Demand supply integrated control of the Next Generation Grid in CRIEPI

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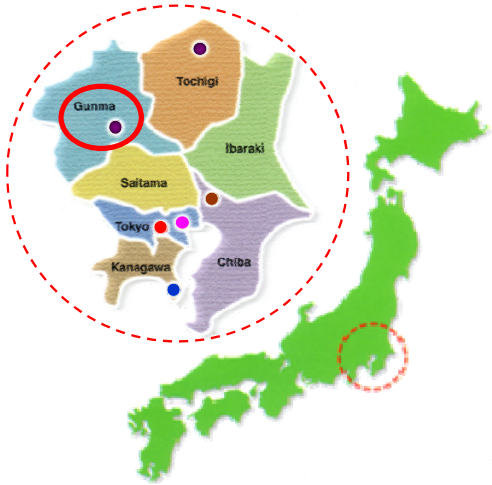
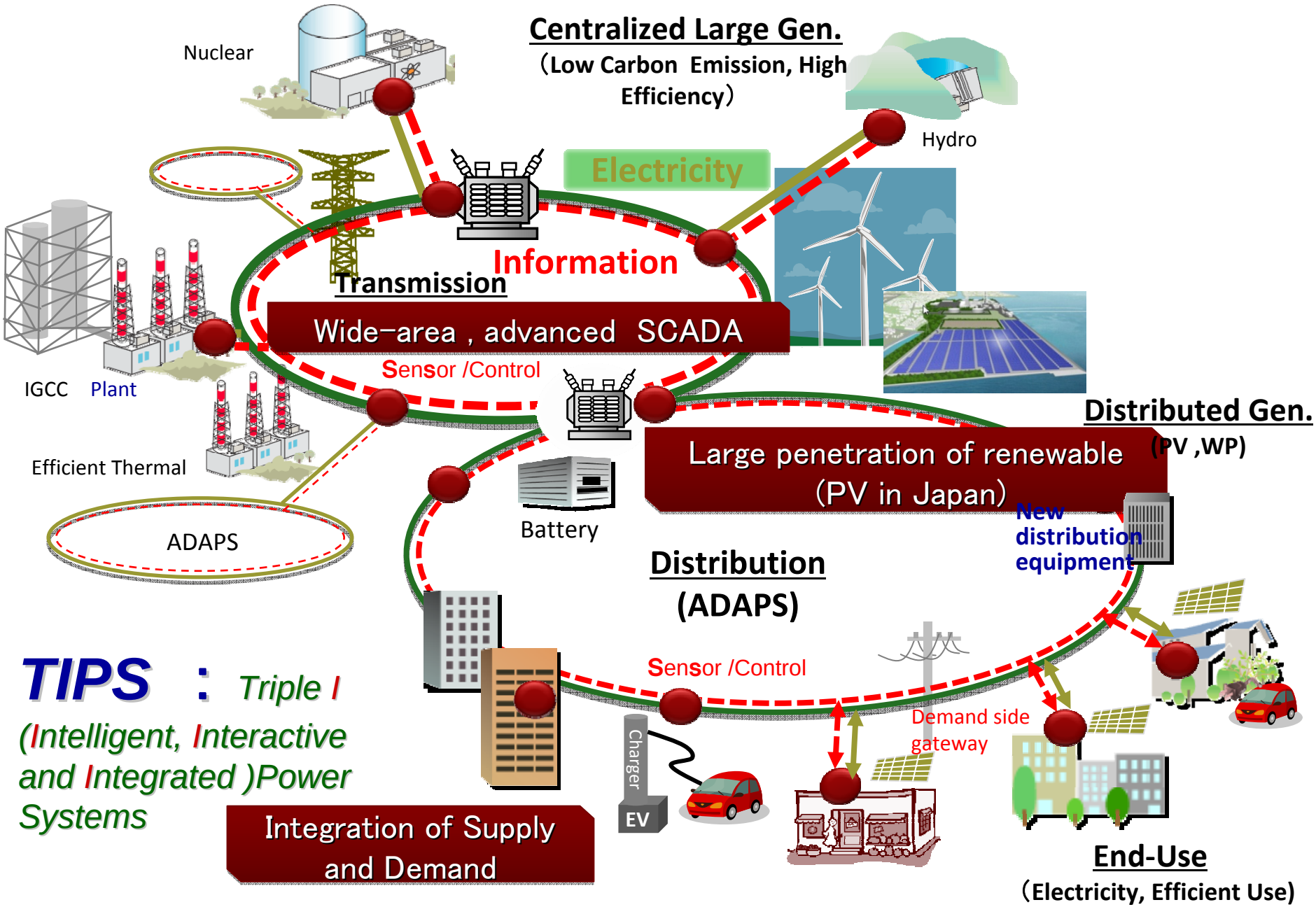


San Diego 2009 Symposium on Microgrids

September 2009
University of California San Diego

CRIEPI AKAGI Testing Center

Japanese Smart Grid



TIPS : *Triple I (Intelligent, Interactive and Integrated)Power Systems*

Requirements of Next Generation Grid

1. **Minimize the risk of large blackout with securing stable operation. Resilient and self-healing system.**

CO_2 reduction

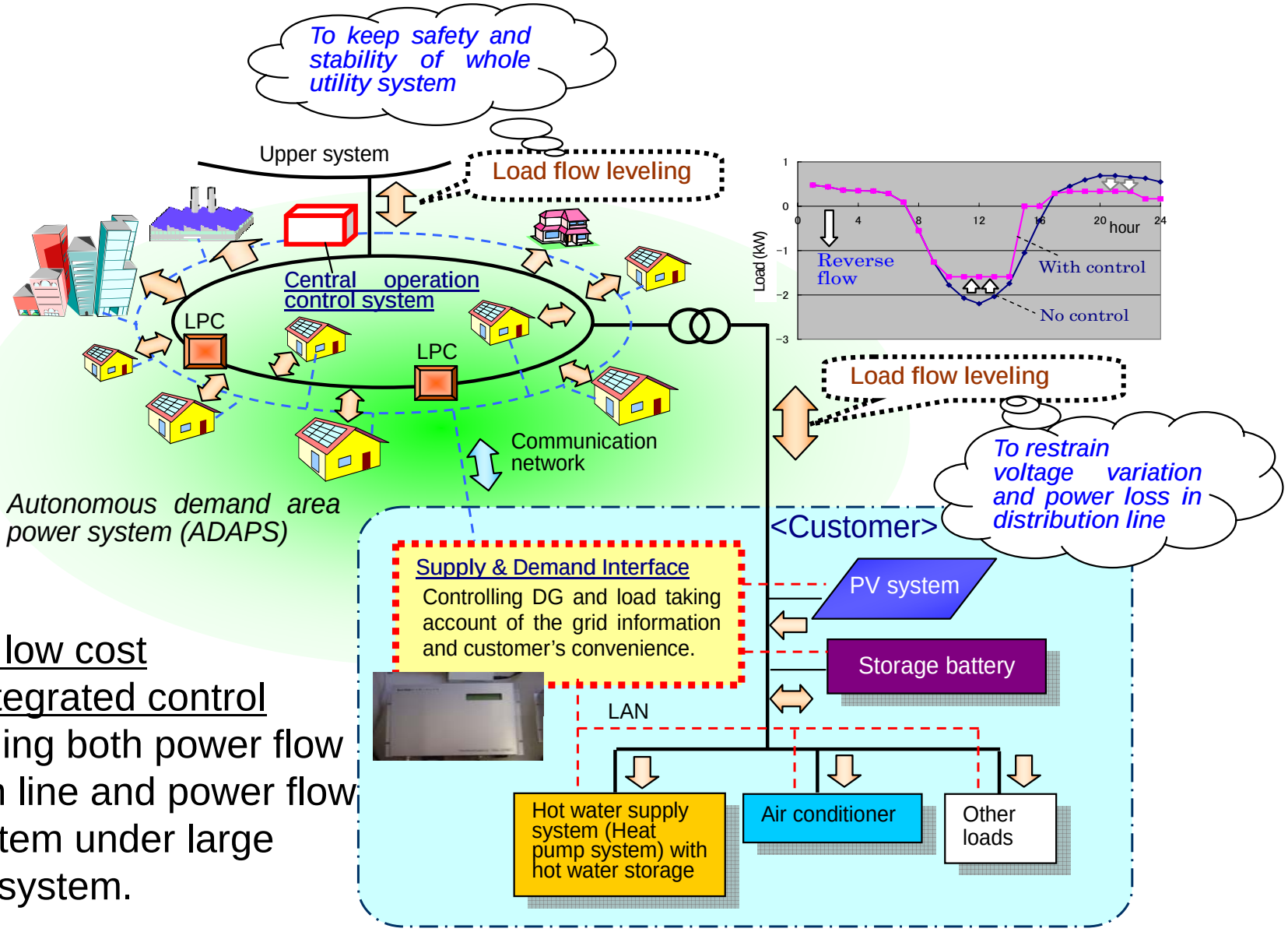
2. **Enable large penetration and effective utilization of distributed generation using renewable energy.**
3. **Enable conservation and efficient utilization of energy with integration of demand and supply side.**

4. **Sophisticate Asset Management and meet to future social needs using advanced power equipments**

R&D of Japanese future power systems called,

TIPS: **T**riple **I** (**I**ntelligent, **I**nteractive and **I**ntegrated) **P**ower **S**ystems

Concept of new power flow control method by supply/demand integration



Objectives:

To develop a new low cost supply/demand integrated control technique for leveling both power flow in local distribution line and power flow to upper utility system under large penetration of PV system.

Integration of DGs into the power system

- DG (RES, PV in particular) will be penetrated largely according to Japanese governmental target toward 2030.
  - ✓ Photovoltaic (PV) power generation : 53 GW
  - ✓ Wind turbine : 0.6 GW
  - ✓ Biomas (Waste): 0.4 GW

- *Power quality*, *safety* and *reliability* on the distribution line may not be kept by the current grid interconnection techniques adopted to DG side only.

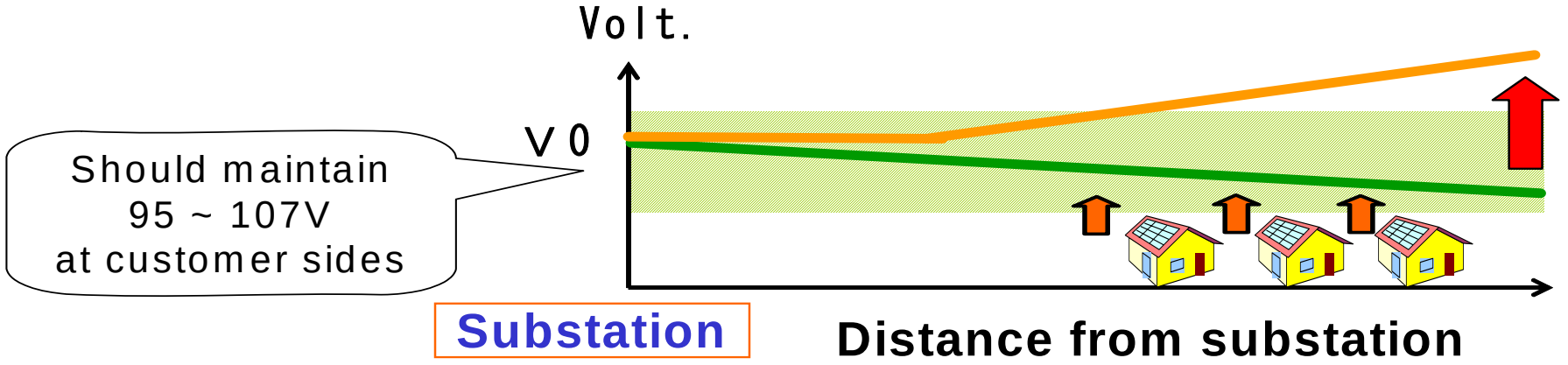
- In 2001, CRIEPI proposed a future advanced distribution system called *Autonomous Demand Area Power System* (ADAPS) to cope with the large penetration of DG. R&D were started in 2003.

Problem in large penetration of DG
- Voltage deviation from proper range -

When reverse power flow from DG occurs, distribution line voltage generally goes up by the distribution line impedance.

-- Line voltage may exceed upper limitation.

-- Large energy loss of DG may occur caused by regulated function reducing real power to prevent the voltage rise.



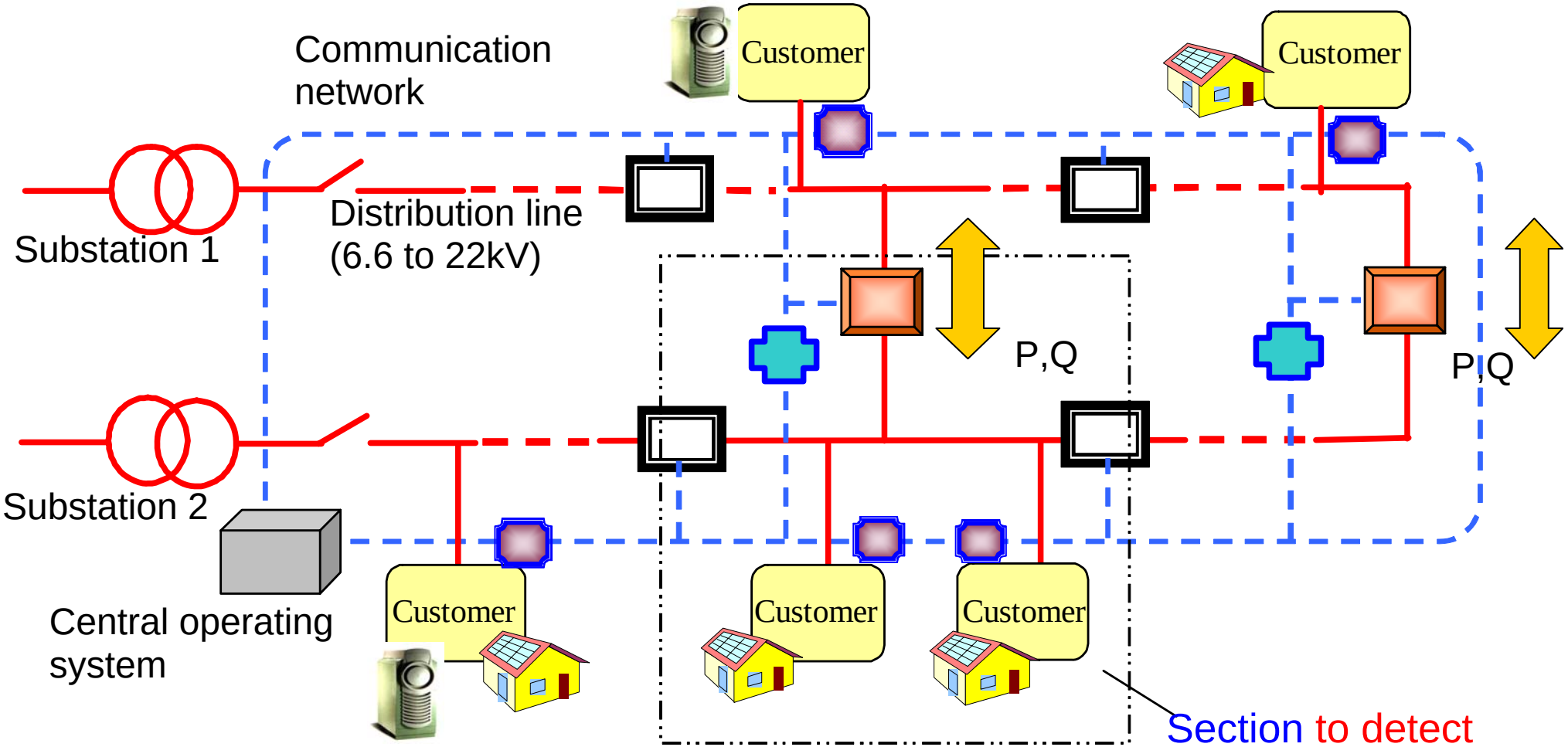
Technical problems and possible penetration rate of DG

- *Results of demonstration test and simulation*
- *Possible penetration rate is restricted 5% to 20% in the worst case.*

Expected technical problems	Penetration rate of DG when problems occur (Note ; under the worst case)
- *Voltage variation* on distribution line due to reverse power flow.	More than 5 to 20%
- *Deterioration of safety* in case of distribution line fault.	
-- Increase short circuit capacity	More than 40%
-- Give a bad influence to the grid protective relay operation	More than 20%
-- Cause islanding phenomena	More than 20 to 30%

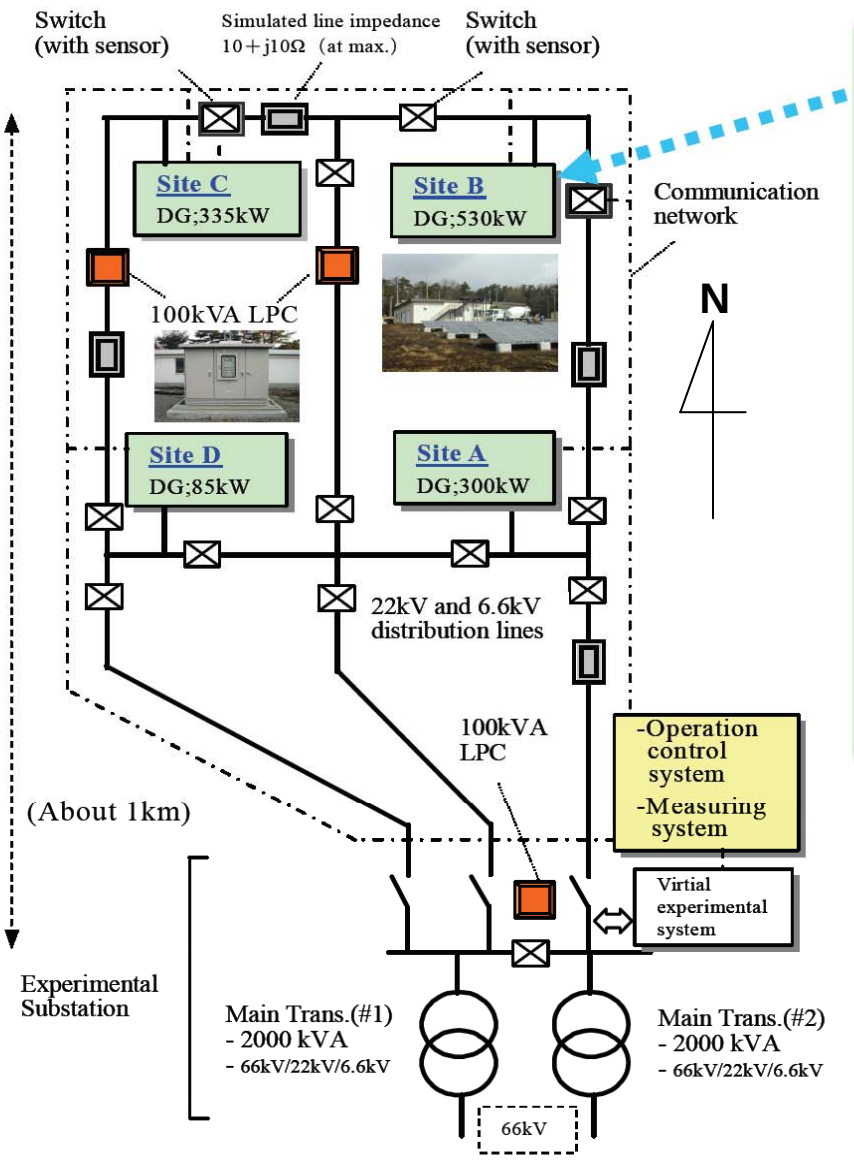
Note) Penetration rate ; Ratio to distribution line capacity

Basic configuration of *ADAPS* using LPC



Loop shaped config. is adopted, LPC installed to control voltage&current of D.L. including fault condition. SDI installed at each customer to control DG autonomously using communication network. Central operation system installed.

Whole configuration of demonstration test facility for ADAPS



Whole configuration of the test facility

Distributed power generations in a site

150kW rotating type generator
(simulates WP, Co-generation)

20kW Inverter type generator
(simulates PV,FC, etc.)

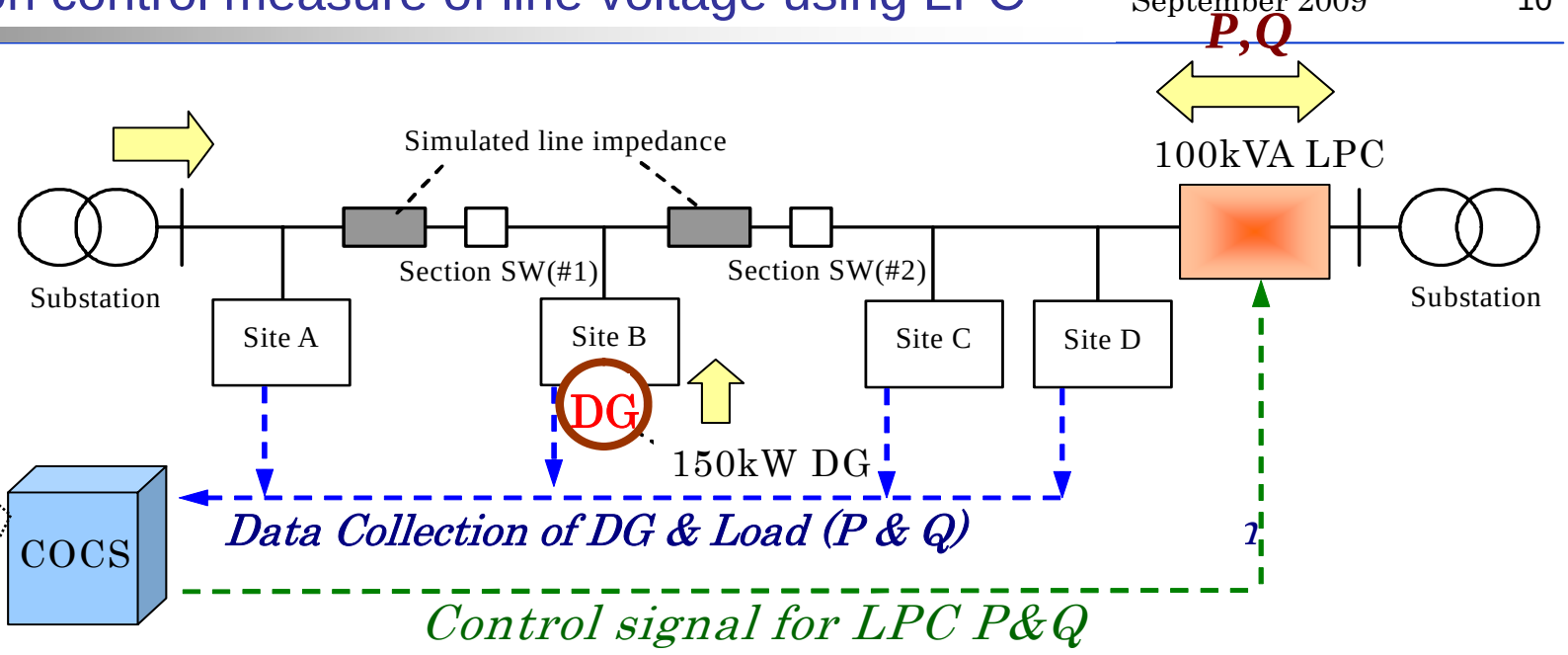
4 to 5 kW power conditioner
for PV power generation

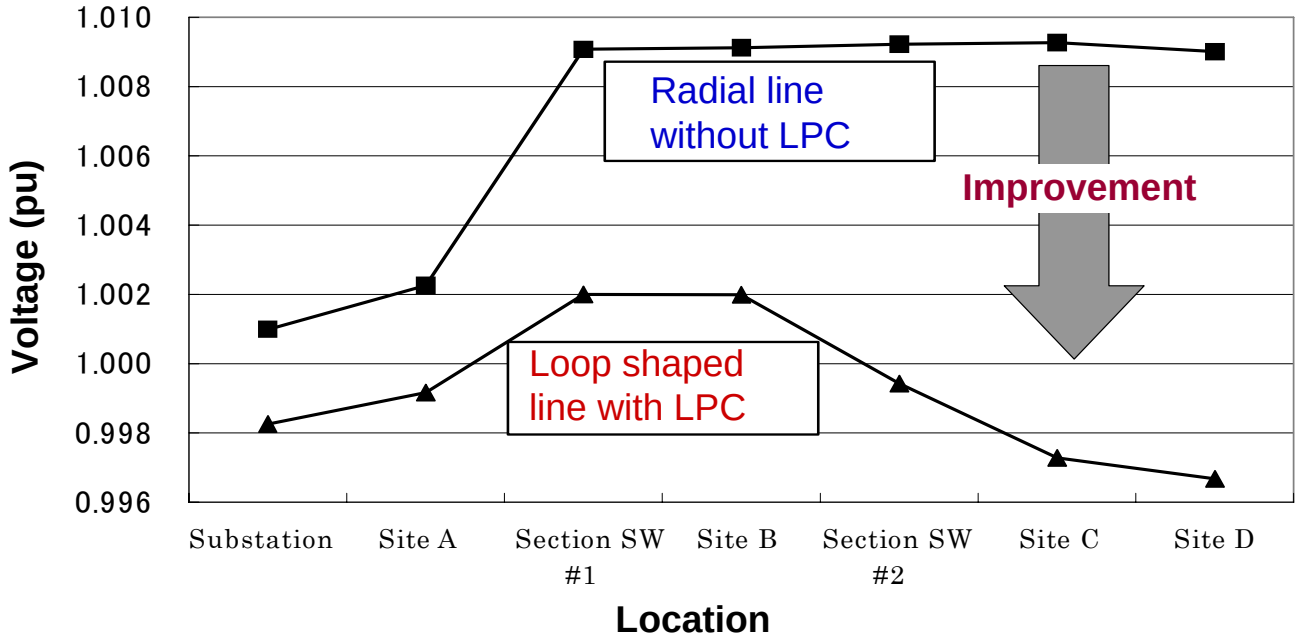
Composition of distributed power generators

Rotating generator	150kW etc.	6 units	600kW
PV system	5kW etc.	16 units	80kW
Simulated FC, PV, Storage battery	20kW 100kW	12 units 3 units	240kW 300kW
MGT	30kW	1 unit	30kW
Total			1250kW

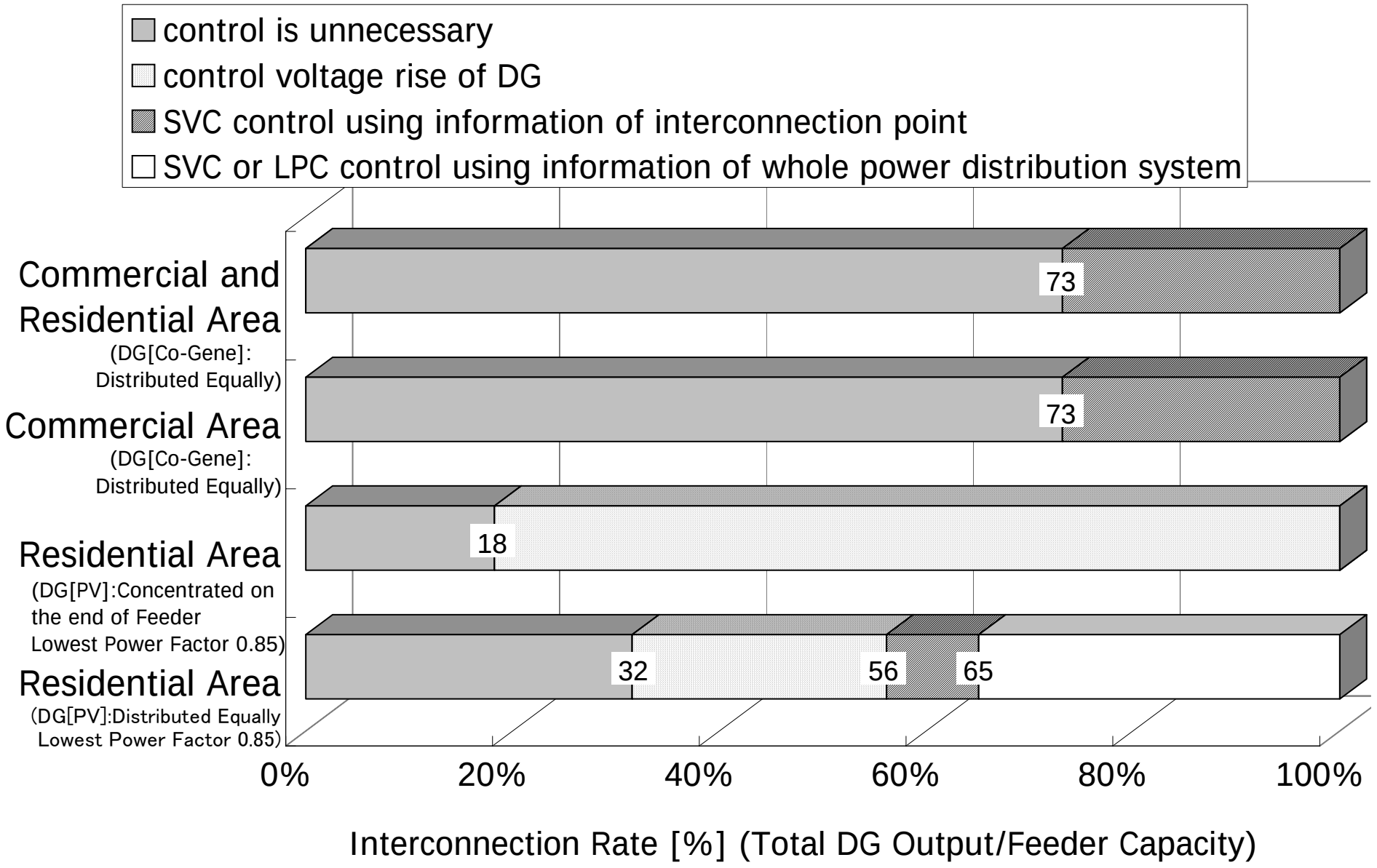
Operation control measure of line voltage using LPC

Calculating optimum P,Q of LPC to keep proper voltage with minimizing LPC output kVA.





Selection of voltage regulation methods

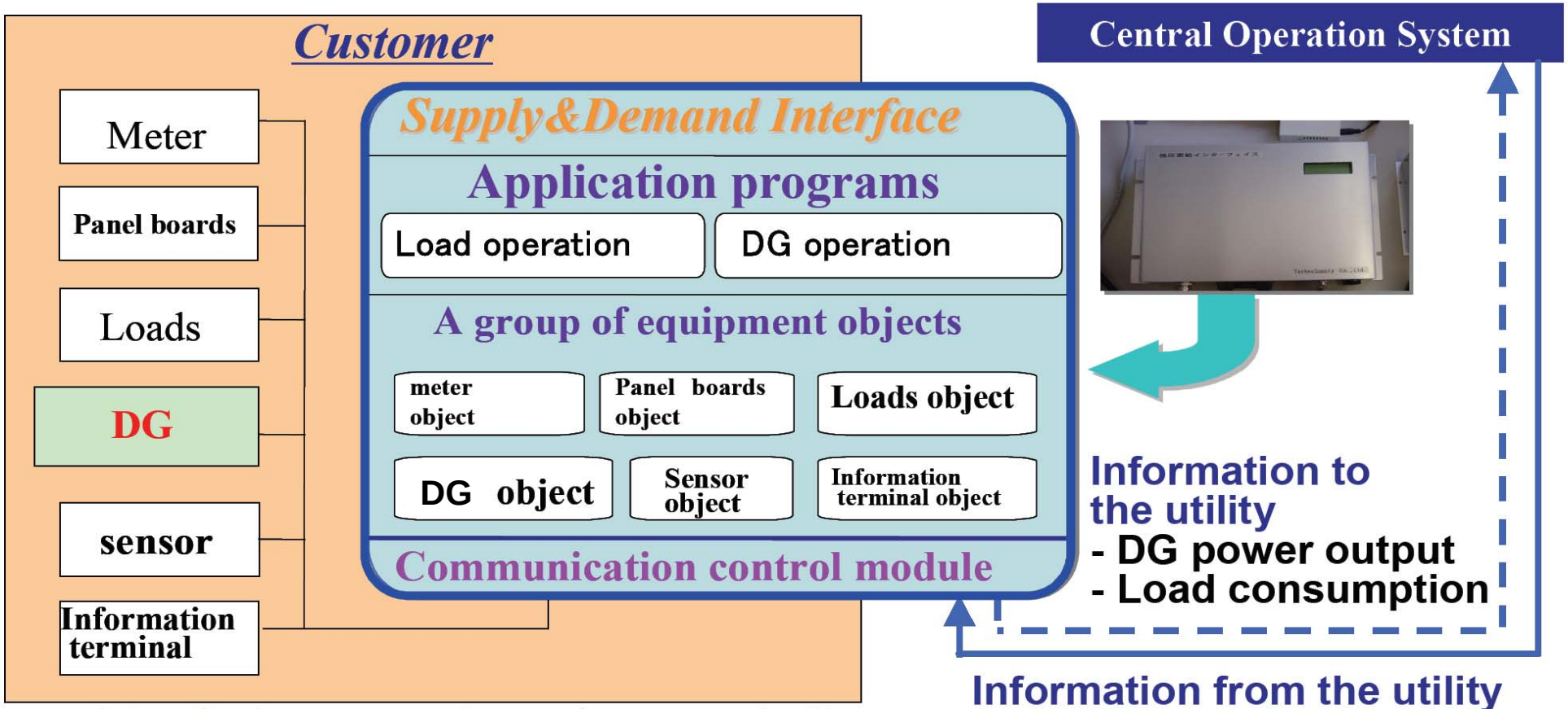


Results of the Autonomous Demand Area Power System (ADAPS)

- Centralized voltage control technique using a new device
  Loop Power Controller (LPC)
- Proper protection and safety methods using communication network

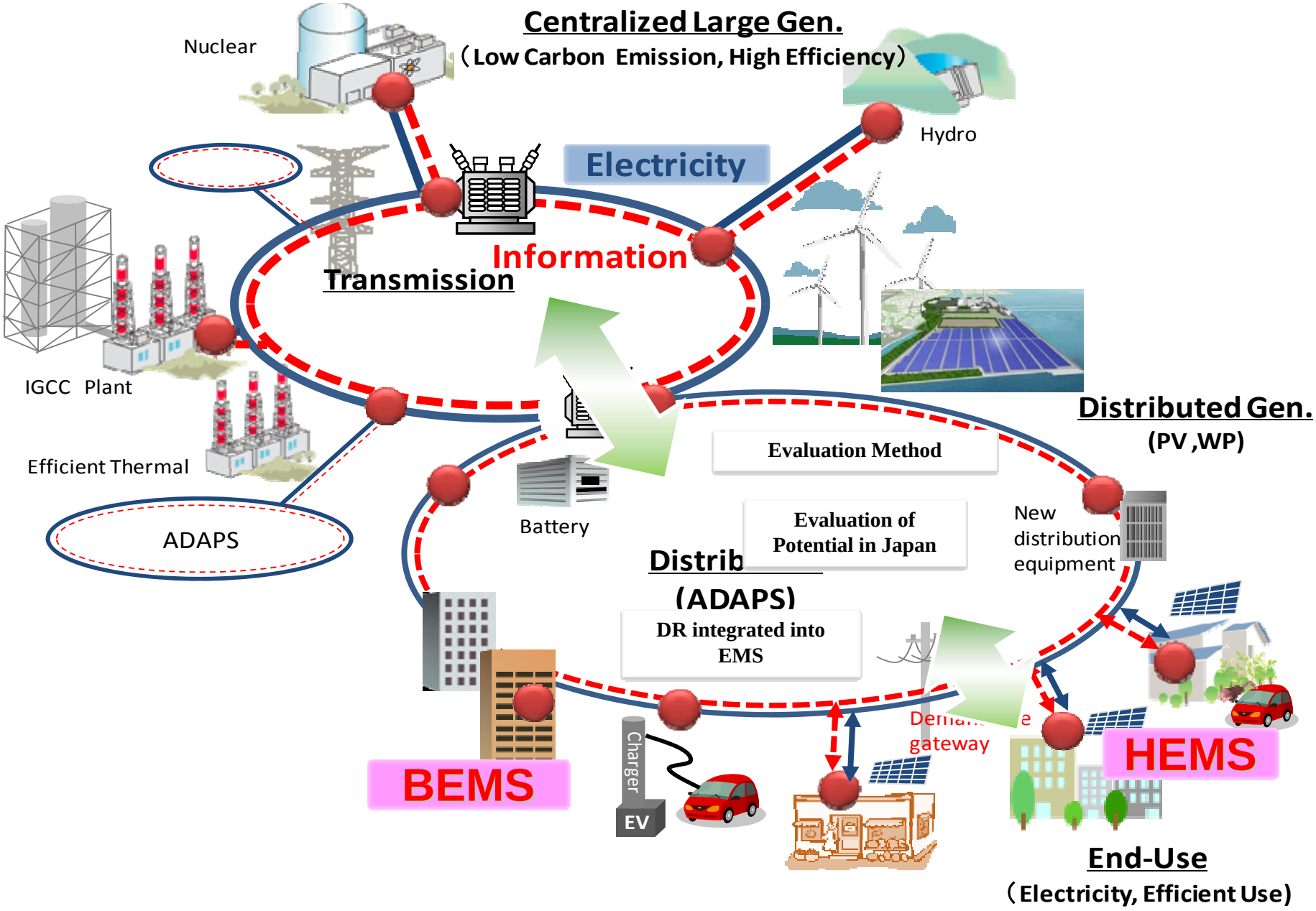
➢ *From those results, possible penetration rate of DG*
in a distribution feeder can reach 100% .

Configuration of Supply/demand Interface



- *consists of micro computer and communication modem.*
- *exchanges information with utility*
- *controls customer's* **DG** *and load automatically* ***to obtain energy saving, cost minimum, improvement of power quality (local area) and load leveling.***

Demand Response in Japan



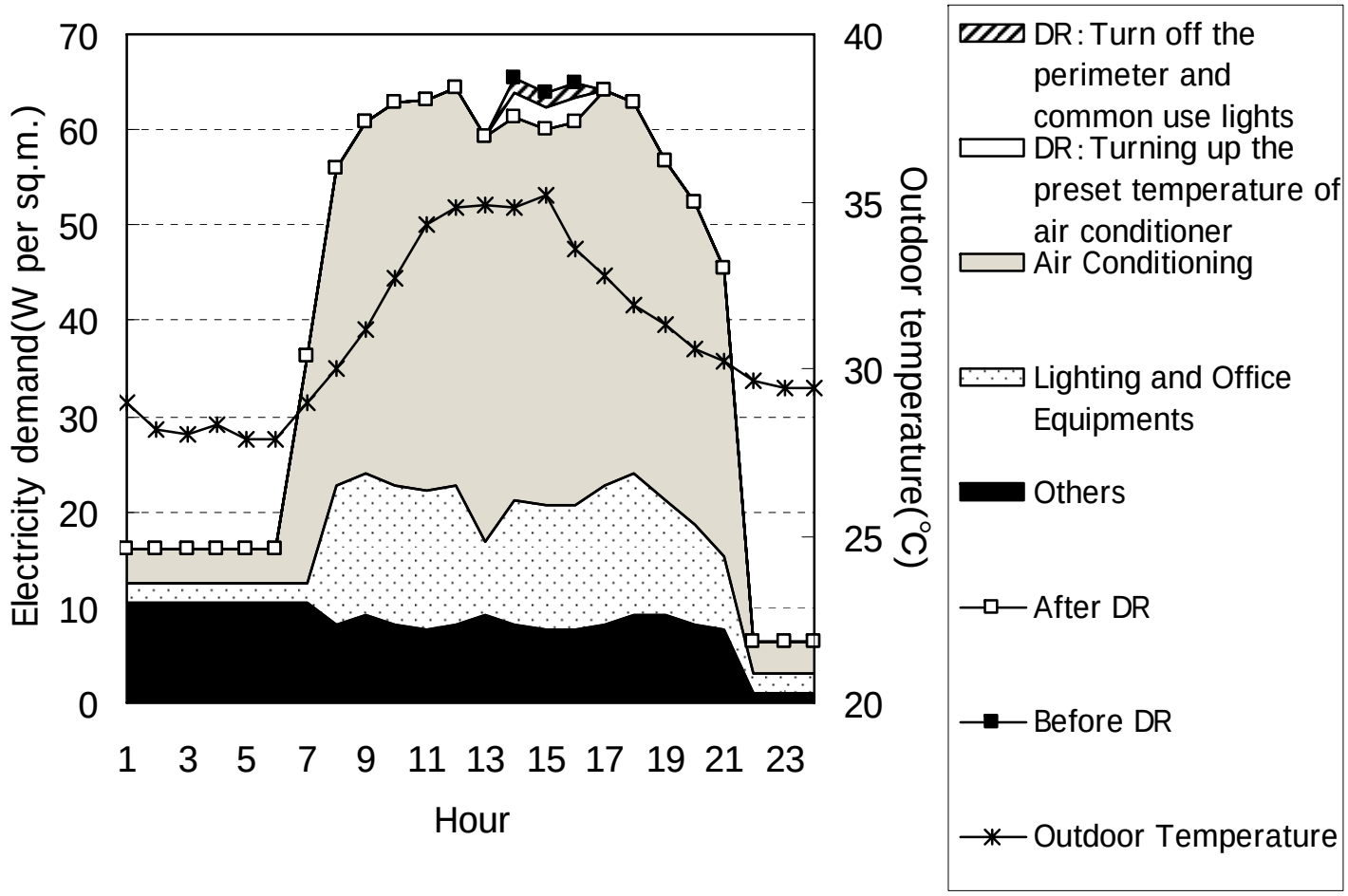
Evaluation of demand response programs

- Project period : FY 2008-2010
- Empirical analysis of load data from PG&E CPP program with DR Research Center, LBNL
- An energy management system modified for automated DR
- An evaluation method of value of demand response (DR) programs to the supplier and customers
- Preliminary analysis of benefits of DR program in Japan

DR Strategies Considered In The Potential Estimation For Japanese Commercial Sector

	Office building	Retail store
Global temperature adjustment	Increase zone temperatures for an entire building, from 26.2℃ to 28℃	Increase zone temperatures for an entire building incl. shop zones 26.2℃ to 28℃
Zone switching	Turn off lights of common spaces and perimeter zones	Turn off lights of stockrooms and back offices
Discharging attached battery of computer appliances	Discharge built-in battery of notebook computer and UPS of server system during a DR period	

Hourly electricity demand curve and shaved demand of an analyzed small-sized office building with decentralized air conditioners



Possible DR in Japan

- **Current DSM programs**
  - **Load adjustment contract: large customers only**
  - **TOU rate**
  - **DSM appliance: HP water heater with storage tank, thermal storage air conditioner**
- **Possible DR in the future**
  - **Demonstration projects of DR**
  - **Penetration of energy management systems**
  - **Emergency programs : outage of large power plants by earthquake**
  - **Integrated demand control with roof-top PV and battery storage: PHEV, technology progress of Li ion battery**

- The power system in Japan is highly reliable and cost effective in current condition.
- It should be changed toward Low Carbon Society.
- The main driving forces of the change in Japan are “PV” and “more efficient use of electricity in highly electrified society”.
- CRIEPI is developing Japanese Smart Grid under the **TIPS** project.

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