Green Technology WS

Mitsubishi Smart Grid Activities

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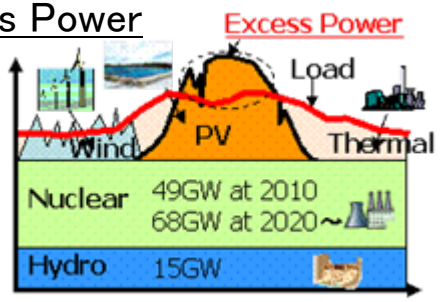
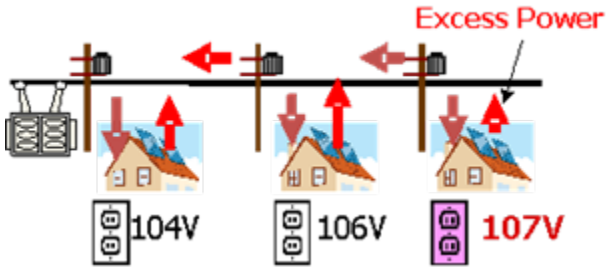
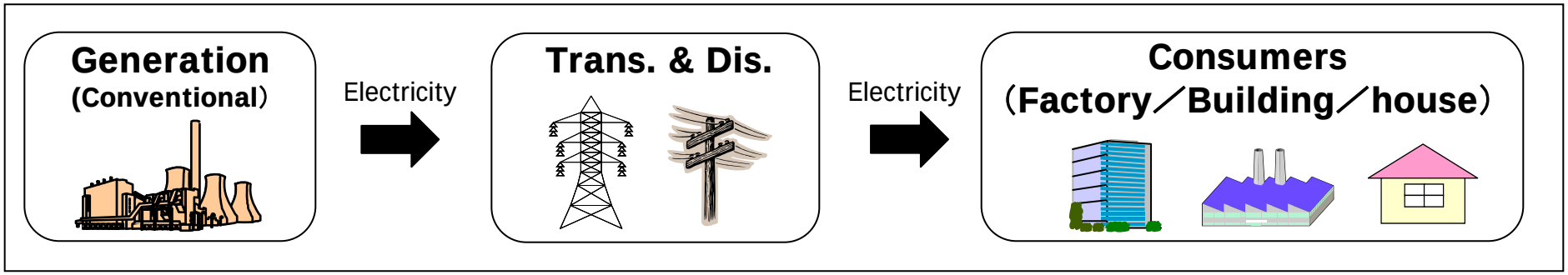
Grid Operation Challenges caused by Renewable Energy Penetration

	Challenge	Reason	Technical Solution
1	Frequency Deviation 	Unstable output from renewable (PhotoVoltaic and Wind Turbine)	・Forecasting ・Control for PV and WT ・Hydro Optimization (Variable Speed Pumped Storage) ・Installation of Battery
2	Excess Power 	A large amount of unstable output from PV and WT at low load period (Weekend of Spring)	・Installation of Battery ・Control for PV and Wind ・EV utilization ・Demand Response
3	Over Voltage, Voltage Deviation 	Excess power output from individual PV panel in the feeder	・Installation of Local Voltage Regulator ・Control for PV ・Optimal Power Flow (Central Control)

Smart Grid

<Current>



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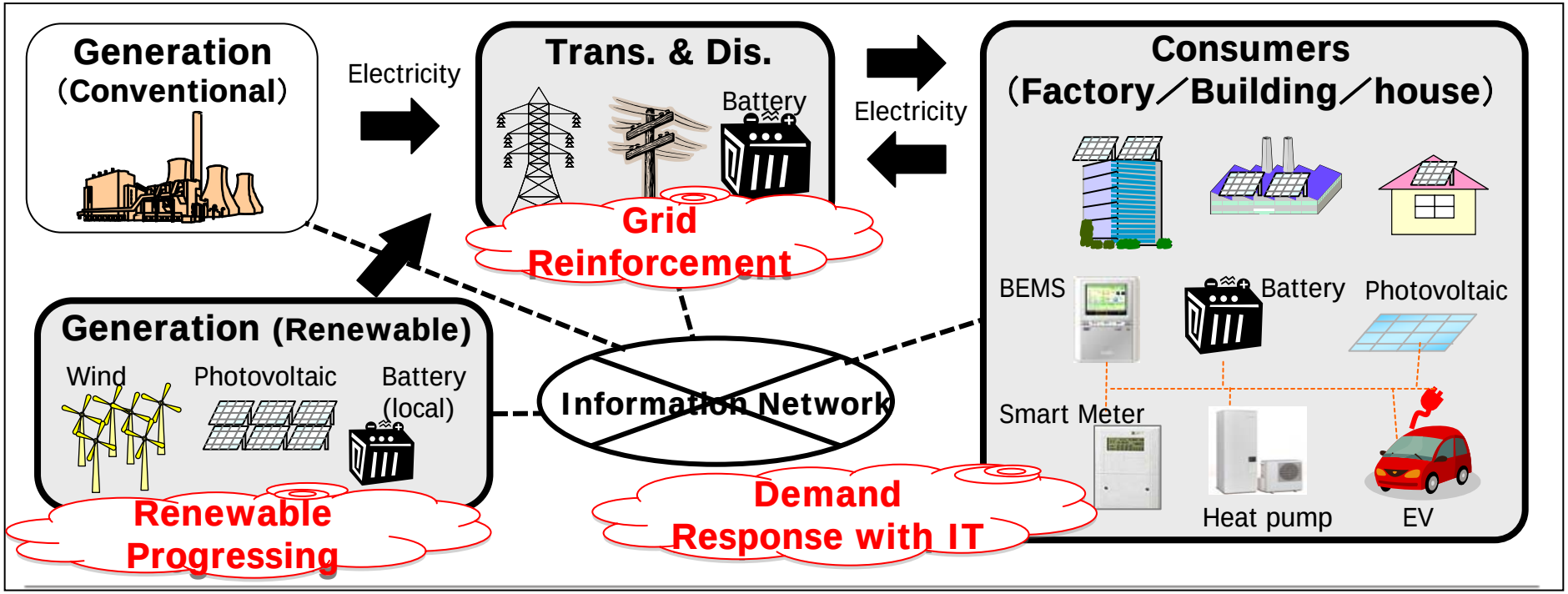
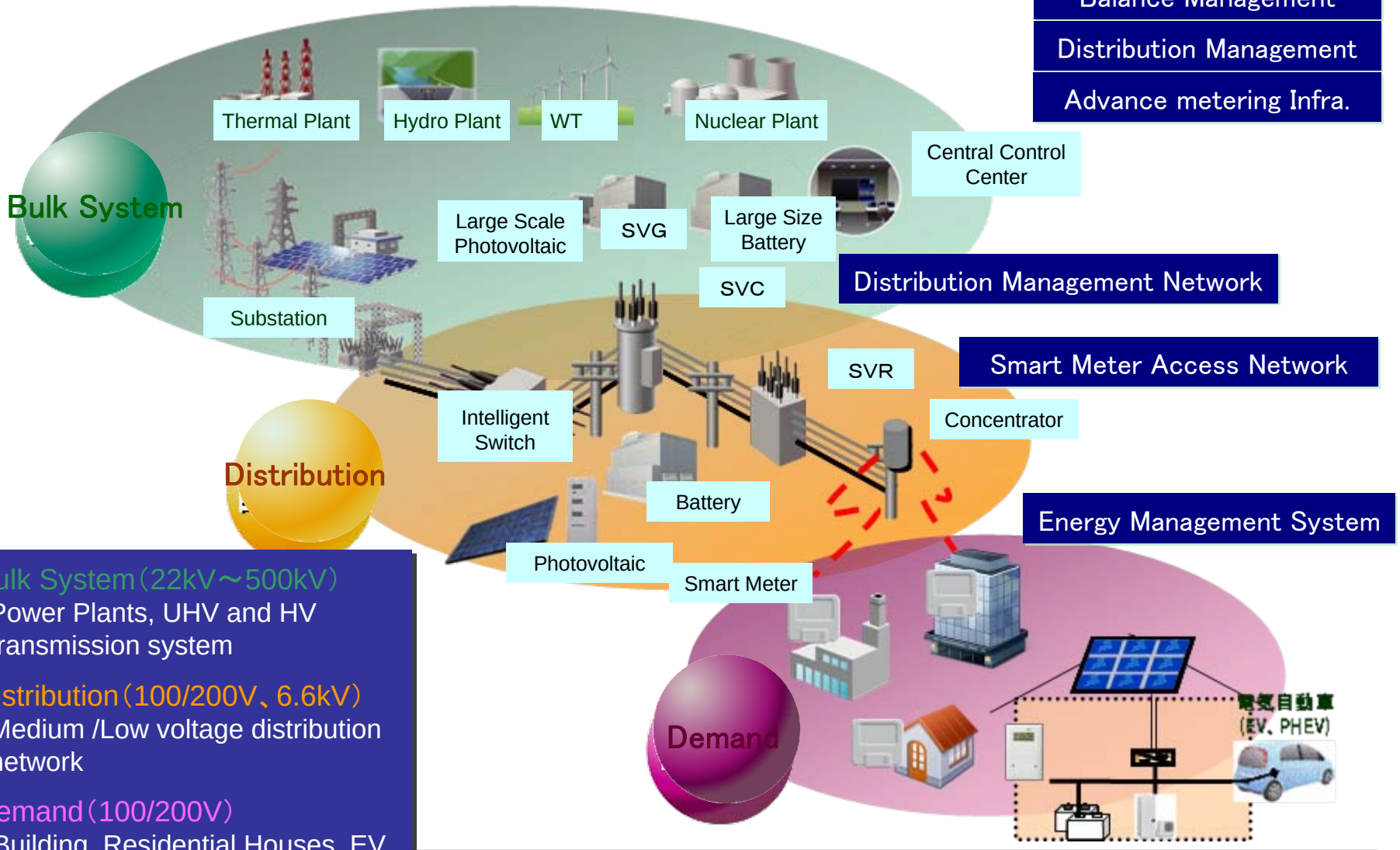


Smart Grid Test Facility: Scope and System



Bulk System（22kV～500kV）
Power Plants, UHV and HV transmission system

Distribution（100/200V、6.6kV）
Medium /Low voltage distribution network

Demand（100/200V）
Building, Residential Houses, EV

Project Objective

The test facility was develop with the intent to have a real analog power system to simulate and verify the performances of algorithms and equipment under the following conditions;

- Political changes (deregulation, interconnection requirements, FIT, wheeling rules)
- Business environment changes (power system management, regional distributed resources).
- Climate changes (solar radiation, wind speed, temperature, etc.)
- Severe power system conditions (earth fault, short circuit, generator fault)

Mitsubishi intend to find the specific requirements to keep the future power system economical and stable, and to provide and validate solutions in the real field

Objective and features

Objective

Technologies and equipments validation for the future transmission and distribution networks

(1) power supply and demand balance with high penetration of renewable energy

(2) distribution voltage stability in case of a large amount of distributed generators

(3) power-saving and energy conservation

(4) blackout prevention and outage time reduction

(5) demand response in severe power system condition

(6) testing of equipment before commercialization

Features

The test facilities can be scaled and arranged to simulate several kinds of smart grid configurations and smart communities

- Balance Management Validation Operation
- Distribution Management Validation Operation
- Total Operation (Balancing and Distribution Management)
- Micro Grid or Island Validation Operation

During each of these operations mode shortage or excess of power, power system troubles such as lighting, voltage drop, short circuit and so on will be tested

MITSUBISHI ELECTRIC
Changes for the Better

Mitsubishi Smart Grid Testbed (Amagasaki Works)

for a greener tomorrow

Bulk

Demand

Distribution

Infra

4MW PV System

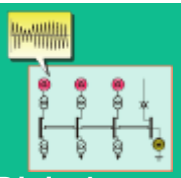
Charge Station・EV

Demand Emulator (Building/houses)

Generators

Control Center

- Balance Management
- Distribution Management
- Advance Metering Infra
- Energy Management



Digital Simulator

Storage

IT Network

Power lines

Substation

Smart Meters

Concentrator

SVR

SVC

Intelligent Switch

Control Center

- Balance Management System

  Ensure the balance between demand and supply instantaneously to keep the system frequency stable

- Distribution Management System

  Controlling local power conditioners and voltage regulation equipments such as SVC and SVR, the DMS ensure a stable voltage profile for the distribution network

- Advance Metering infrastructure

  Real time acquisition of metered consumption and web publication to encourage energy saving and demand response

- Energy Management System for buildings (BEMS)

  Optimizing the energy utilization the energy management system helps to reduce the CO2 footprint for buildings and factories

Assets

	System/equipment	Characteristics
Infra-structure	Large Scale Photovoltaic System (4,000kW)	5 types of PV Power Conditioner (5kW for home use, 10kW, 100kW, 250kW and 500kW for commercial use)
	Distribution network (6.6kV, 7km-16km)	A real distribution network for testing propose. The length can be adapted based on the type of test
	Communication Network	3 types of communication network: high speed optical fiber, metal cable and wireless
Bulk system	Balance Management System	Optimal balance control system for thermal and hydro generators, batteries and PV
	Digital simulator and BTB	Connected digital and analog power network with a BTB to simulate many power network situation (West Japan area, Kansai, island, fault, etc.)
	Variable Speed Pump Storage Thermal Generator Batteries（NAS: 500kW、Li-ion: 250kW）	A set of generation assets to simulate several kind of power system

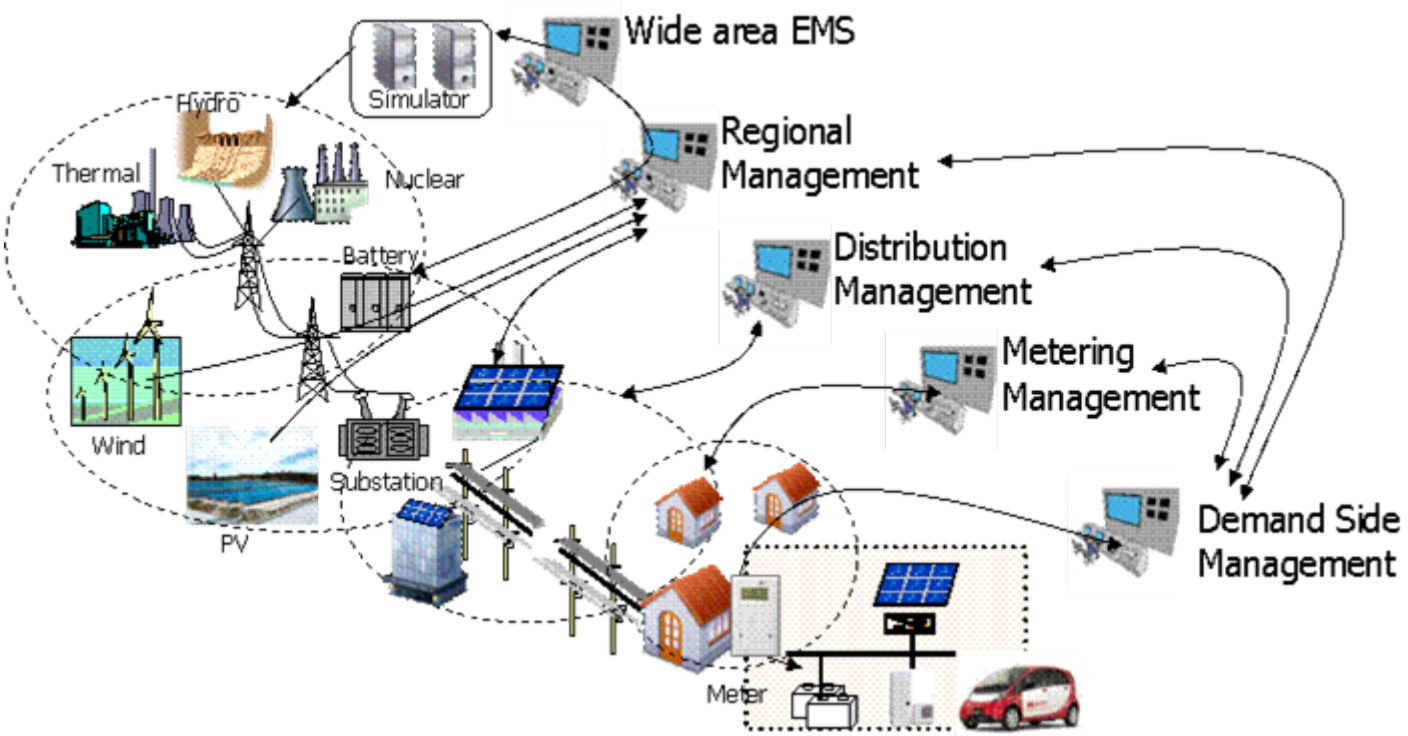
BTB: Back to Back (AC-DC-AC converter)

Assets

	System/Asset	Characteristics
Distribution	Next Generation Distribution Management System	Next generation DAS, includes voltage control, loss minimization power flow and phase unbalance monitoring
	Instantaneous switching equipment Intelligent switch	Switching equipment that allowed the switching from one feeder to another without black out and collect power system information
	Advance Metering Infrastructure	Mesh network based AMI supporting 429 and 950MHz band
	Smart Meters (150)	Smart meter to monitor real time consumption of offices and factories
Demand	Demand Emulator	Programmable active and reactive demand to create several scenarios

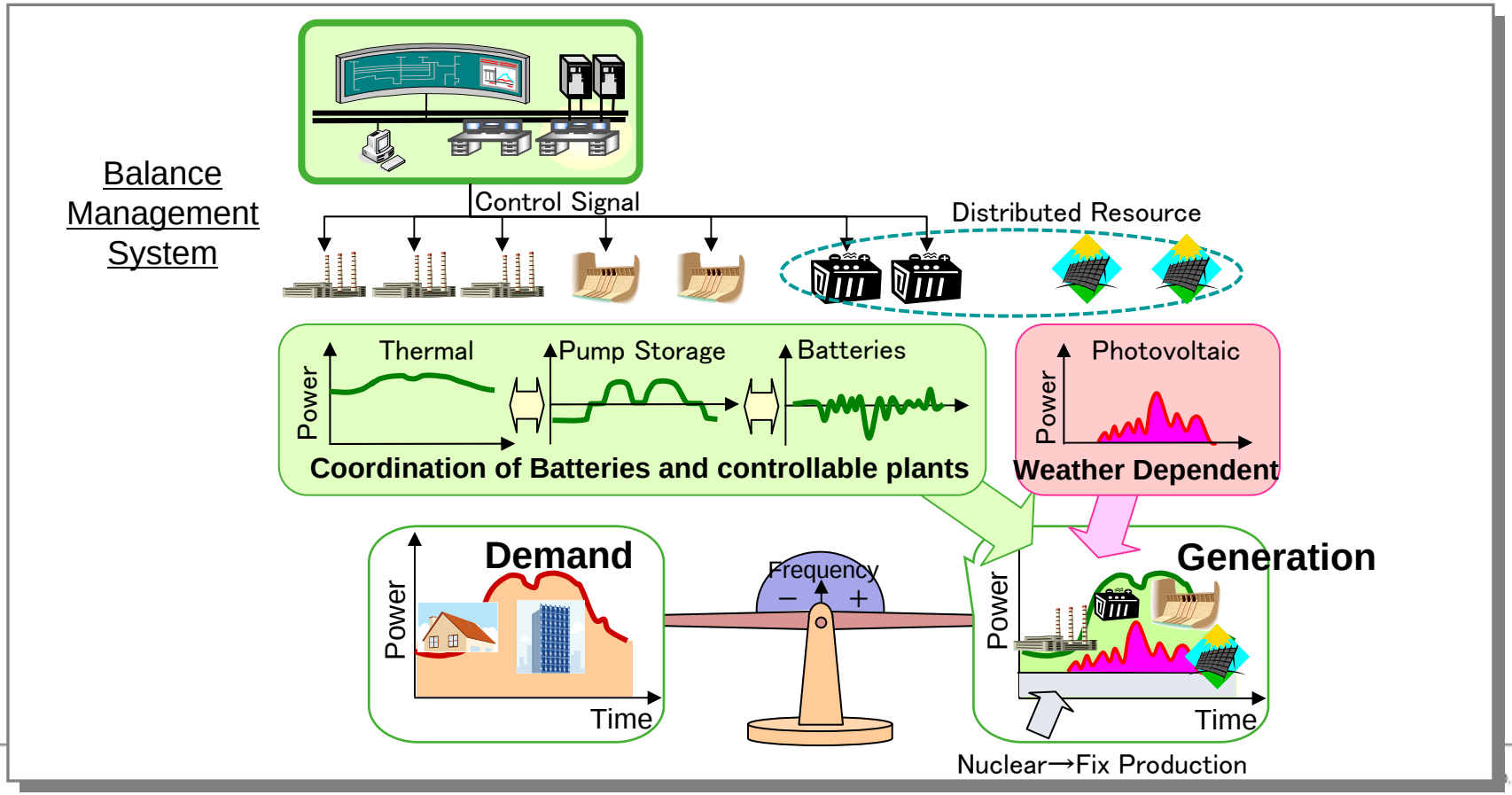
Smart Grid Management Systems

-Power System Stability Control and Optimal Energy Dispatch
-Distribution Management
-Metering Management
-Demand Side Management



Demand Supply Balance Management

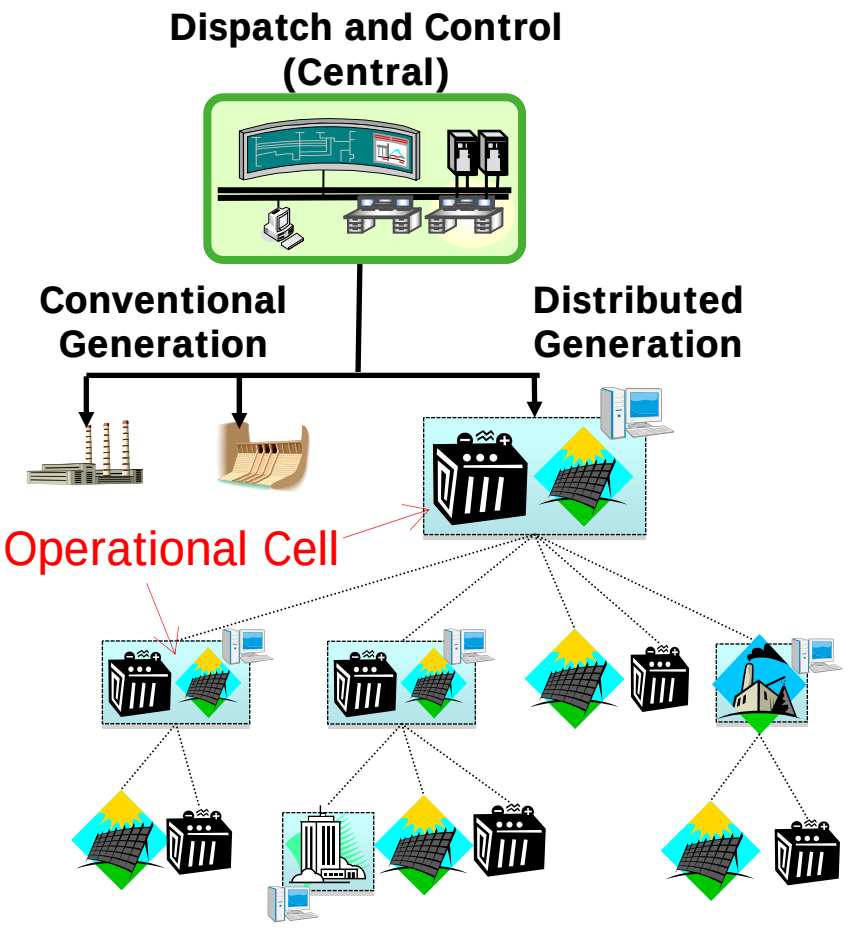
- Large amount of photovoltaic may cause imbalance in the production and a consequent deterioration of the power quality
- Optimal dispatch of the supply resource coordinating thermal power plants, pump storage plants and batteries
- The dispatch and control algorithm was tested in a scenario with high penetration of photovoltaic and the power quality level (frequency within +/-0.2Hz from nominal value) was ensured



Hierarchal Recursive Monitoring and Control

- **Large amount of resources have to be monitored and controlled. In addition resources can be owned and operated by different organization.**
- **Coordination and standardization of operation needed**

- Hierarchal object-oriented definition of operation cell. Each cell may contain loads, batteries, and distributed generators.
- Each cell may contain another cell with the same conceptual definition.
- Each cell is operated by a control system that interface with each element of the cell and with another cell or the central control center
- The control system can operate the cell in independent mode or follow the instruction of the upper cell or of the central control center.



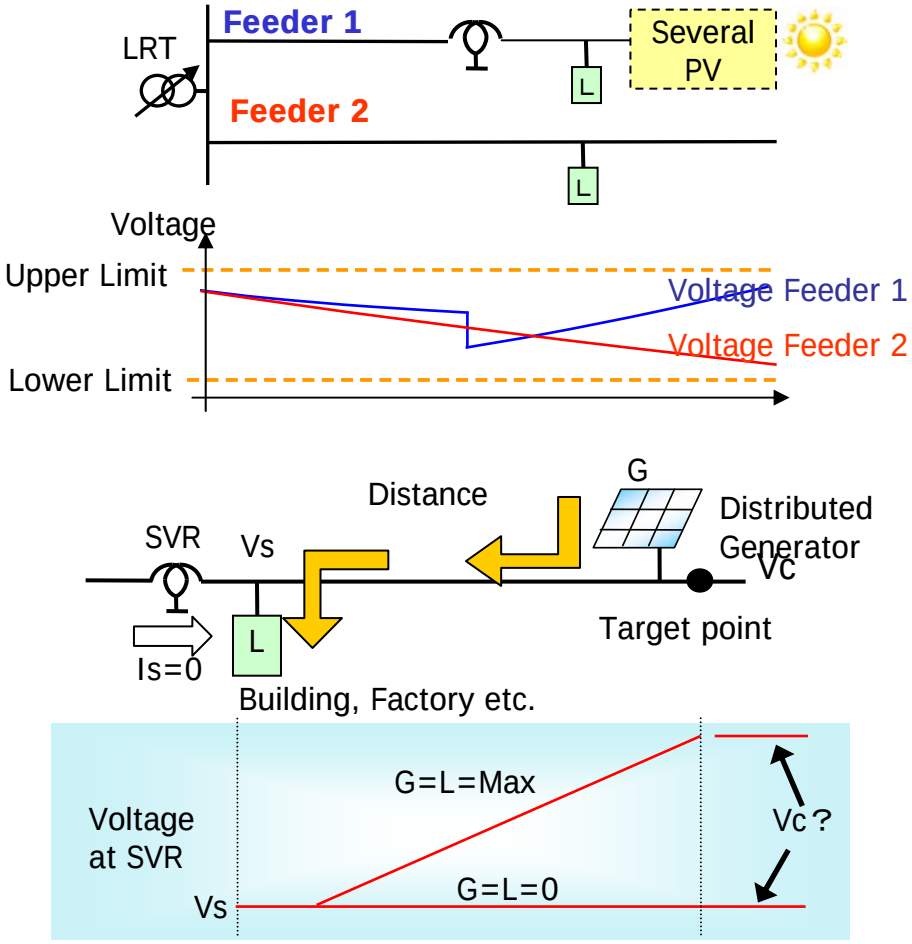
Local Voltage Control with Conventional and Power Electronics Devices

- **Distributed generators affect the distribution network voltage. It is expected an increase of voltage and high fluctuation in the profile.**
- **Voltage increase may cause damage to customers appliances and PV stopping.**

- Power electronic devices able to monitor the voltage locally and to supply or absorb reactive power can be a solution to the challenge:

1) LRT (Load Ratio Control Transformer)
2) SVR (Step Voltage Regulator)
3) SVC (Static Var Compensator)

- Location and sizing of the devices are designed using power flow simulation



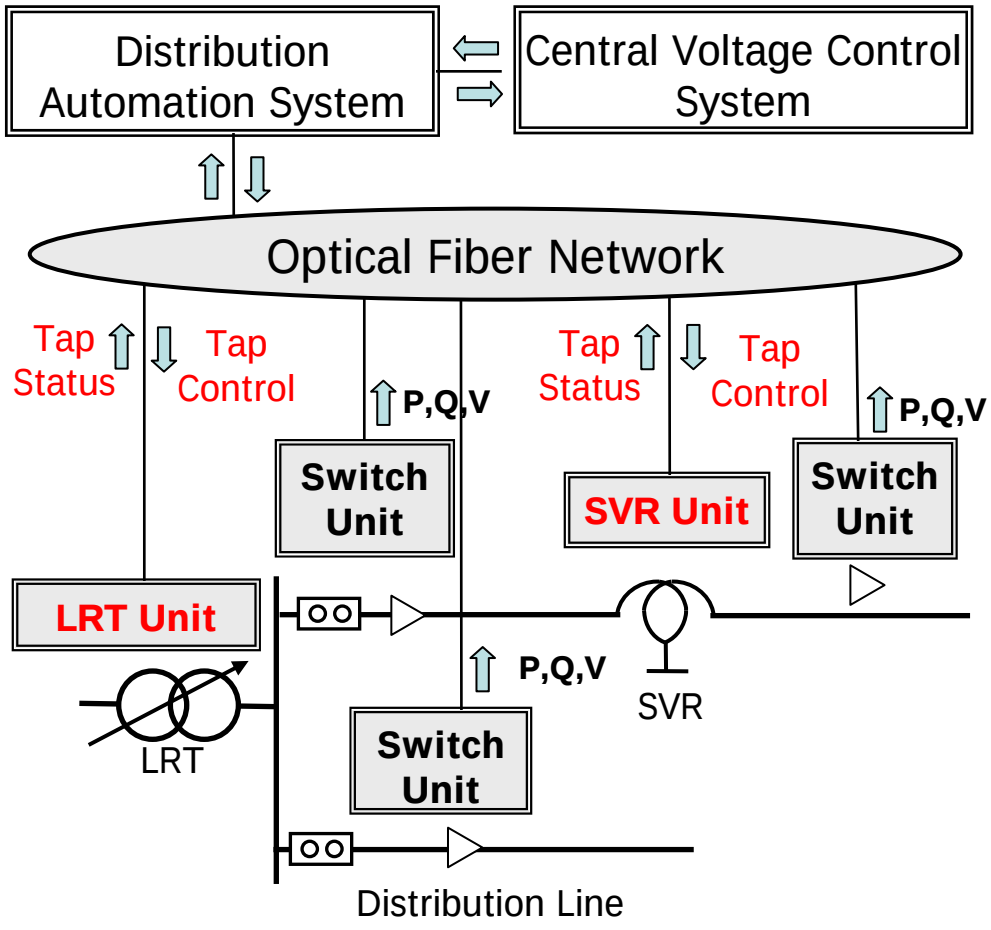
SVR (SVC) can detect only voltage at its location. Voltage at Target point can be strongly

Central Voltage Control

Local controlled devices can help in solving some problems but due to the narrow vision of the network status they may not be sufficient.

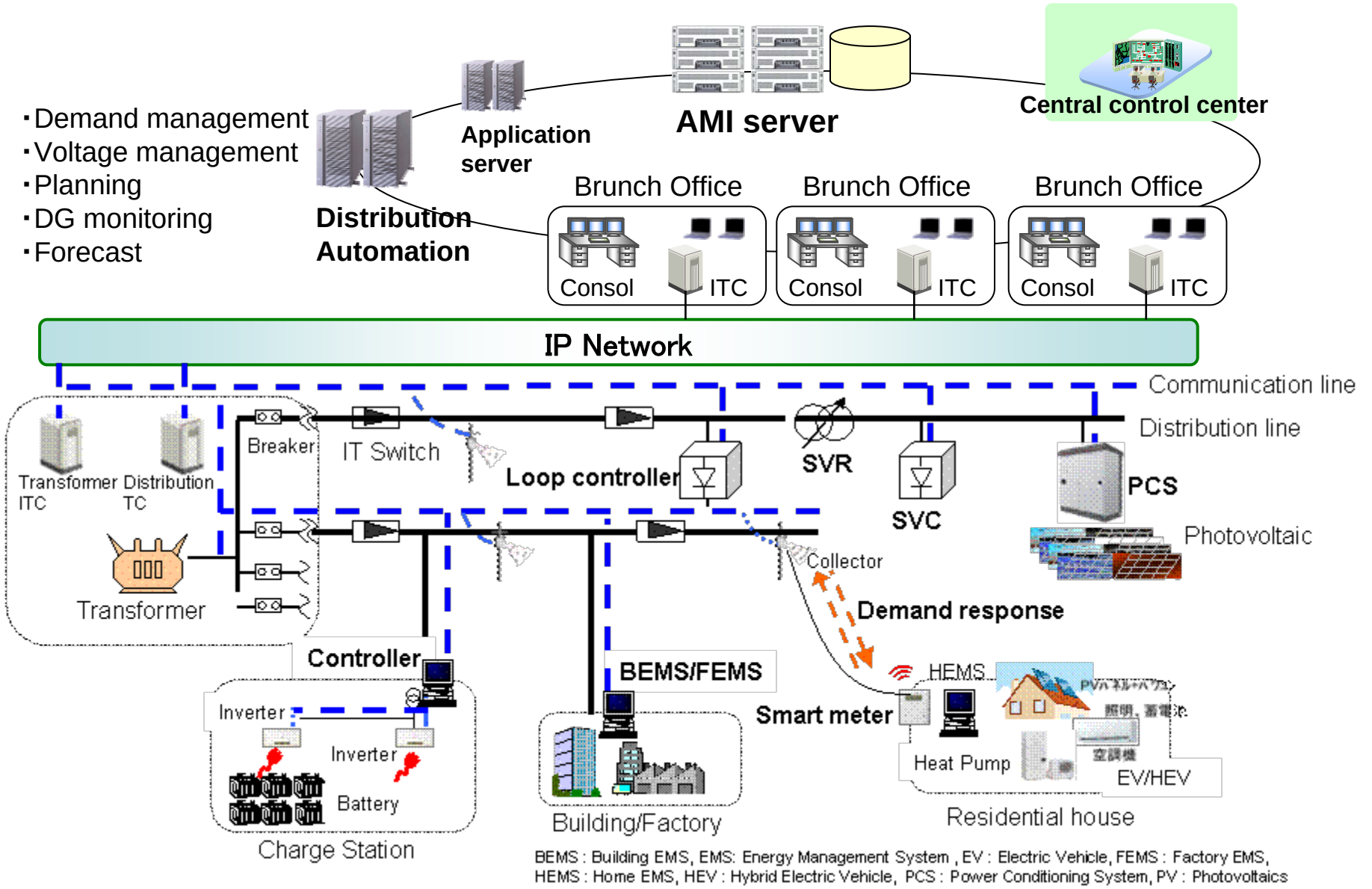
Central Voltage Control System:

- Acquisition of several data of the network using sensors installed in the switch.
- State estimation for non-monitored network points
- Optimal power flow calculation for tap position of LRT/SVR and reactive power output for SVC based on loss minimization.
- On line control of distribution equipment



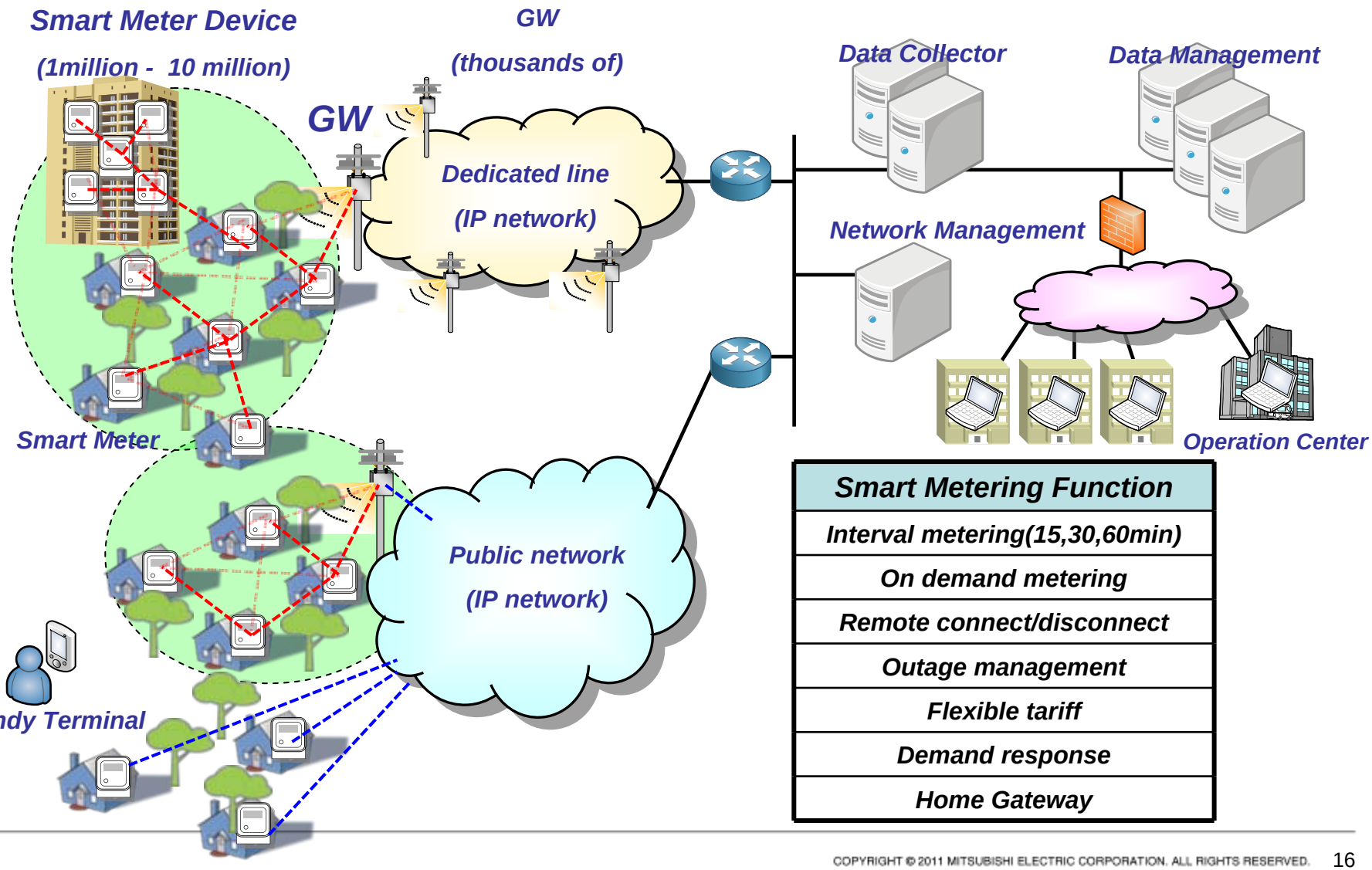
Distribution Management

- Demand management
- Voltage management
- Planning
- DG monitoring
- Forecast



BEMS : Building EMS, EMS: Energy Management System , EV : Electric Vehicle, FEMS : Factory EMS, HEMS : Home EMS, HEV : Hybrid Electric Vehicle, PCS : Power Conditioning System, PV : Photovoltaics

Smart Metering



Smart Metering Function
Interval metering(15,30,60min)
On demand metering
Remote connect/disconnect
Outage management
Flexible tariff
Demand response
Home Gateway

Smart Grid/Smart Community Concept

Compatibility between a low-carbon society and prosperous lifestyles: Smart community/Smart grid

Realize optimal energy control integrating Mitsubishi Electric's expertise in all areas, from power systems to consumer electronics