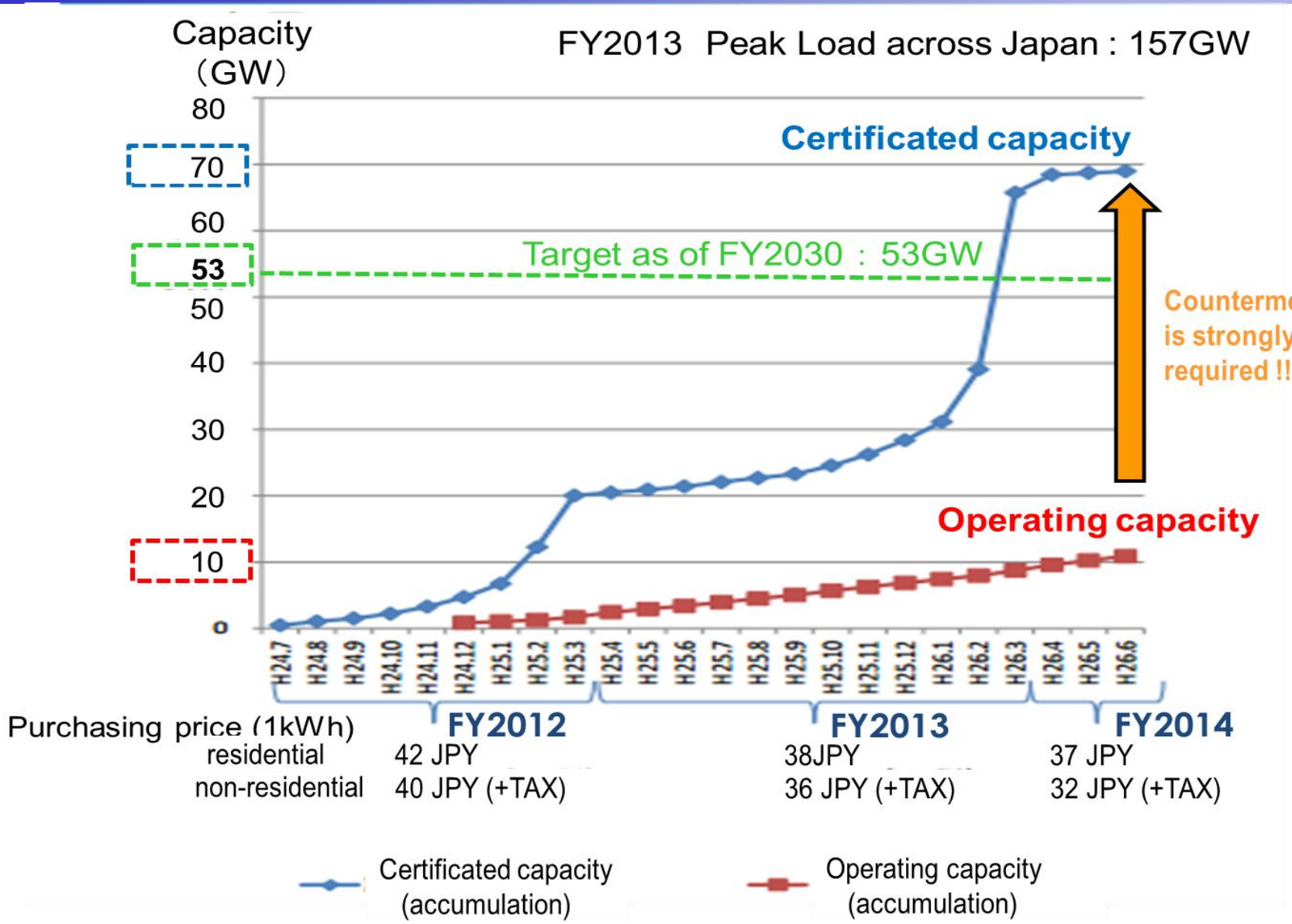
- 40JPY/kWh (initial)
- all generation
- fixed over 20 years

Certification

Two steps are required.

- ✓ Certification by the Minister (METI)
- ✓ Interconnection approval by the local Utility

Operating and certificated capacity of PV (as of June, 2014)



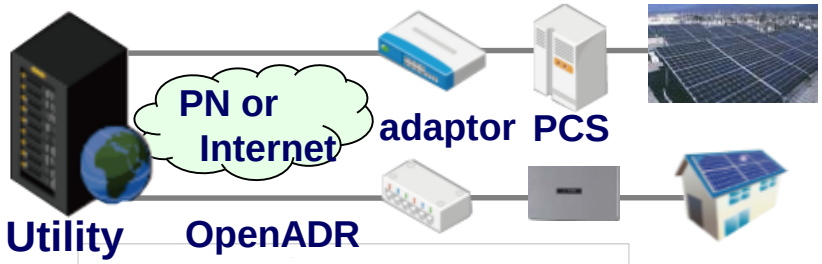
Revision of FIT by METI/ANRE (December, 2014)

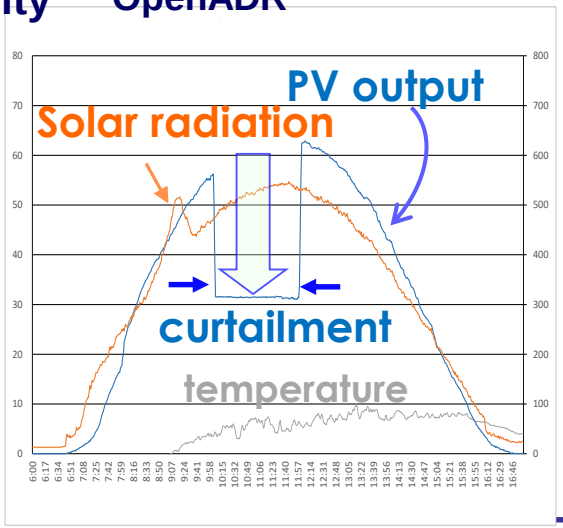
New Output Control Scheme

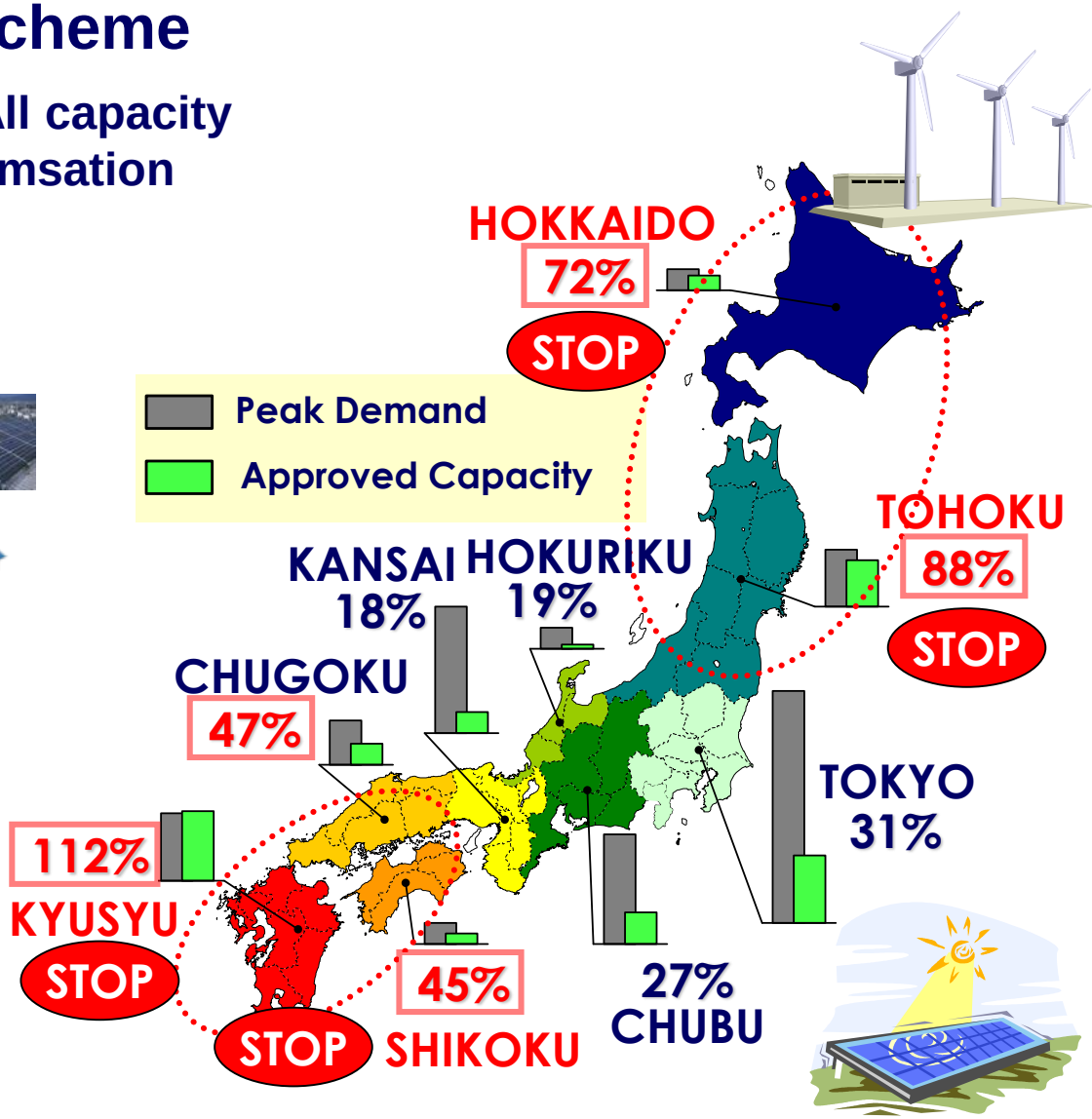
- Remote control function, All capacity
- <360hr/year, without conpemsation

Demonstration PJ

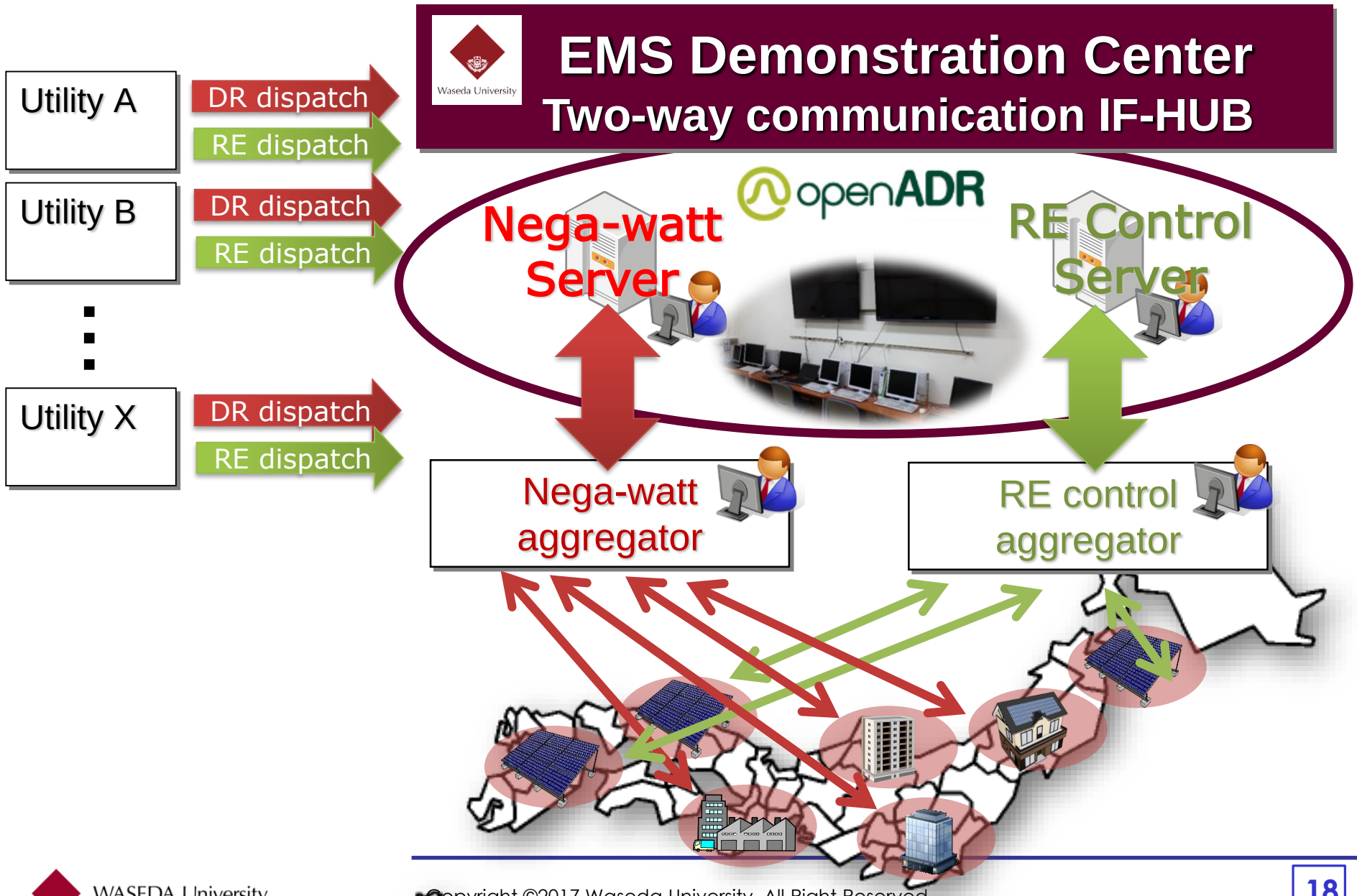
(Dec. 2015-Jan. 2016)







Role of DR & RE dispatch center



Research Perspective

Distribution line voltage control

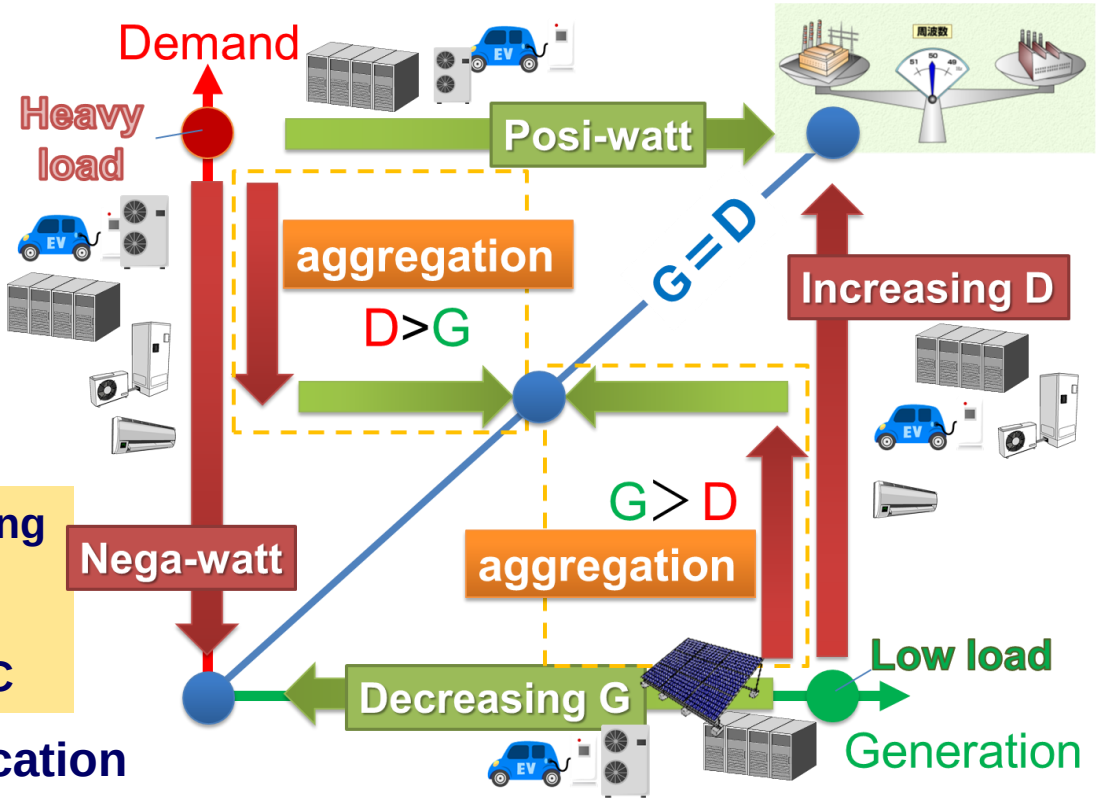
- Sensing : voltage / current
- Utilizing AMI
- Autonomous / Central control of voltage regulators (SVR, LTC, etc.)
- Forecat : Demand, PV generation
- Smart Inverters

Energy Resource Aggregation

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

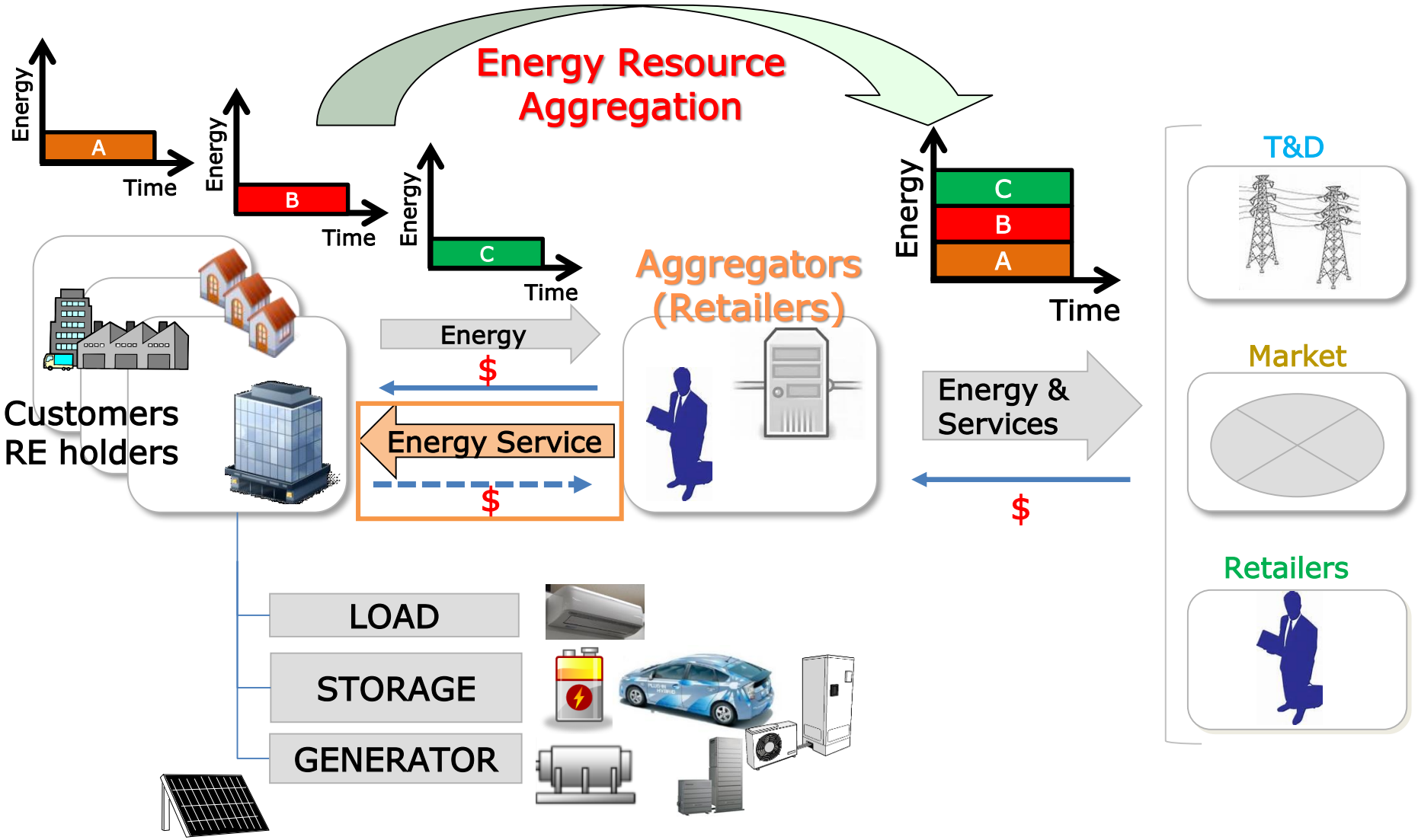
✓ Load : Air conditioner, Lighting Water Heater
✓ Storage : Battery, EV/PHV
✓ Generation : PV, Generator, FC

- Architecture, Function Allocation & Standard Communication



Energy Resource Aggregation (Virtual Power Plant : VPP)

Extended use of OpenADR for VPP messaging

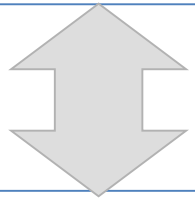


Promotion of VPP

Energy Resource Aggregation Business Committee

- 4 experts, 42 companies (Utilities, Electricity retail companies, Aggregators, Vehicle Companies, communication companies, electric-appliance makers, home builders etc.)

- Established working groups for technical discussion
  - Communication Protocols
    - ✓ HEMS～Appliances
    - ✓ Inter-aggregators, aggregators～HEMS,BEMS(GW)
  - Cybersecurity
  - Baseline for Demand Response

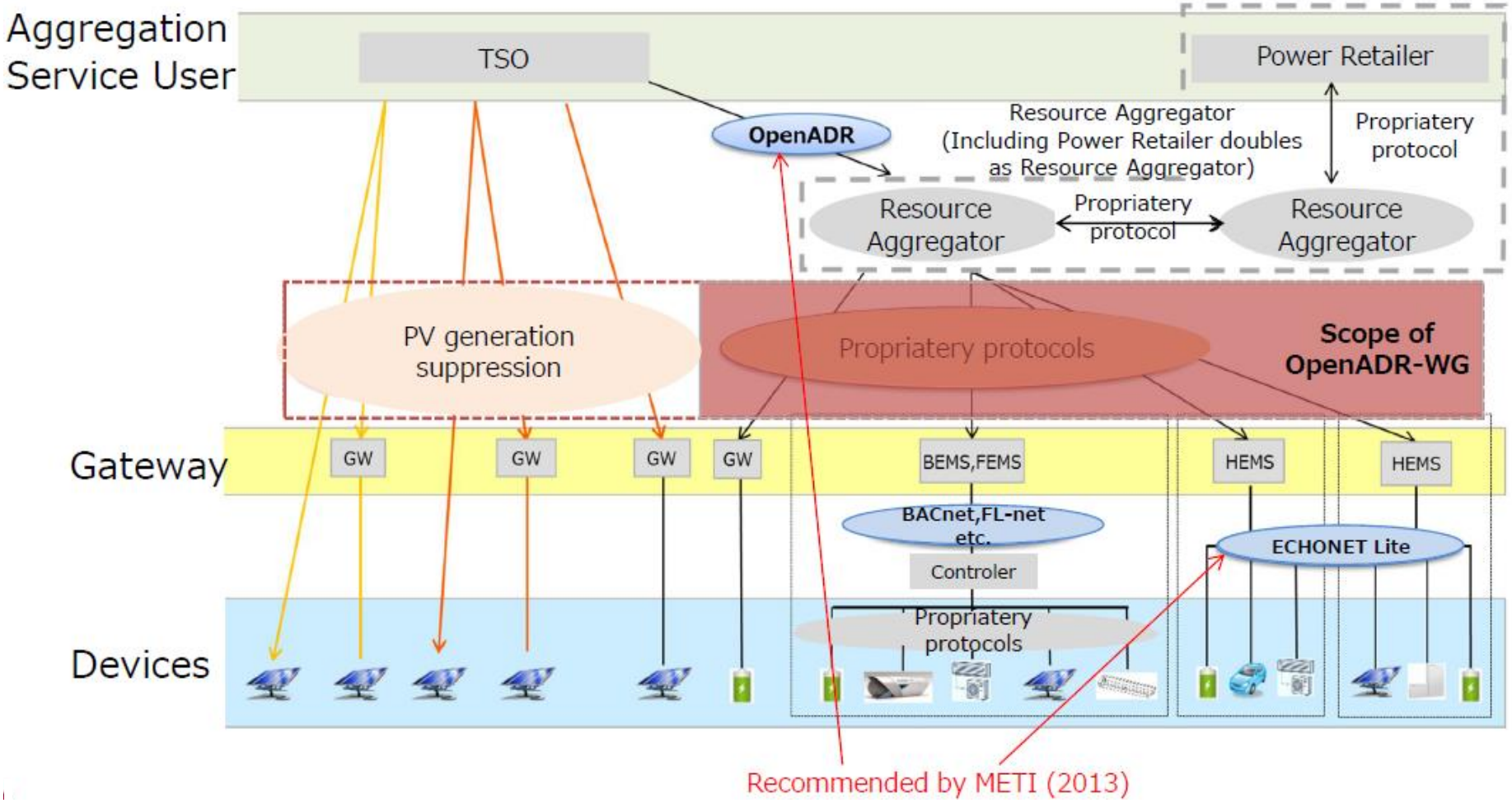


Virtual Power Plant Subsidy 30M USD in 2016 (2016-2020)

㊀Increase the remotely controllable VPP resource

㊁Verify the credibility of aggregated resource

System Architecture and Communication Interfaces



Use Cases for ERAB

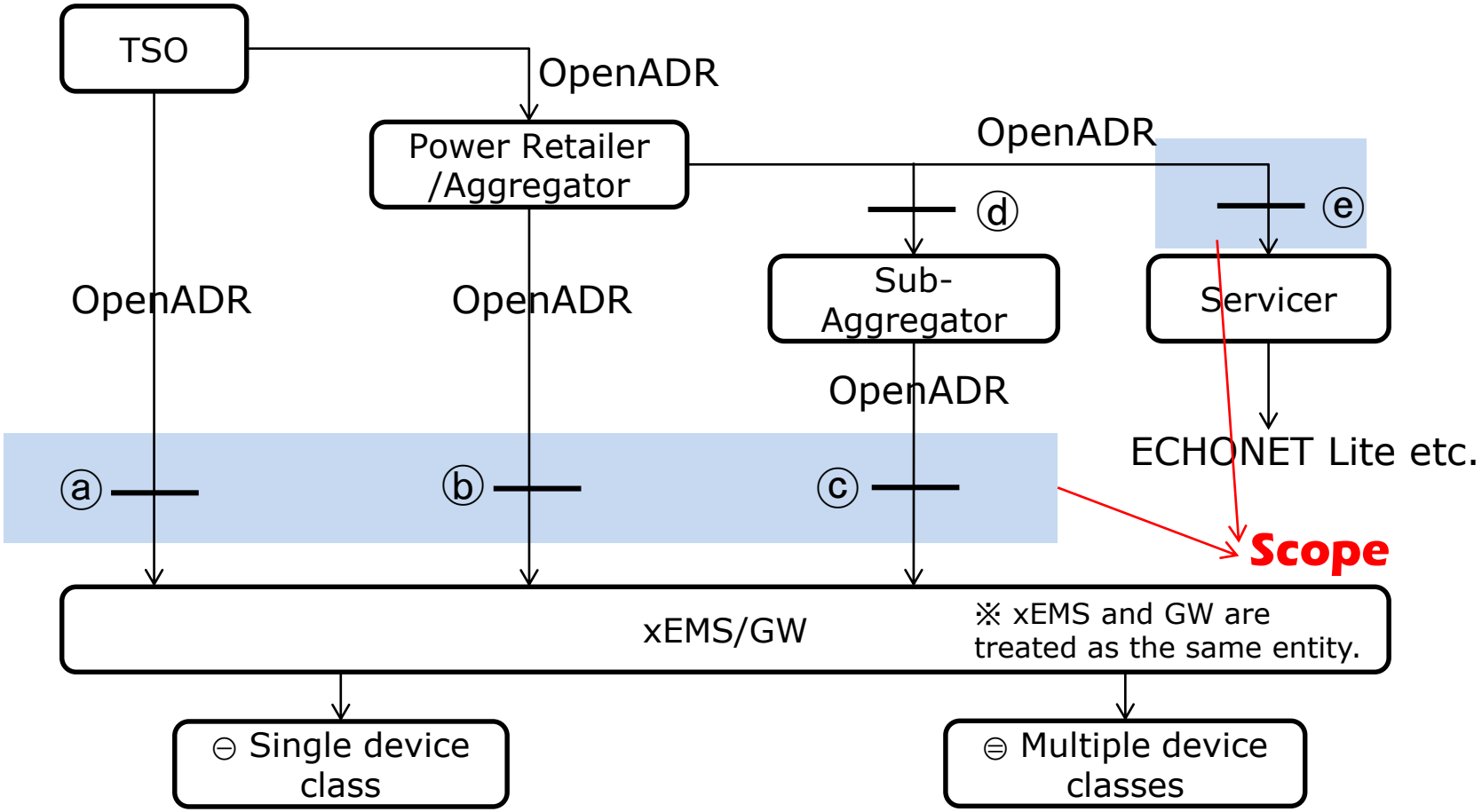
- **71 Use Cases from 29 companies**
  - ✓Each described in a table and a diagram format like OpenADR DR Program Guide
- **Evaluation on 6 device class groups**
  - ✓PV/WT, FC/Generator, Storage battery, EV, Water Heater, and AC/Lighting/Ventilator.
  - ✓Use cases of ancillary services are out of scope of current study

DR Operator	TSO	2
	Power Retailer /Aggregator	69

Customer	Home	46
	Building	57
	Industry	47

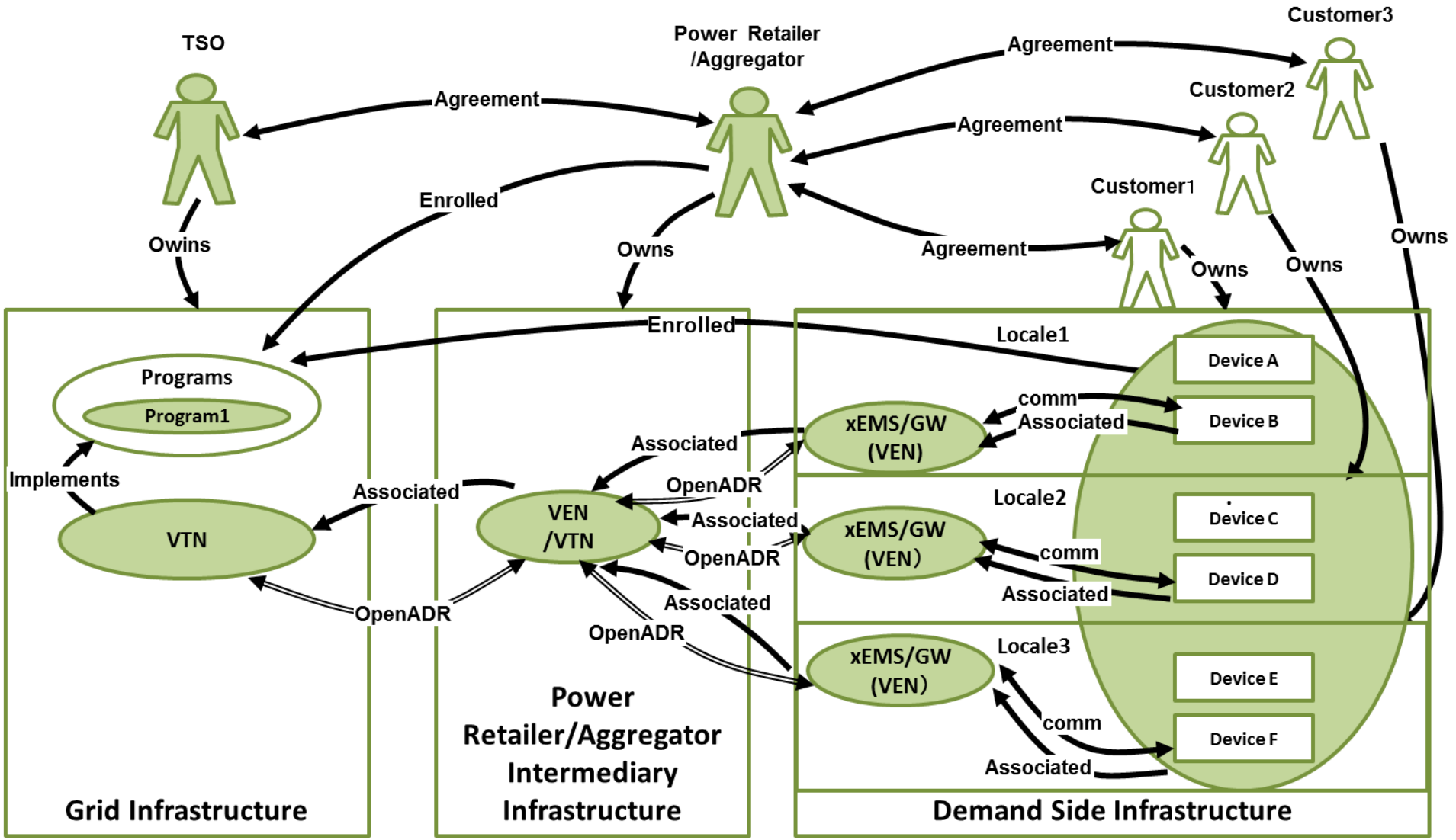
Device classes											
PV	WT	FC	Generator	Generator (not specified)	Storage battery	EV	Water Heater	AC	Lighting	Ventilator	Load (not specified)
15	4	15	12	4	40	15	9	21	3	2	8

Actor roll model and POIs



Example of Reference UC Diagrams (POT ⓑ- ⊜)

- Power Retailer/Aggregator controls multiple classes of devices via xEMS/GW



Use Case Analysis : OpenADR2.0b Mapping

Use Case Analysis

1. Classifying use cases based on the POIs and xEMS/GW types
   - To see the dependency of communication interfaces to POIs and xEMS/GW types

2. Mapping OpenADR2.0b message sequence to communication processes

3. Mapping OpenADR2.0b EiEvent message payload to the information items for device control
   - signalName, signalType, and itemBase

4. Mapping OpenADR2.0b EiReport message payload to the information items for device monitoring and measurement
   - reportName, reportType, itemBase, and readingType

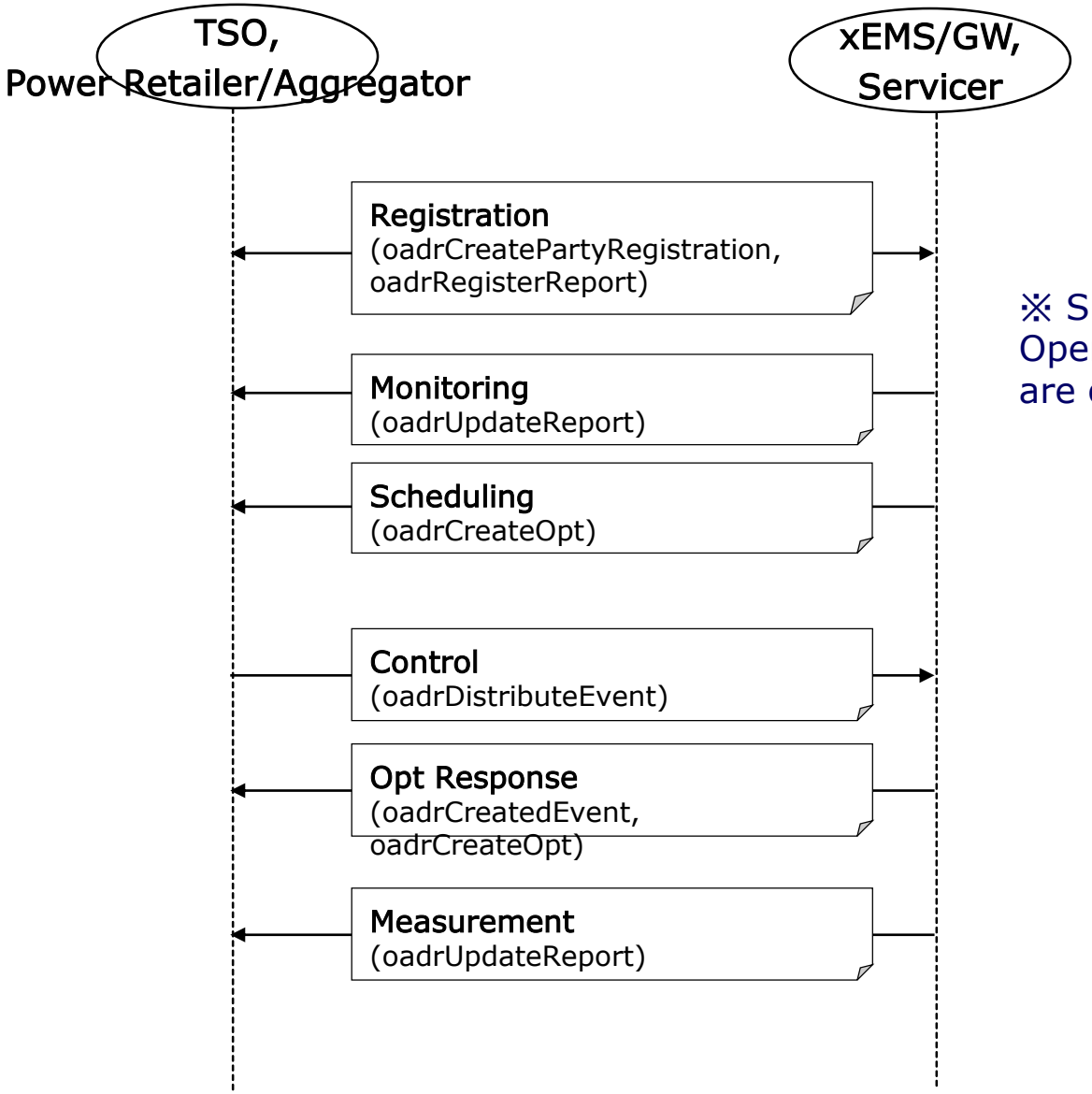
5. Gap analysis

Results of Analysis (Message Sequence)

- All communication messages of each use case are classified into 5 sequence patterns.
- These sequence patterns can be implemented using OpenADR2.0b services from the view point of functionality of the messages.

Functionality (OpenADR2.0b Service)	Registration (EiRegisterParty /EiReport)	Monitoring (EiReport)	Scheduling (EiOpt)	Control (EiEvent)	Opt Response (EiEvent /EiOpt)	Measurement (EiReport)
Sequence1	○	○		○	○	○
Sequence2	○		○	○	○	○
Sequence3	○			○	○	○
Sequence4	○			○	○	
Sequence5	○	○	○	○	○	○

Example of Message Sequence (Sequence 5)



※ Subsidiary OpenADR2.0b messages are omitted.

Results of Analysis (Event)

◆**Most device control messages can be mapped using predefined OpenADR2.0b EiEvent signals corresponding to the device classes.**

(1) Multiple device classes UC

- ✓ Can be mapped using signalNames within CR510 (SIMPLE, LOAD_DISPATCH(setpoint), ELECTRICITY_PRICE).
- ✓ A few use cases require LOAD_CONTROL or LOAD_DISPATCH(delta).

(2) Generation device (PV/WT, Generator/FC) UC

- ✓ Can be mapped using LOAD_CONTROL or LOAD_DISPATCH, if usage of negative values is standardized.
- ✓ But new signalNames for generation device classes are more desirable.

(3) Storage battery UC

- ✓ Use cases which need both charge and discharge can be mapped using CHARGE_STATE.
- ✓ Use cases which need only discharge can be mapped using LOAD_DISPATCH.

(4) EV UC

- ✓ Results are mostly the same as those of storage battery, but some use cases need specific operating state controls for their control devices.

(5) Load device (Water Heater, AC/Lighting/Ventilator) UC

- ✓ Can be mapped using SIMPLE or LOAD_DISPATCH, but some water heater use cases need specific operating state controls for their inverter.

Results of Analysis (Report, etc.)

◆Report

- ✓A great variety of information items depending on device classes are required to convey by report messages.
- ✓Most of them can be mapped using OpenADR2.0b EiReport payloads, if they are defined as custom reports.
- ✓Custom reports should be standardized in Japanese DLC Program Implementation Guide.

◆Other work items

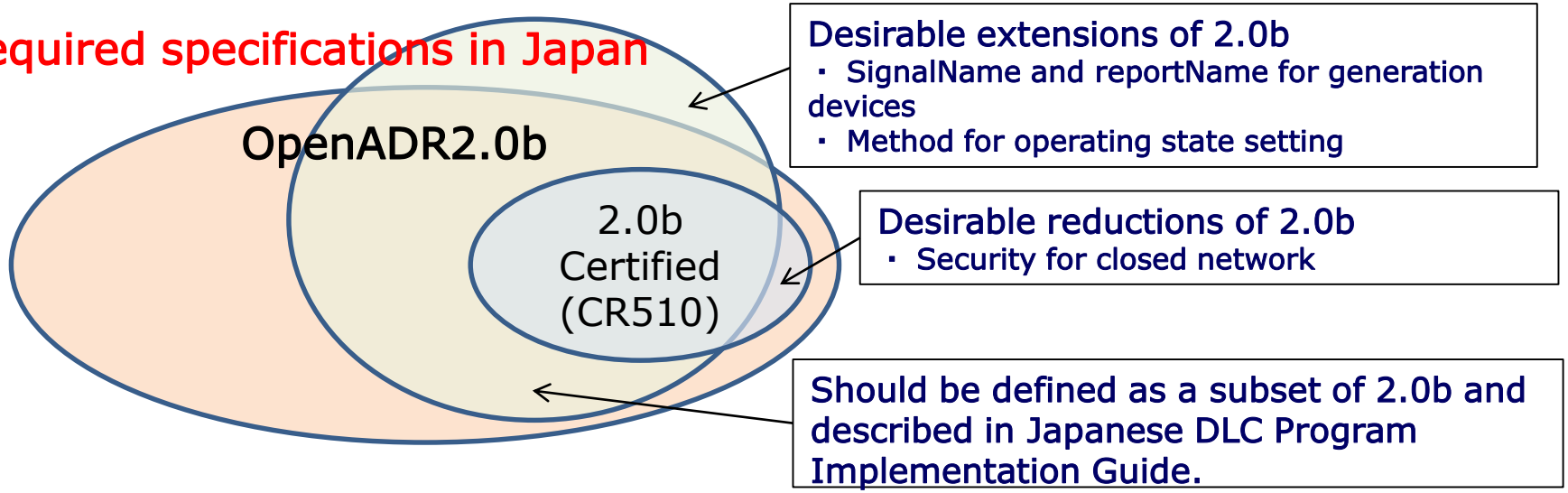
(1) EiOpt should be included in Japanese DLC Program Implementation Guide.

※ EiOpt is not included in the current version of Japanese DR Interface specifications.

(2) The method of device class designation (usage of eiTarget) should be standardized in Japanese DLC Program Implementation Guide.

Summary of Gap Analysis

- ◆Most of Japanese DLC use cases can be implemented using a subset of OpenADR2.0b.
  - ✓A few extensions or reductions are desirable to OpenADR 2.0b.
- ◆This subset includes many optional event signals and custom reports.
- ◆To ensure the interoperability of DLC communications, it is necessary to define the subset and describing it in Japanese DLC Program Implementation Guide.



Results of Analysis (Report, etc.)

◆**Japan wants to propose the following three amendment to OpenADR2.0b. in order to apply it for DLC communications between Resource Aggregators and xEMS/GWs more conveniently.**

(1) Supporting power generation devices

- ✓Adding new signalName and reportName
- ✓Or clarifying the usage of negative values of LOAD_DISPATCH and LOAD_CONTROL, and usage of reportNames like TELEMETRY_USAGE for power generation

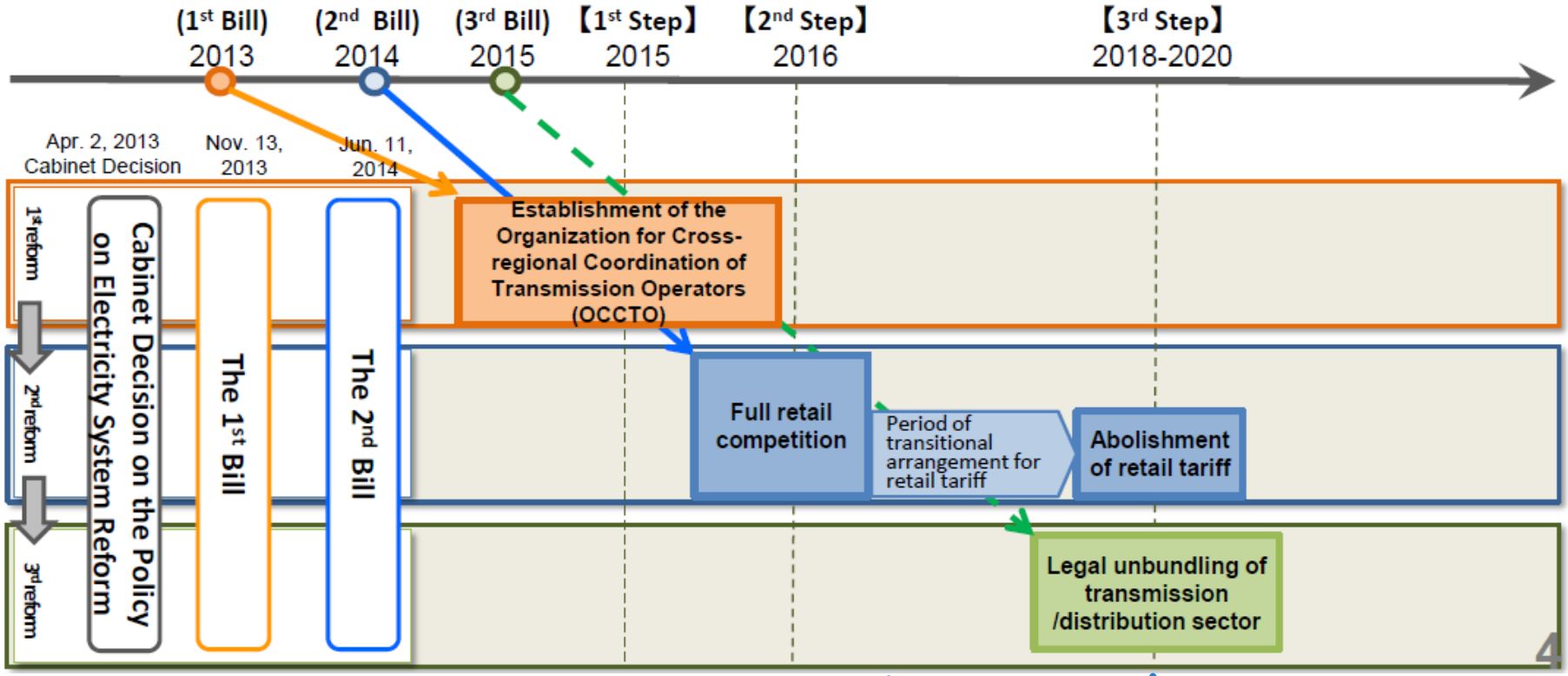
(2) Introducing new method for setting operating states of devices

- ✓OpenADR2.0b provides ON/OFF device control using LOAD_CONTROL, but it cannot be applied to multiple state devices.
- ✓Using LOAD_CONTROL, there are some ambiguities like the treatment of event duration and the returning state after the end of the event.

(3) Introducing simpler security for closed network

- ✓Basic Authentication on HTTP between VTN and VEN within the same closed network, for example.

Electric Power System Reform & Markets



Spot Market (day ahead)

Hour-Ahead Market

Imbalance adjustment

Negawatt Market

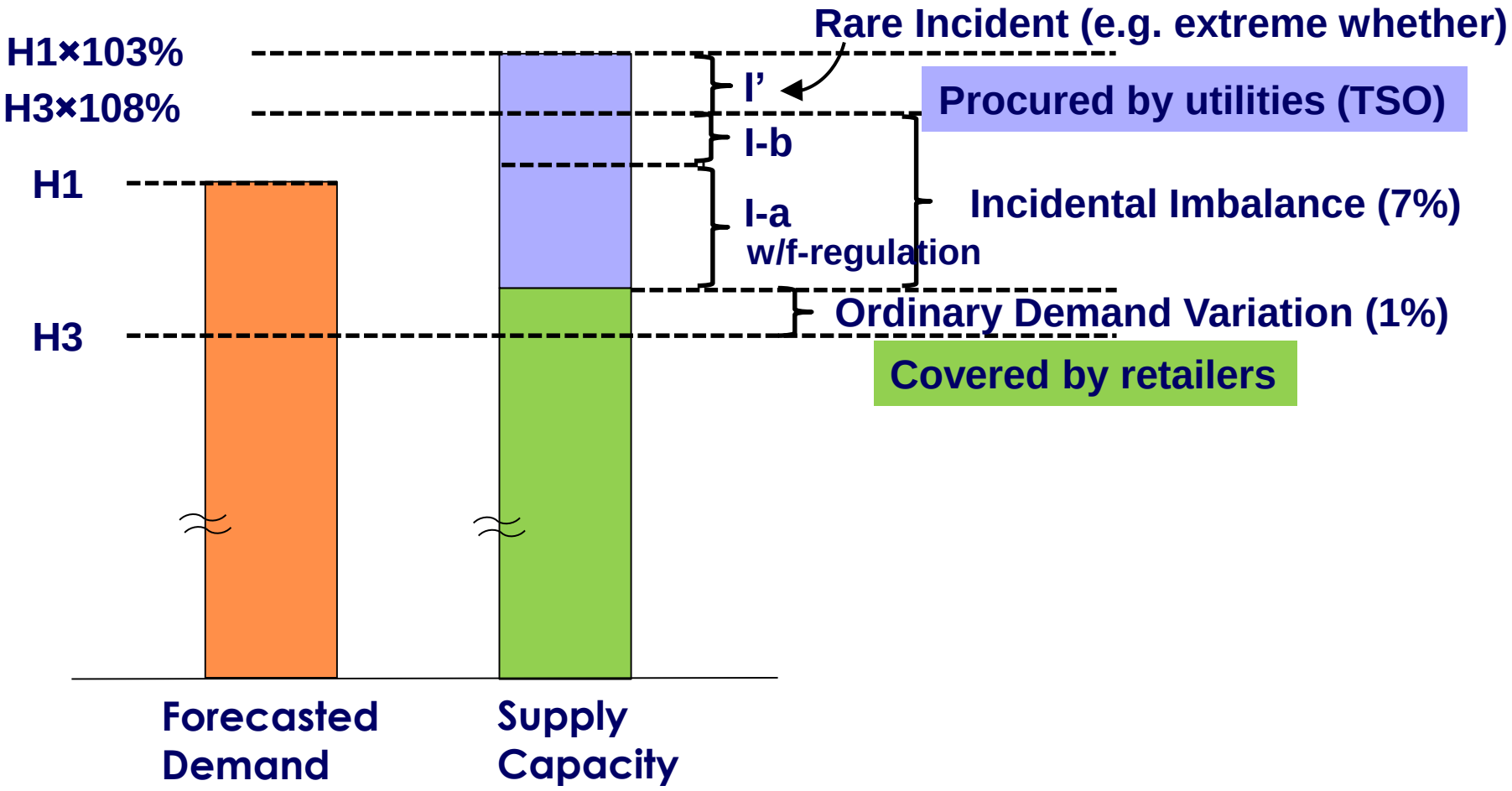
Real-time Market

Capacity Market

Adjustment Capacity Procurement

Non-Carbon Value Trade Market

Category and required capacity for adjustment



Adjustment Capacity Procurement

- **Generator I' : 958MW of DR (35 MUSD) by 4 utilities**
- **Generator I-b is also open for DR, but none**

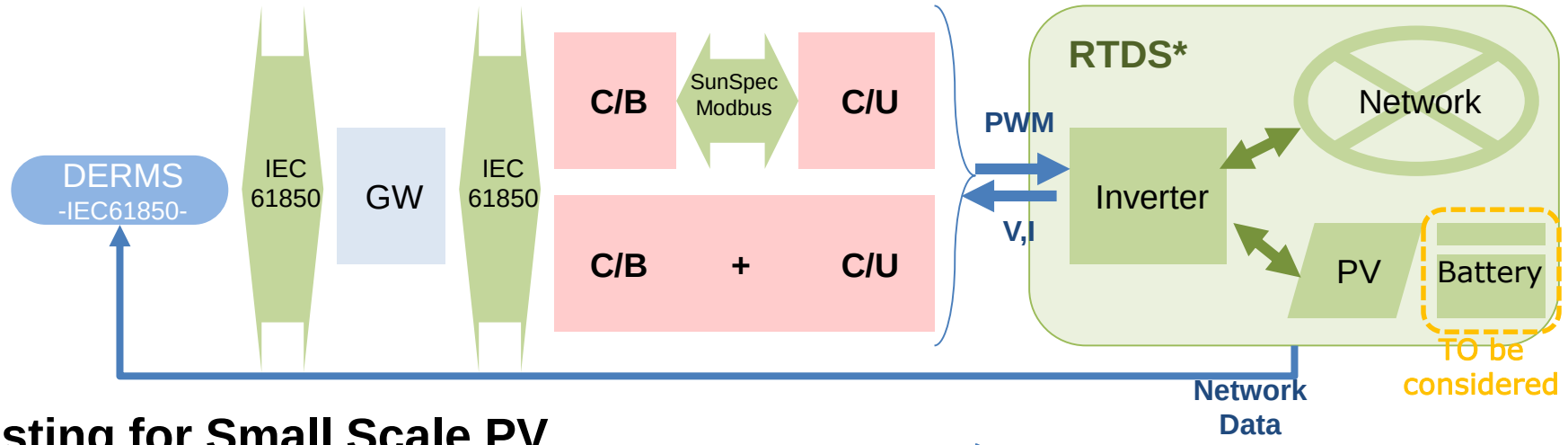
	Generator I-a	Gnerator I-b	Generator I'
On Line Control	Mandate	Mandate	none
Frequency Regulation FN	Mandate	None	None
Response Time	<5 min.	<15 min.	< 3 hours
Duration	7 – 11 hours	7 – 16 hours	2 – 4 hours
Minimum Capacity	5 – 15 MW	5 – 29 MW	> 1 MW
DR (negawatt)	Not allowed	allowed	allowed

Future Work

- **Expand UCs of Integrated / Aggregated DER**
  - Frequency regulation / ancillary service : I-a category
  - Voltage regulation
  - Protocol for these Ucs : OpenADR still applicable?
- **Address the value of Integrated / Aggregated DER and Incentivize Customers**
- **How to measure the state and the performance of Integrated / Aggregated DER**
  - Telemetry & Settlement : acceptable delay, resolution
  - Baseline

Smart Inverters / DERMS Architecture

❑ Testing for Large Scale PV



❑ Testing for Small Scale PV