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TS PGCF-2

Verification tests of the energy system integrated of CGS and renewable energy

Kunihiro Nakao
Osaka Gas Co., Ltd.

IGU
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- Background
- Aims
- Methods
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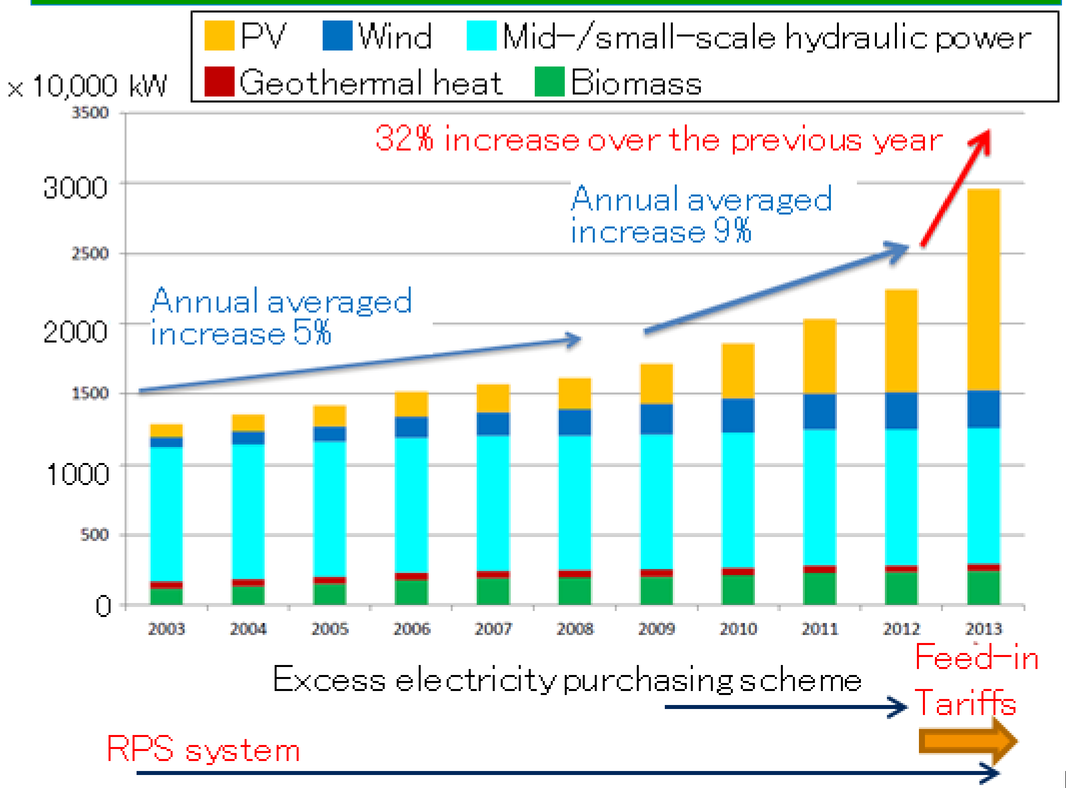
- Summary/Conclusions

Challenges for the grid interconnection

Due to the shut down of nuclear power plants after the earthquake disasters and the introduction of Feed-in Tariff system, the various problems of power system in Japan are becoming obvious.

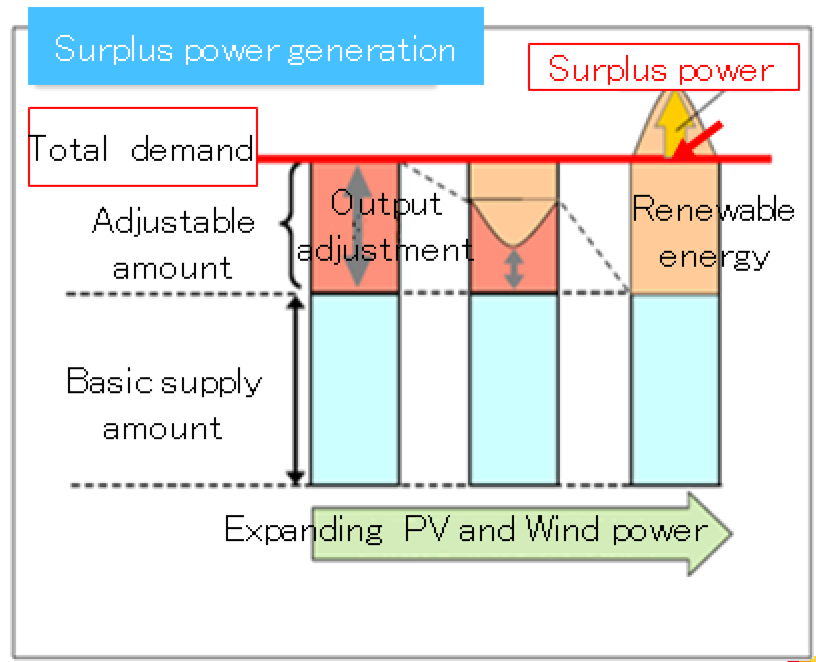
Transition of installed capacity of renewable energies



Reference: Material by the 1st New and Renewable Energy Subcommittee, METI (June 17, 2014)

Problems of power system

Some power utilities have already suspended acceptance of interconnection.



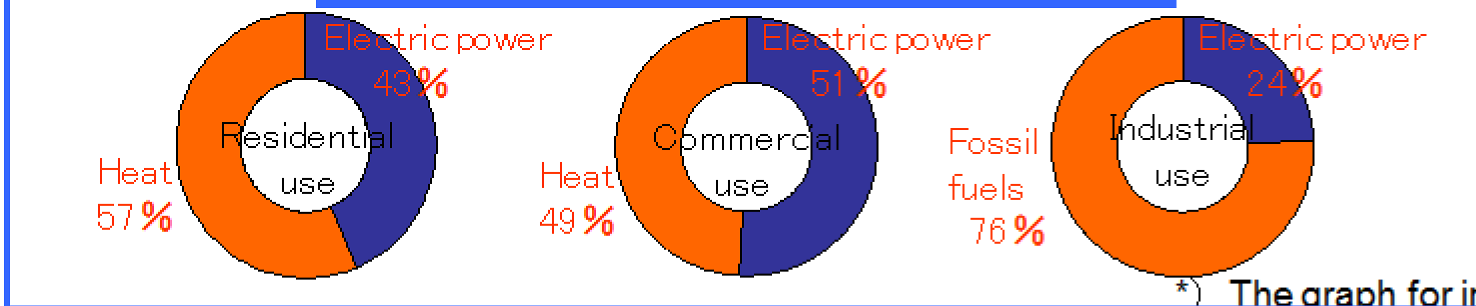
Reference: Material by the 2nd New and Renewable Energy Subcommittee, the Federation of Electric Power Companies of Japan (August 8, 2014)

Challenges for CO_2 emission reduction

In order to accomplish 25% reduction in CO2 emissions by 2020 (Japan's target), it is important to focus efforts on achieving low carbon not only in electric power generation but also in heat energy resources, which account for more than half of the total energy demand. So, widespread use of CGS will contribute to the challenges.

Percentage of heat and electric power in total energy consumption

Source: Handbook of Energy & Economic Statistics in Japan (2008)



*) The graph for industrial use indicates the percentage of electric power and fossil fuels in final energy consumption.

Efforts for low carbon

Heat energy

- Promotion of cogeneration system installation
- Promotion of conversion to natural gas and its advanced utilization
- Diffusion of high-efficiency water heaters (latent heat recovery type)

Electric energy

- Promotion of renewable energy usage
- Improvement of efficiency of thermal power generation and promotion of CGS

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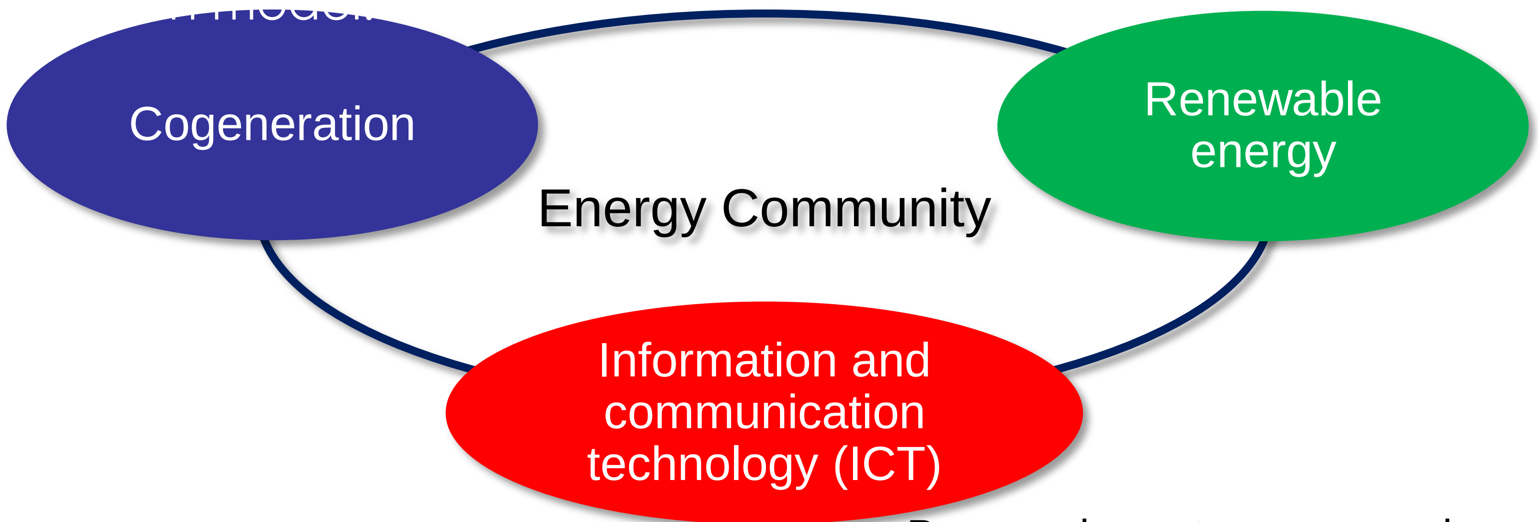
Concept of "Smart Energy Network"

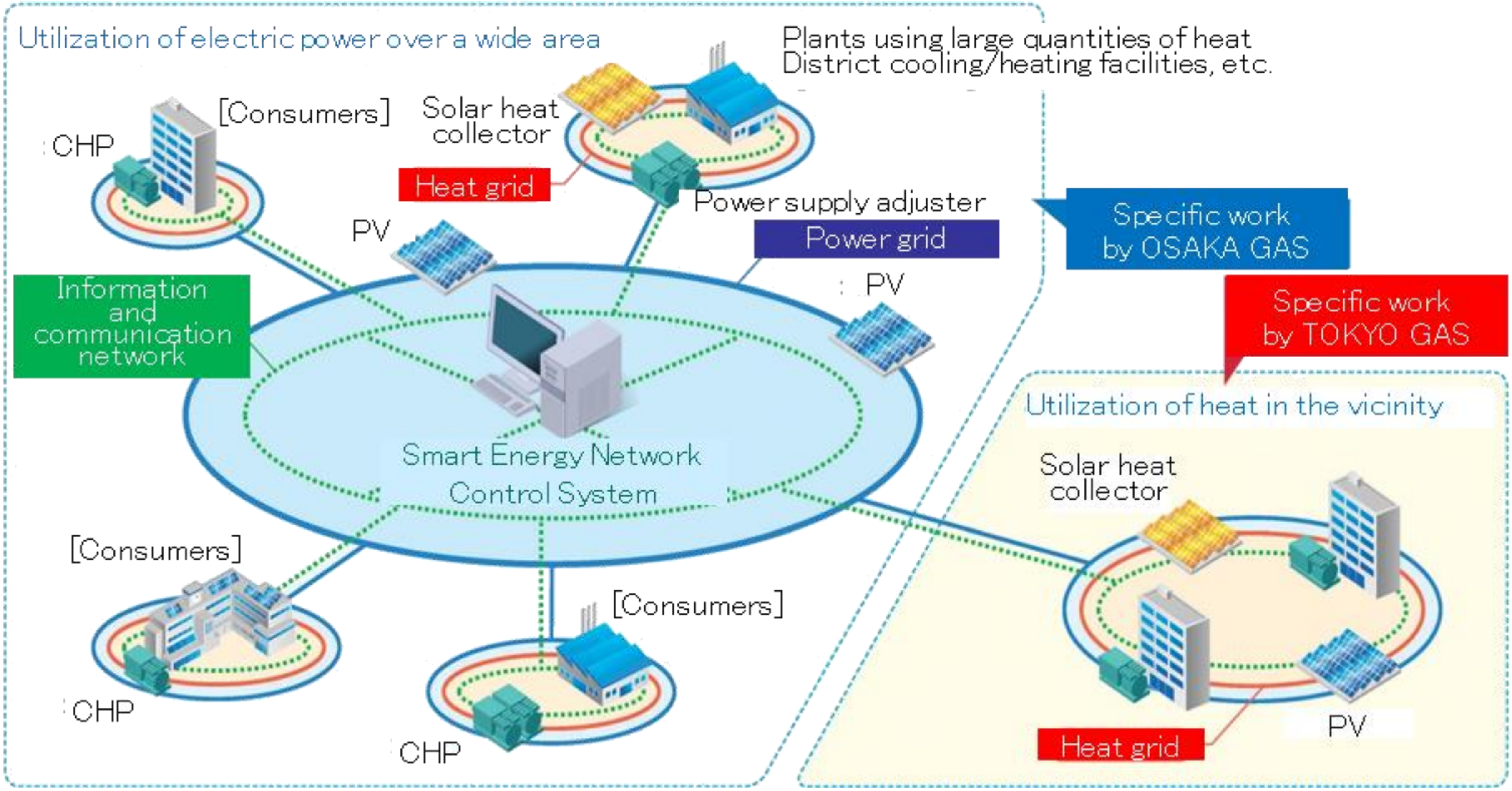
Osaka Gas brings forward an energy concept to solve the difficulties of supply/balancing power deficiency and CO_2 emission reduction. Our concept model can utilize distributed power supply by connecting it with ICT. The model is called a "Smart Energy Network," and we've already tested a



<Challenges>	<Proposed countermeasures in Smart Energy Network>
CO_2 emission reduction	High-degree utilization of heat and electricity generated by CGSs
Balancing power shortage	Smoothing output fluctuation of PV /Fast-DR of aggregated CGSs
Supply power shortage	Demand response of aggregated CGSs

Outline of demonstration project

Osaka Gas, collaborating with Tokyo Gas, has been conducting the “Distributed Energy Complex Optimization Demonstration” sponsored by the Ministry of Economy, Trade and Industry (METI). With the cooperation of actual users of CHP systems in Kansai region, the three major concepts of CGS are demonstrated.



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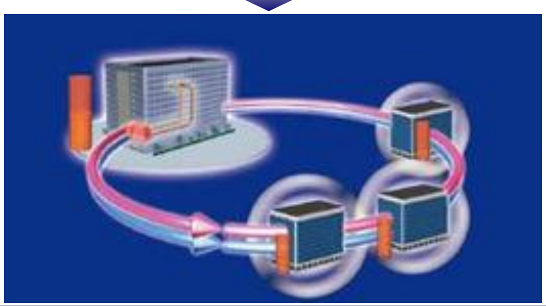
Contents of the demonstration test

These are the three tests to verify capabilities that previously mentioned countermeasures to various challenges.

Test A
(For CO_2 emission reduction)

【Use fossil fuel more efficiently】

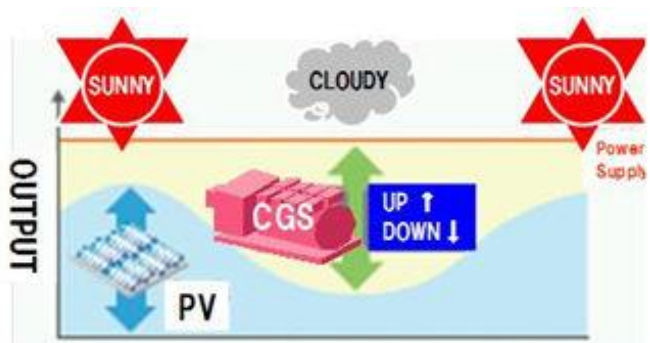
Typical use of CGS in Japan



To interchange heat and electricity generated by CGS to use energy more efficiently

Test B
(For balancing power shortage)

【Smooth PV fluctuation for contributing to power system stabilization】



To control CGS outputs to smooth PV fluctuations

As a option, test for checking adaptively to PJM code was also conducted (Fast-DR test)

Test C
(For supply power shortage)

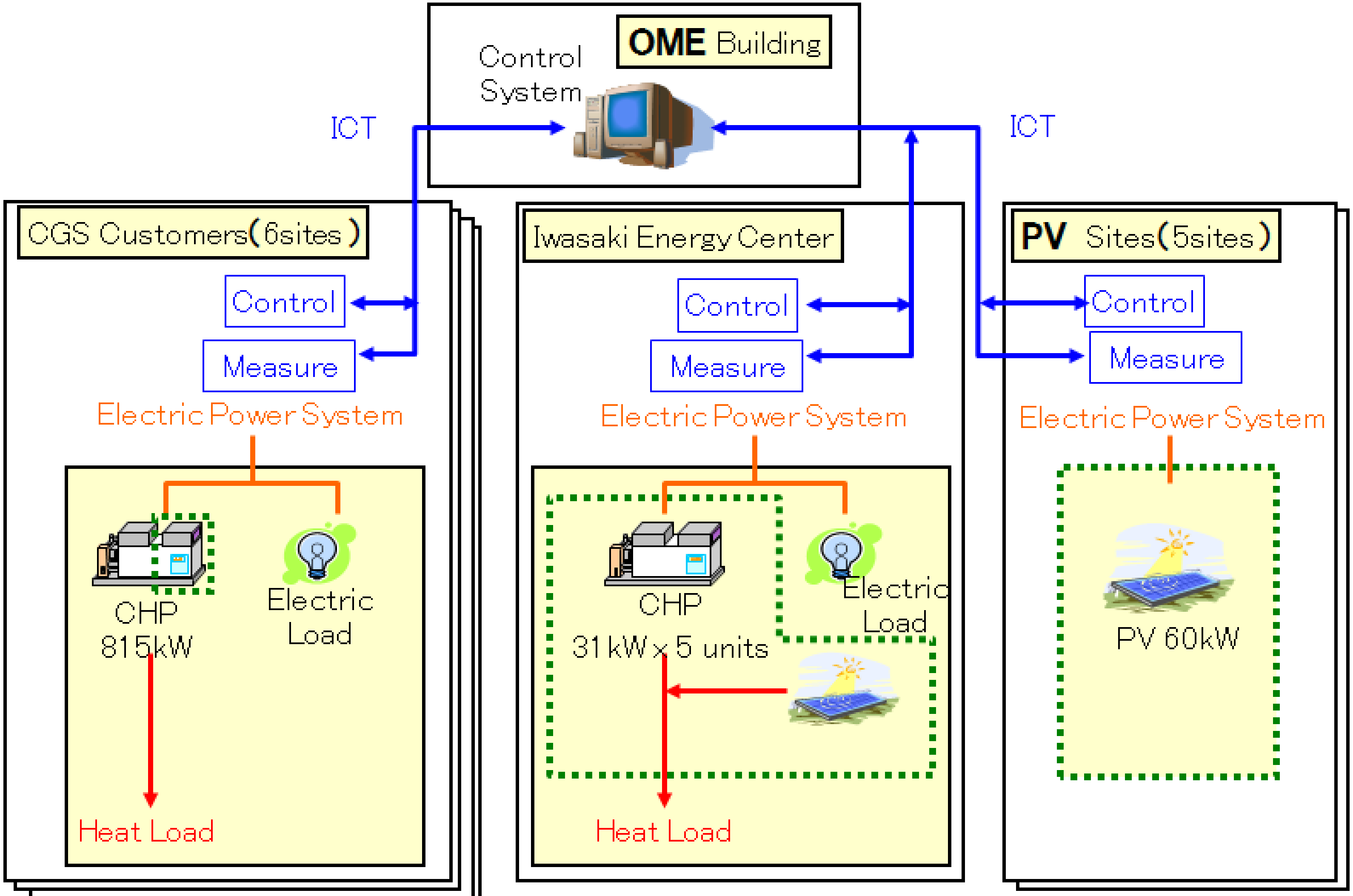
【Supply power at emergency and electric shortage, etc.】

Huge Thermal Power Plant

To control numbers of CGS outputs and use them like virtual power plants

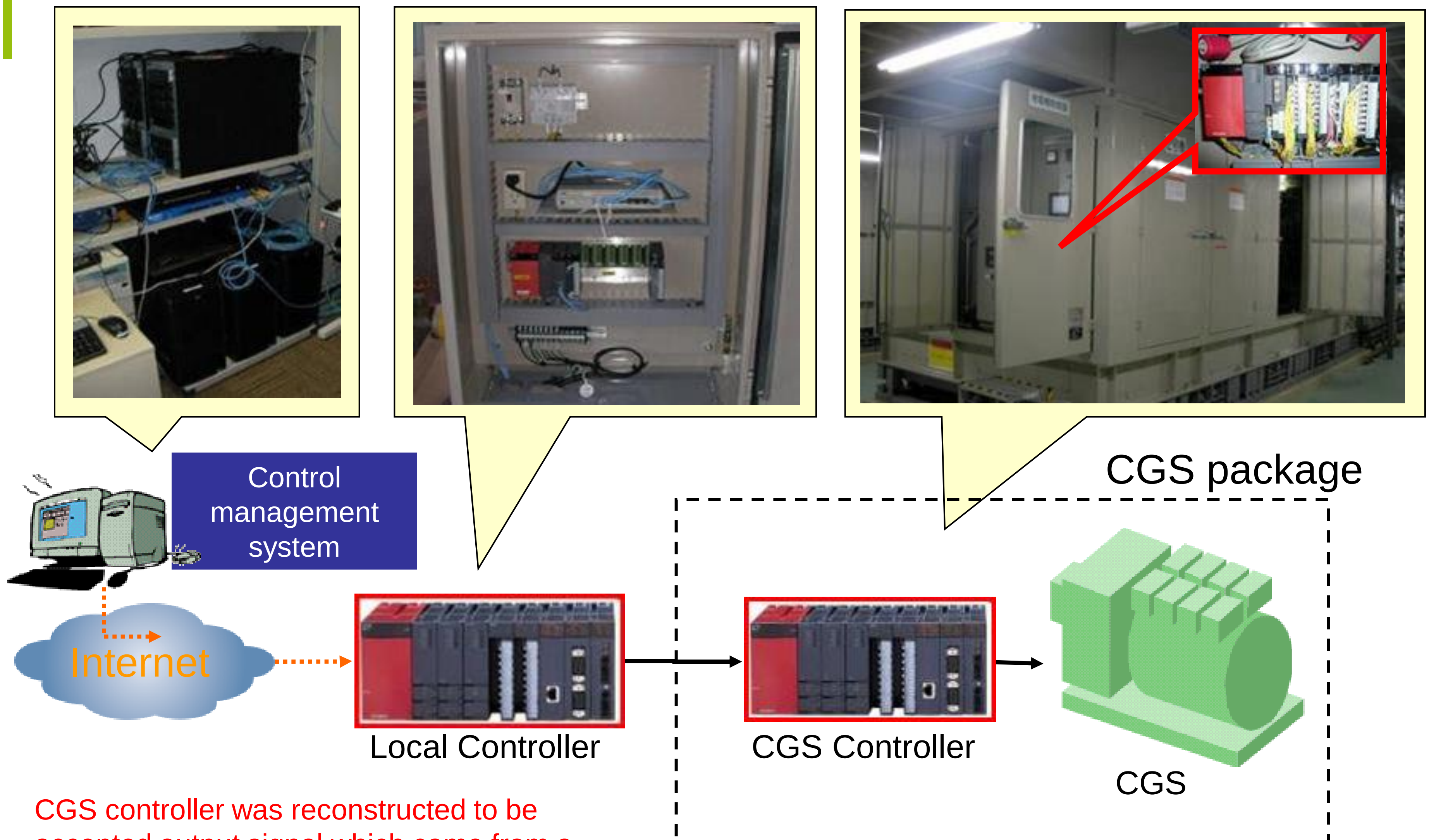
Composition of the test system

Demonstration system is composed by 7 sites where CGSs are installed and 5 sites where PVs are installed, and those sites are supervised and controlled by a center system.



Photos of CHP Customers joining this project

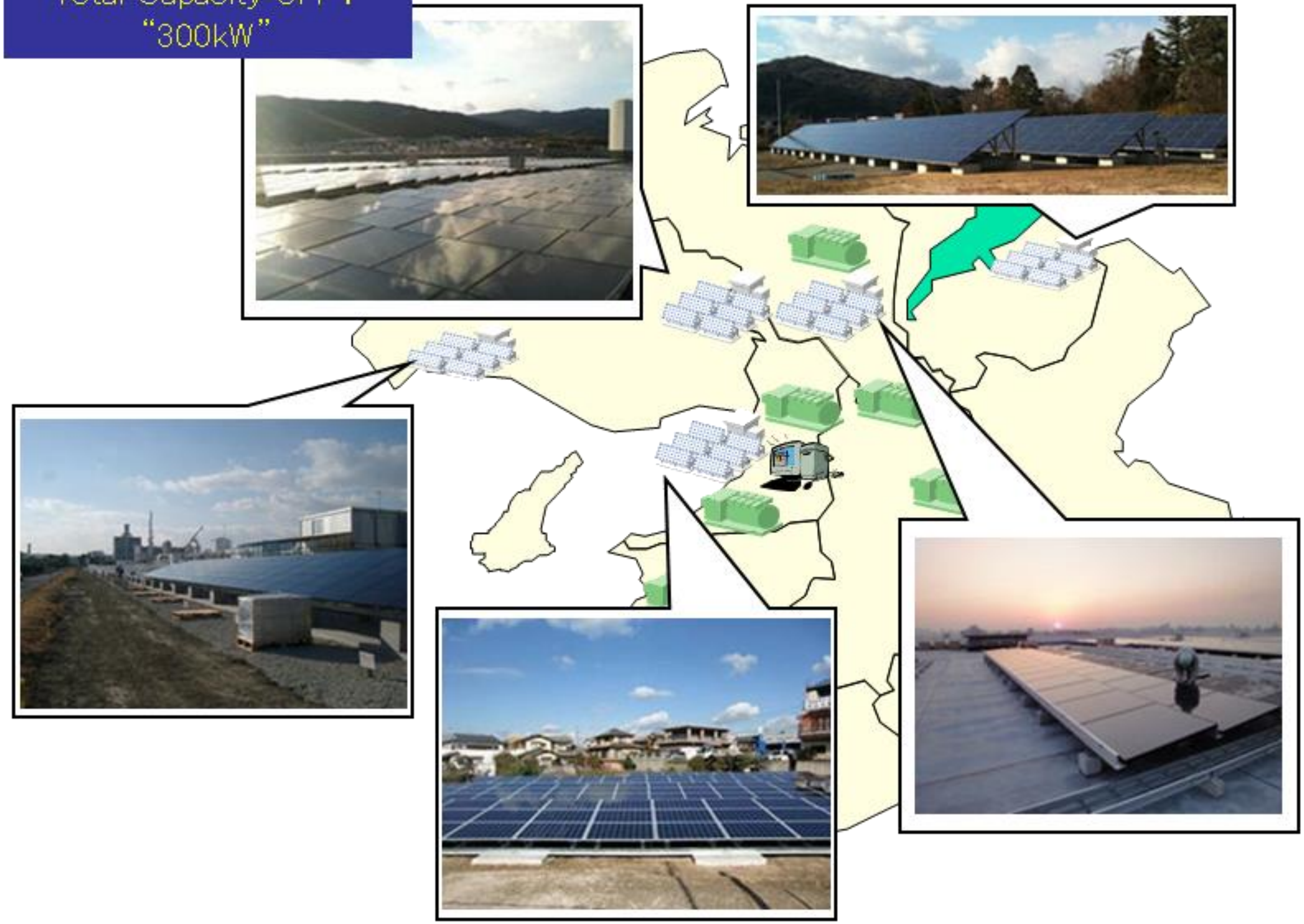
Photos of control system (Center system – each CGS)



CGS controller was reconstructed to be accepted output signal which came from a center system via internet.

Photos of PV sites

Total Capacity of PV
"300kW"



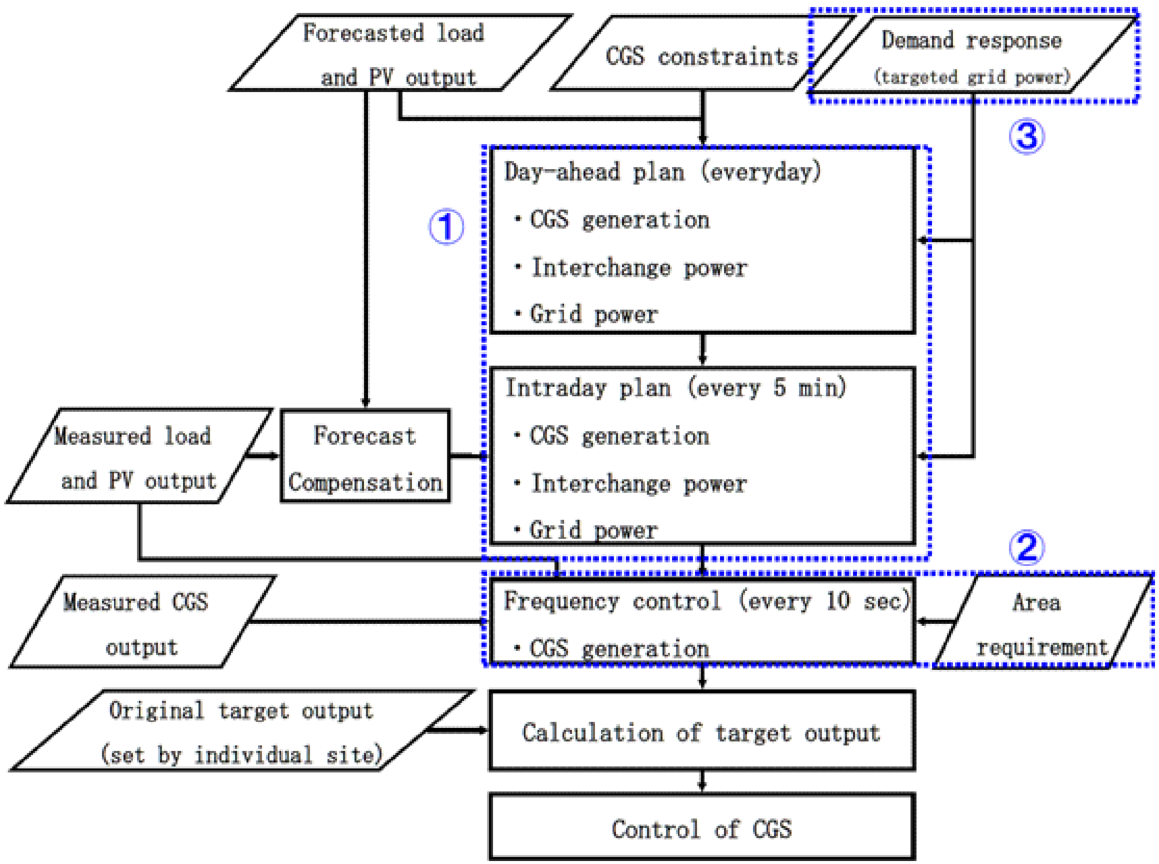
Flow diagram of control system

There are three functions that are corresponding to the previously mentioned tests.

(1) The function for planning optimized operation throughout the whole community on the day-ahead according to the various constraint conditions

(2) The function of generation and demand adjustment in real time on the day (≒Fast DR function)

(3) The function of demand response



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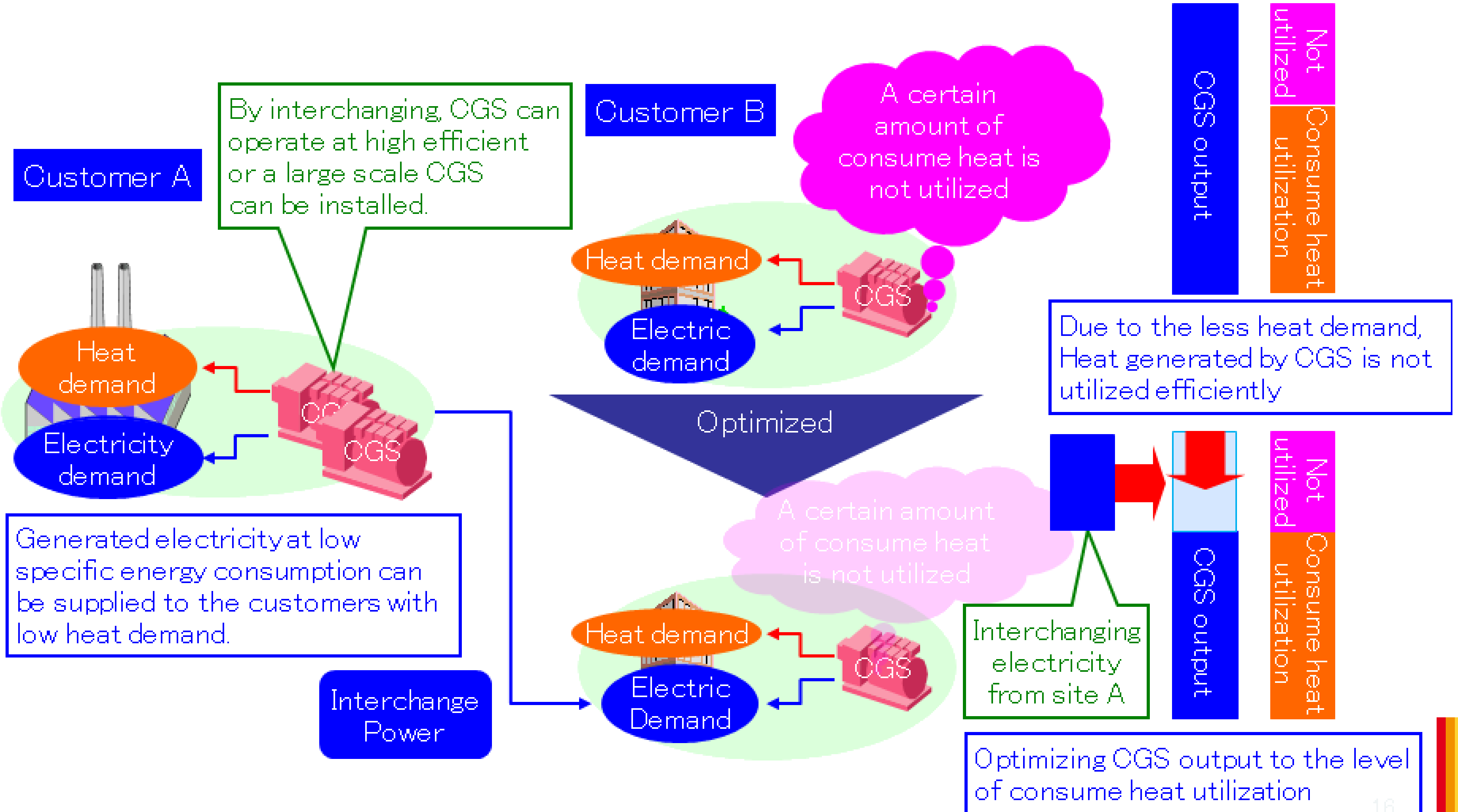
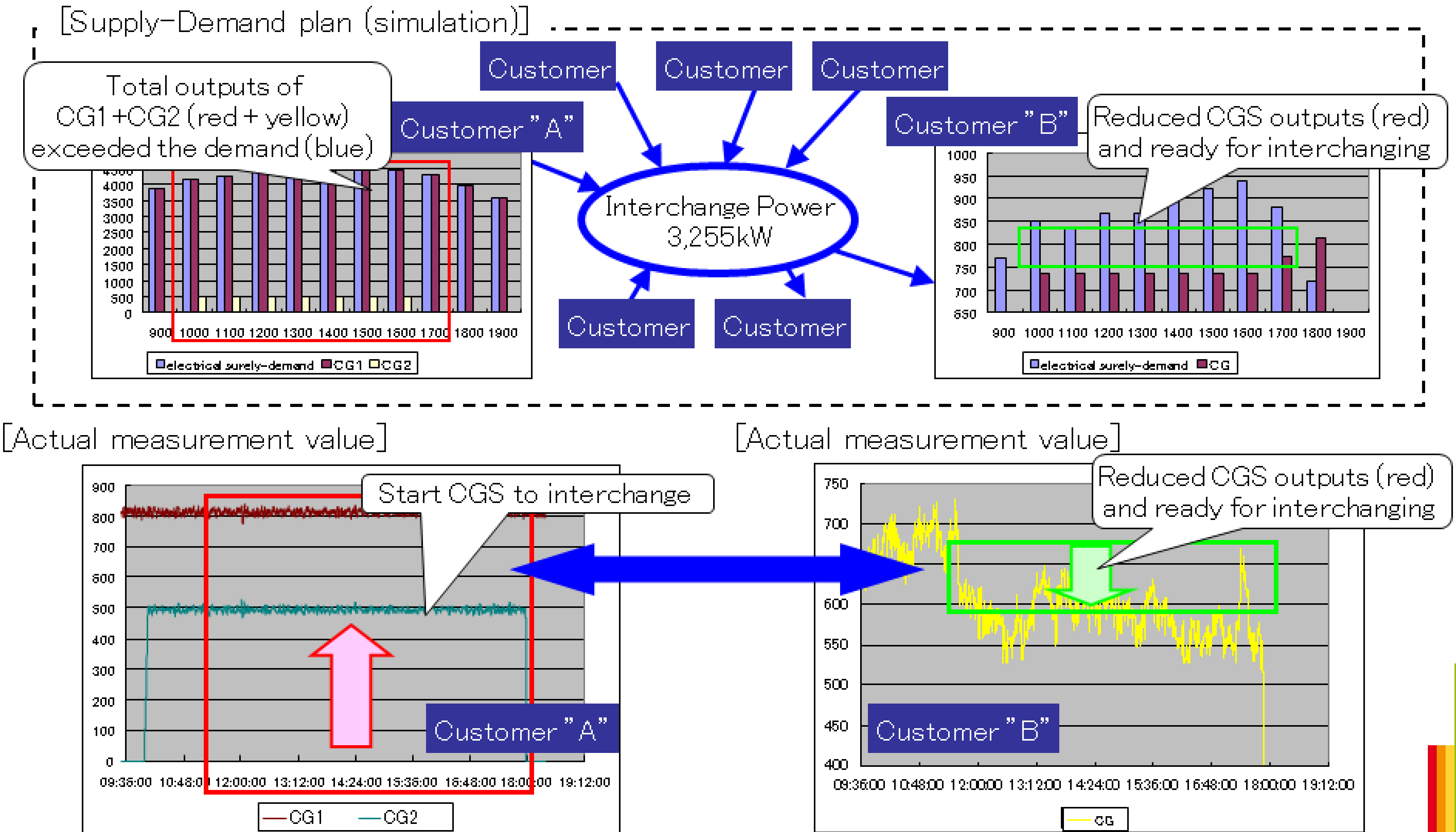
Test A Overview

Promotion of energy conservation and CO2 emission reduction by interchanging heat energy and electricity within a community.



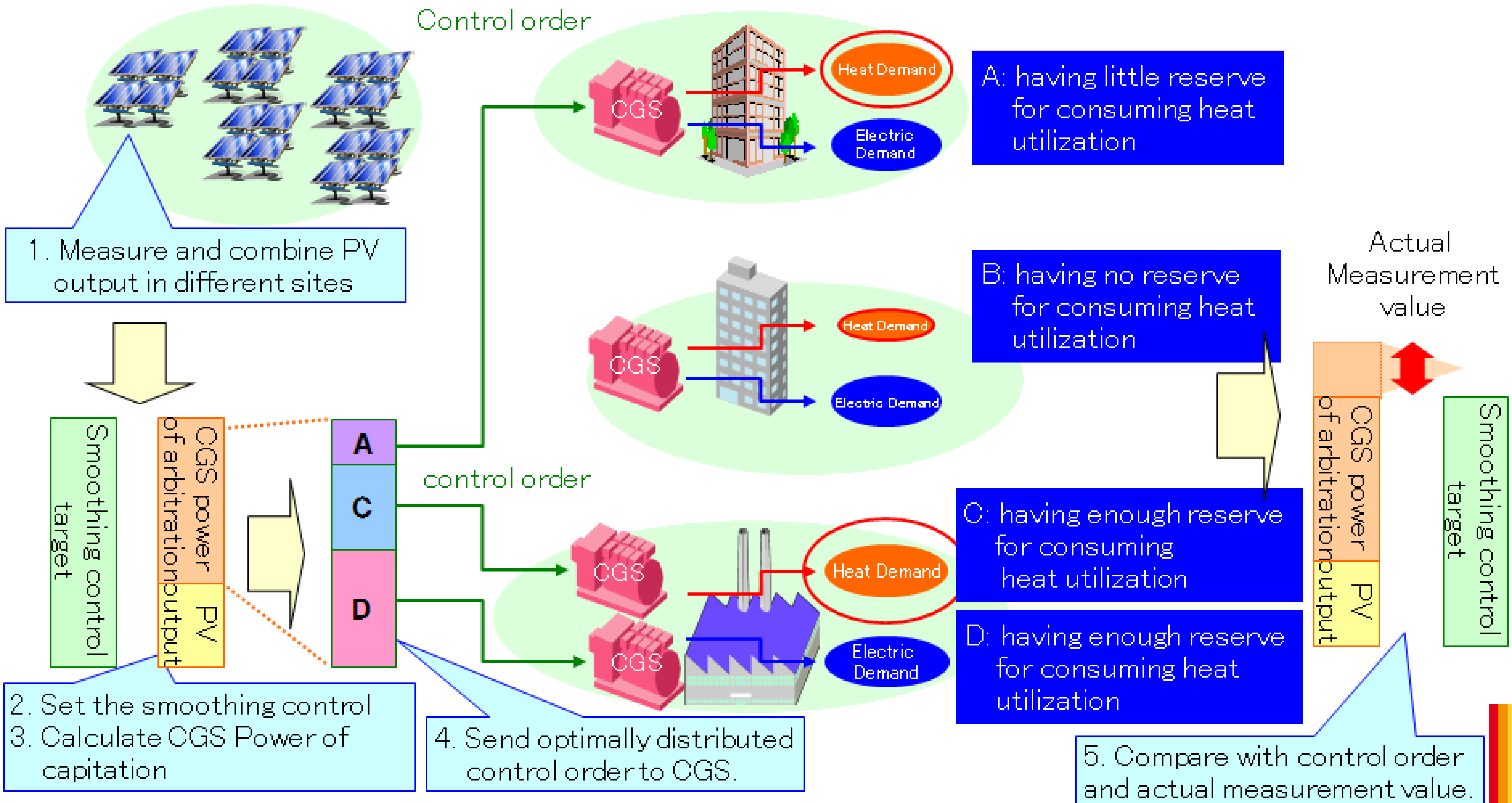
Result of Test A

CGS outputs in Customer “A” is interchanged to Customer “B” by controlling real CGS.



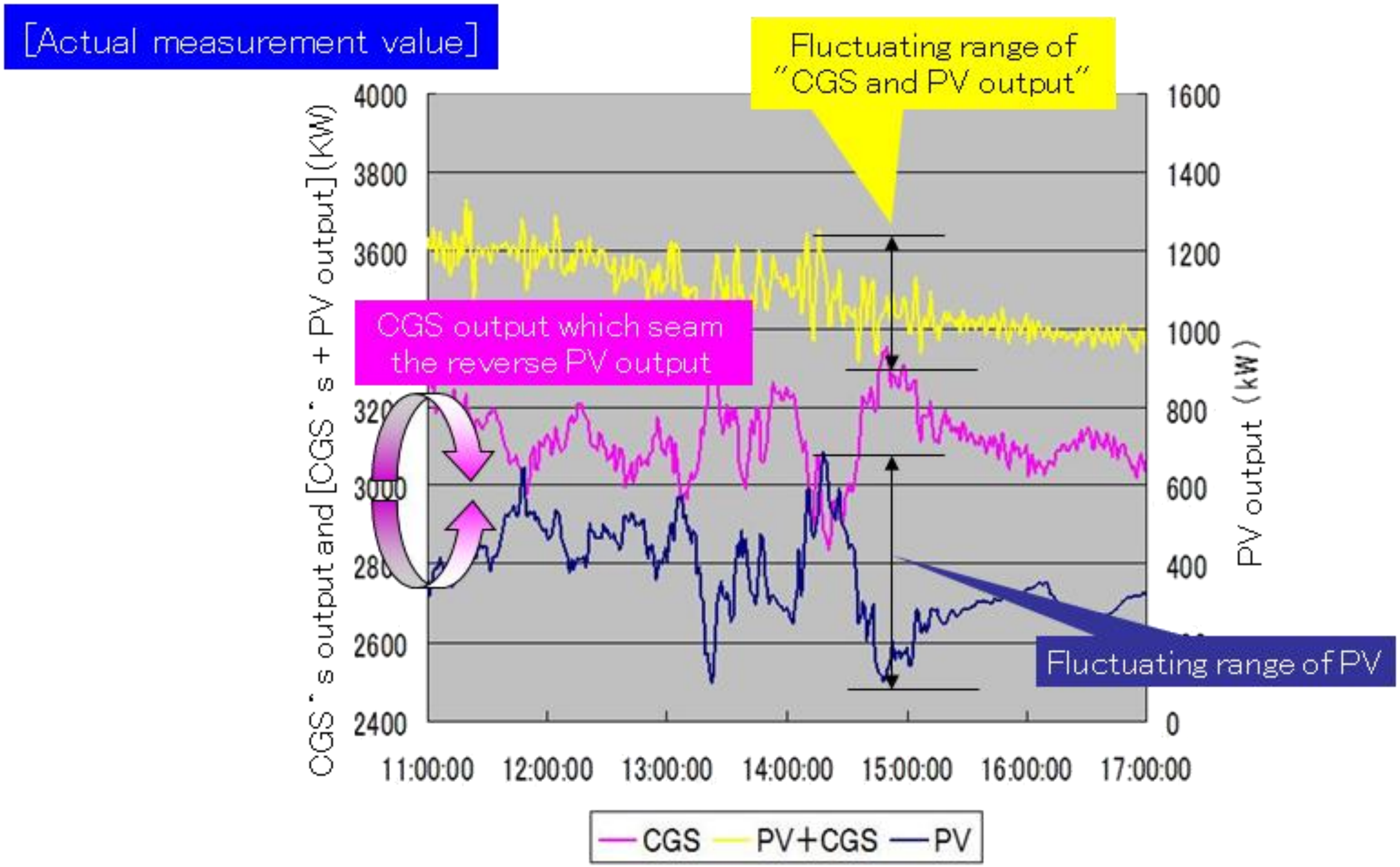
Test B Overview

To promote the introduction of renewable energy through collaborative control of CGS and PV, it is needed to develop the control logic for smoothing PV fluctuation by controlling numbers of CGS, which is considered to meet customers' energy usage and operational aspect.



Result of Test B

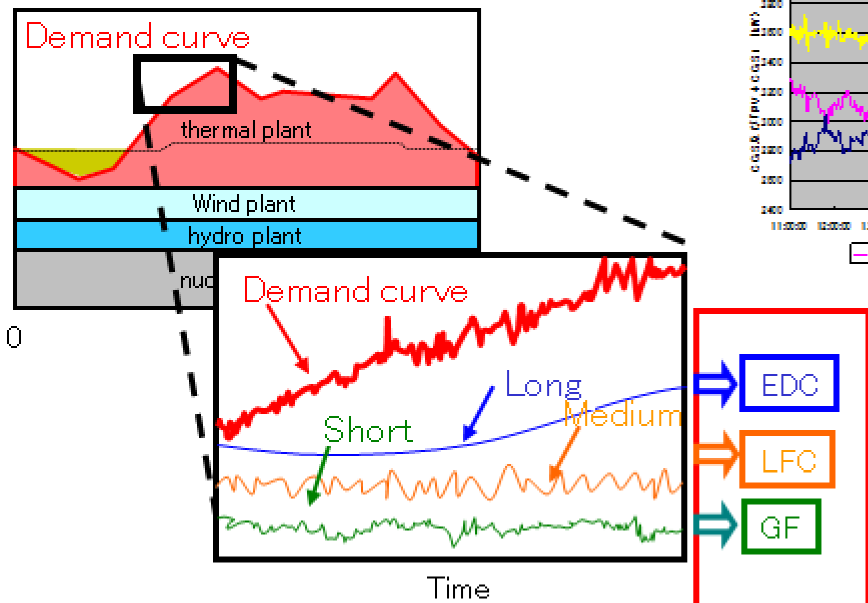
Controlled four CGS outputs are located at the different customers' to smooth PV fluctuated outputs.

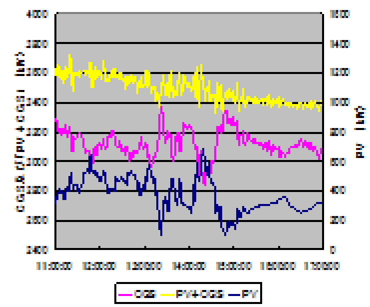


Target fluctuations of PV outputs

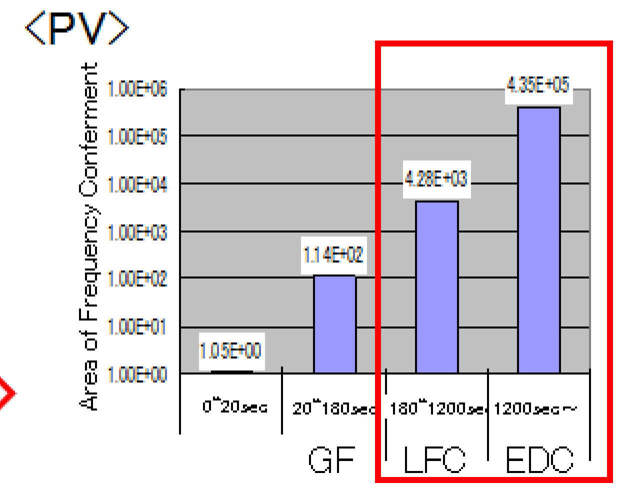
We evaluated the fluctuation smoothing effect by FFT analysis. The targeted frequency is Load Frequency Control domain and we accomplish certain level of reduction.

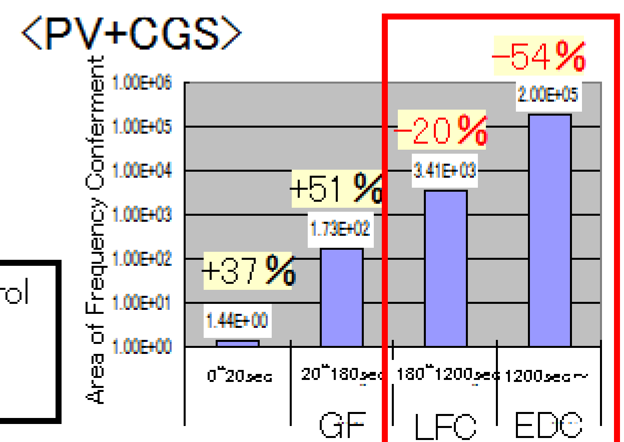
Demand Fluctuation Range

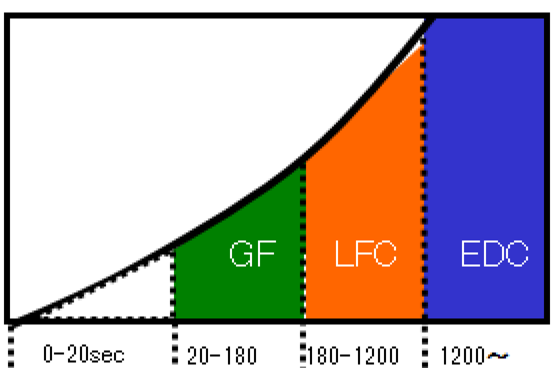




[Analysis's FFT]







EDC: Economy Dispatching Control
LFC: Load Frequency Control
GF: Governor Free

Resource: Electric Technology Research Association Vol.56,No.4,2001

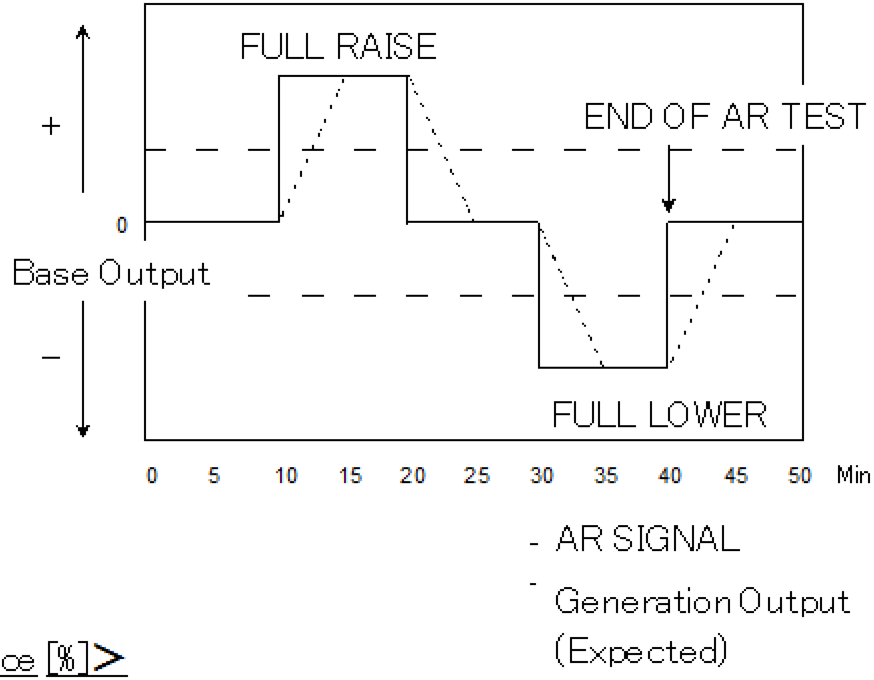
Test B(Optional): AR (Area Regulation) TEST Overview

In the previous test, fluctuation smoothing capability within a community is examined. But, of course, output of renewable energy should be smoothed in whole grid.
So, we conducted additional test to evaluate the capability using PJM test cord.

【PJM's rule】

Electric power plants (generations) which bit into Regulation Market at PJM must have the capability to follow the AR TEST signals.

TIME	Specification of AR TEST
T0 – T10	■AR Test signal = 0 □T10 (10min, later from the start): output insists the standard (base-output)
T10 – T20	■AR Test signal = (full raise)
T20 – T30	■AR Test signal = 0
T30 – T40	■AR Test signal = (full lower)
T40	■AR Test signal = 0 End of the test



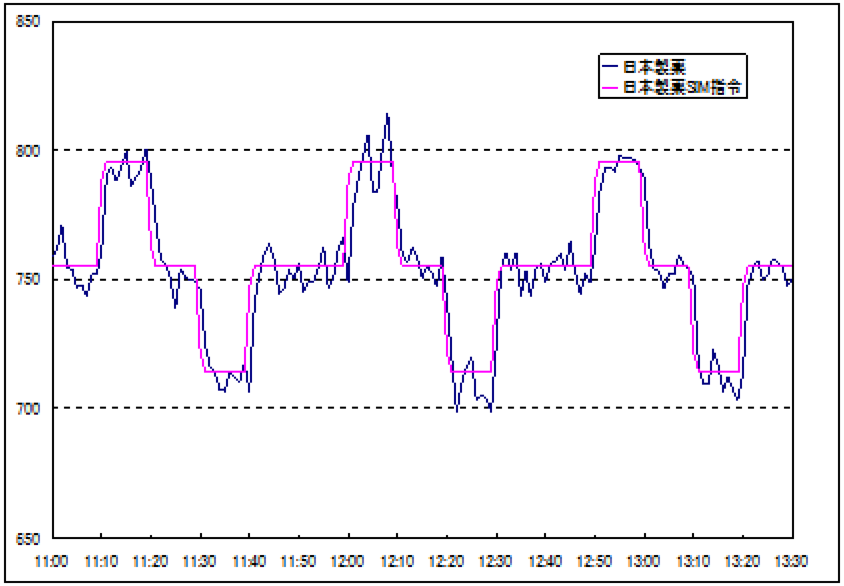
【Evaluation Method】

RRC <Rate of Response Compliance [%]>
Response Compliance against AR signal
RMC <Regulation Mismatch Compliance [%]>
Mismatch Compliance between 15–20min.
TS <AR Test Result[%]>
RRC + RMC ⇒ Needs to satisfy more than 75%

Test B(Optional): AR (Area Regulation) TEST Result

To control CGS outputs to make sure that CGS has capability to satisfy the AR TEST signals.

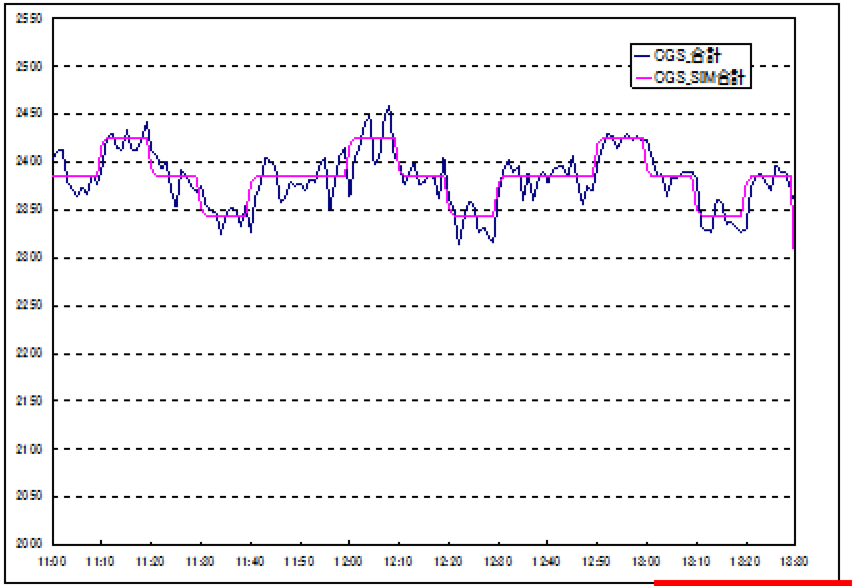
CGS815kW
Control Capacity: ±40kW



75%more

RRC	RMC	TS
88.55	95.58	92.07
95.73	95.36	95.54
100.98	98.06	99.52

CGS2,445kW
Control Capacity: ±120kW

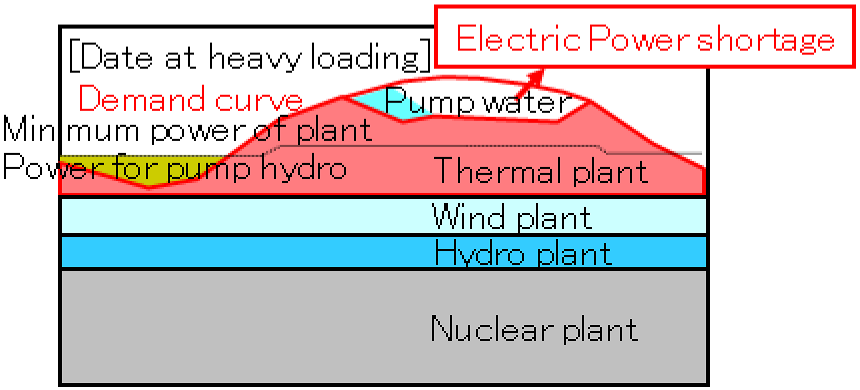


75%more

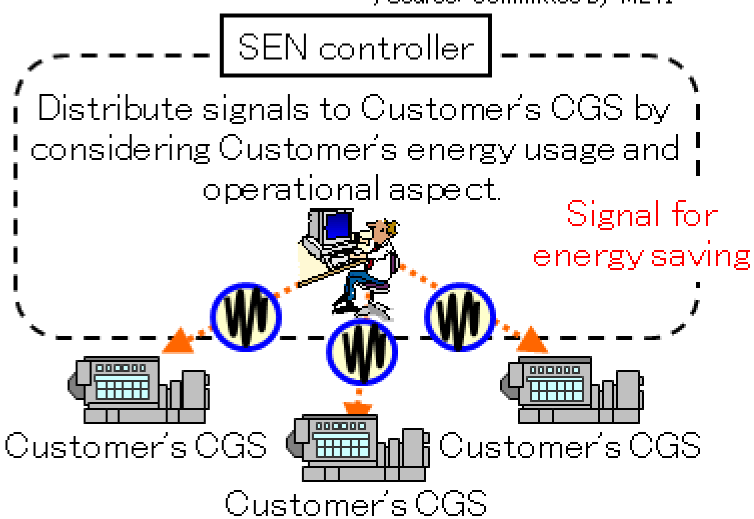
RRC	RMC	TS
96.25	98.11	97.18
94.69	99.25	96.97
95.96	98.63	97.30

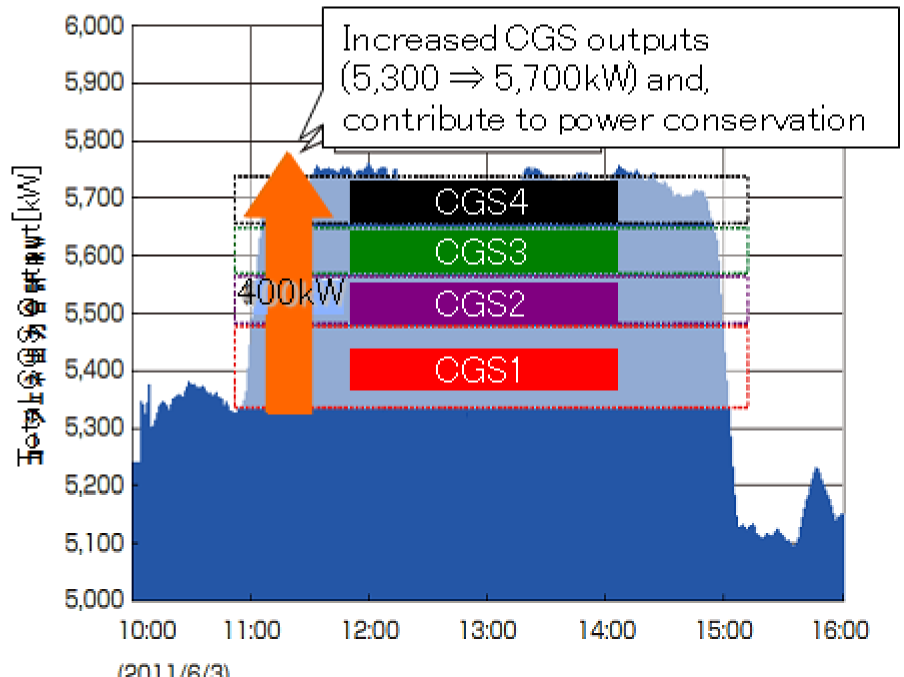
Test C [Power Supply] Result

Provision of supply-and-demand adjustment capability by supplementing system power supply based on the integrated control of multiple CGSs.
Power supply: The amount of power received from the grid is reduced by restart CGS or increase CGS outputs.



*) Source: Committee by METI





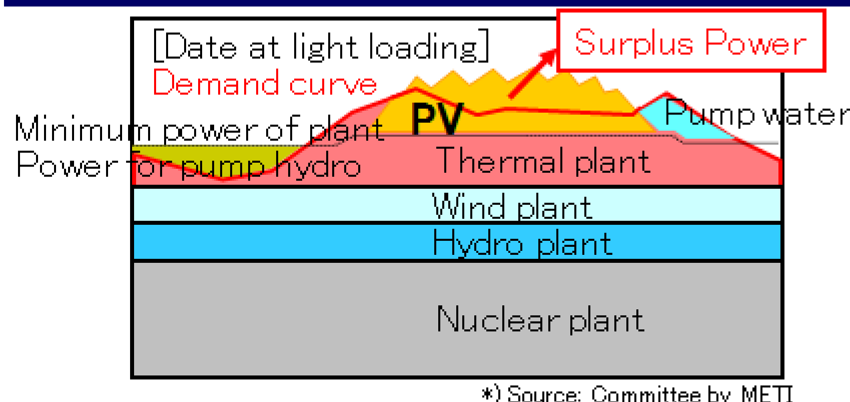
"Electrical power shortage has been occurring"
Developing the imaginary scenario, and controlling four CGS outputs to increase power; in result, CGS outputs were increased to satisfy electric demand instead of receiving electricity from the grid, and contributed to power conservation.

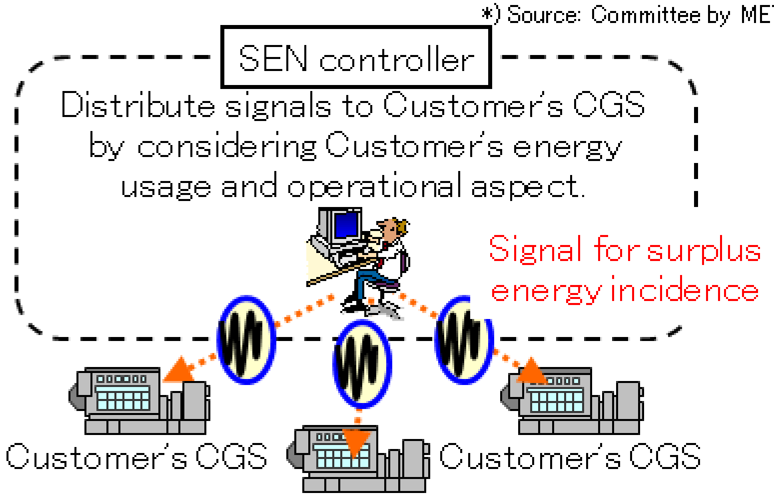
Test C [Reduce Surplus Power] Result

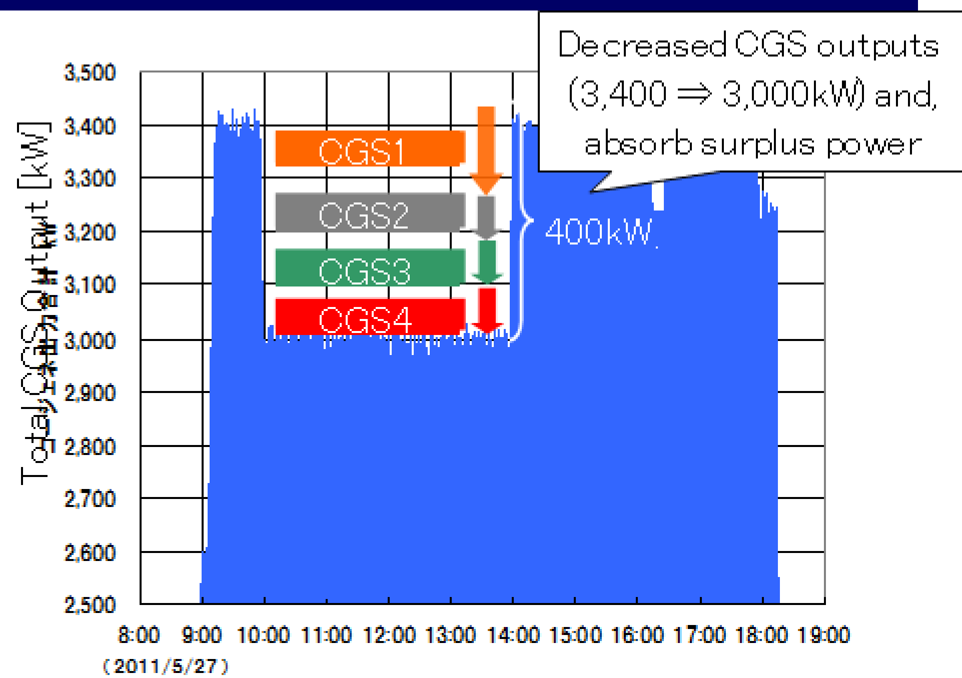
Provision of supply-and-demand adjustment capability by supplementing system power supply based on the integrated control of multiple CGS.

Provision for reducing surplus power:

When surplus power occurs at the time of mass-PV installed, the amount of power received from grid is increased by stopping or reducing CGS outputs.







"Surplus power has been occurring"

Developed the imaginary scenario, and control four CGS outputs to decrease power. In result, CGS outputs decreased to absorb surplus power.

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Results of the demonstration test

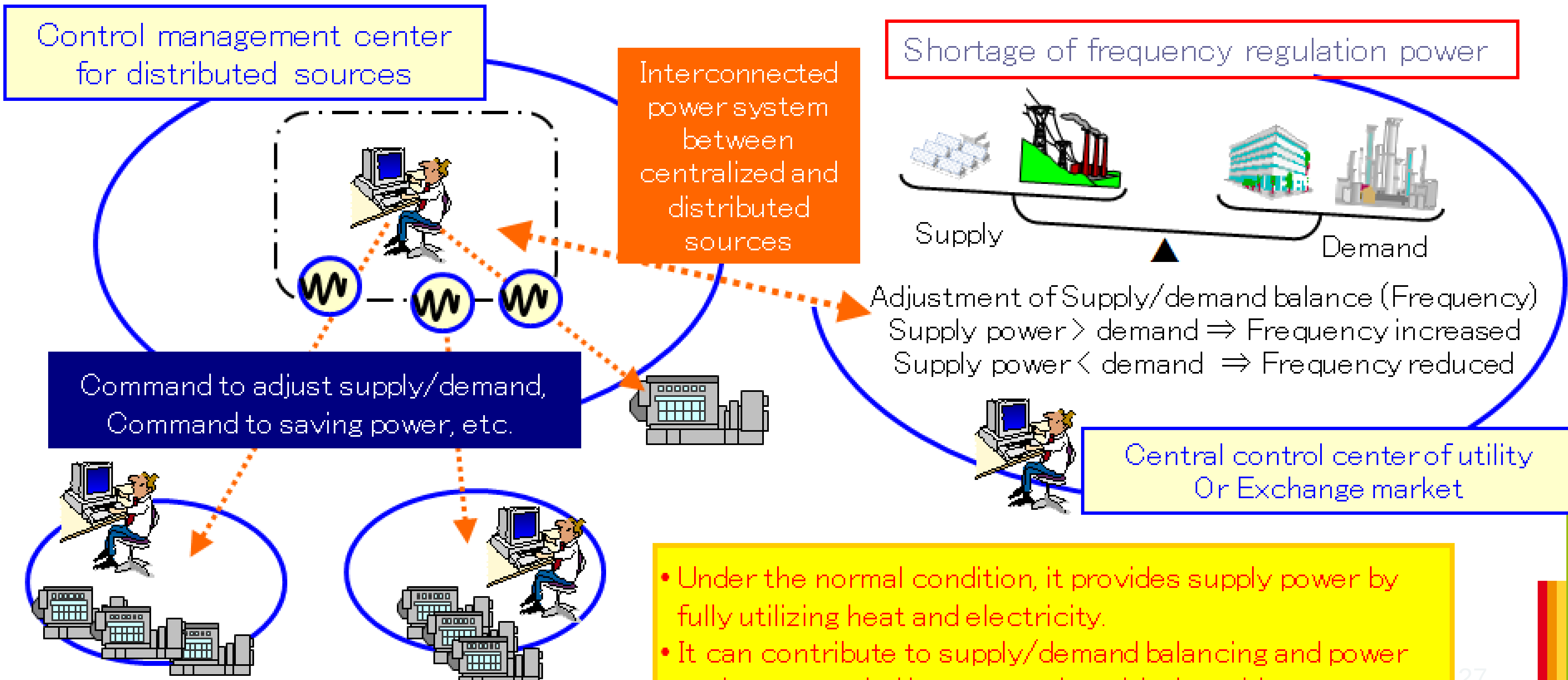
Favorable results are obtained by three test menus. So, the way of control method for aggregated CGSs is established.

Challenges	CO2 emission reduction	Balancing power shortage	Supply power shortage
Proposed countermeasures	High-degree utilization of heat and electricity generated by CGSs	Smoothing output fluctuation of PV / Fast-Demand response of aggregated CGSs	Demand response of aggregated CGSs
Test menu	Test A	Test B	Test C
Results	• Optimum planning function is assured in consideration of the constraint conditions both for heat and power. (It is estimated that 30% of CO2 emission reduction is achievable when appropriate demands are combined.)	• Fluctuation suppressing control for PV output is assured to be available within various time range, but mainly in LFC range, by group control of CGSs. (Reduction for 20%-50% was achieved in area value of FFT integral.) • Additionally, the sufficient capability contributing to the whole grid is verified by the test assuming of PJM grid code.	• Capability of supply power by CGS group is assured in the assumed condition, such as ‘request for saving energy’ and ‘occurrence of surplus power.’ (Achievement rate of control: more than 99%.)

Meaning of this demonstration project and future vision

It is important for us to assume stable power supply and demand in cooperation with concentrated and distributed power generation sites in a time when a large amount of distributed power supply, such as renewable energy and CGS, is widely used.

In the demonstration project, we realized energy saving and CO_2 emission reduction within a community by aggregating the resources of distributed power. Moreover, we verified the technology for contributing to utilizing distributed power in the whole grid, and we established its basic technology and defined technology requirement.

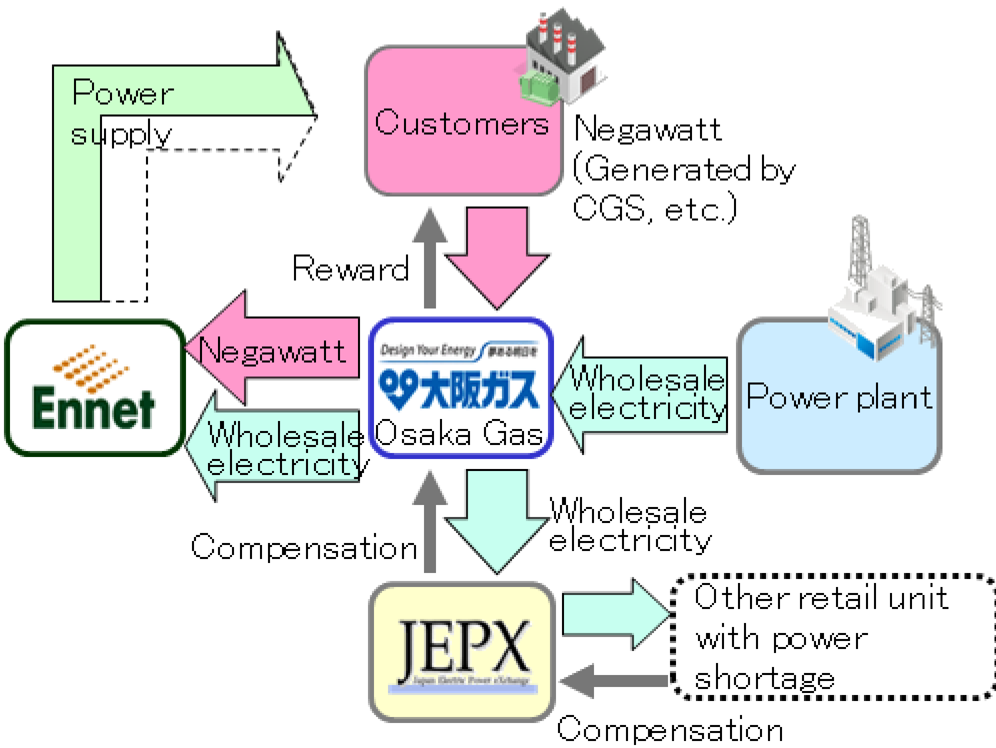


- Under the normal condition, it provides supply power by fully utilizing heat and electricity.
- It can contribute to supply/demand balancing and power saving as needed in cooperation with the grid.

Demand response by CGS: Achievement

After the demonstration test, we put these outcomes to actual service to our customers.
This slide shows the scheme of demand response service by utilizing CGS; which was awarded the Energy Conservation Grand Prize in the fiscal year 2012.

Example: JEPX application model



Total energy efficiency improvement is achieved by operating at tight supply and demand.

Achievement in the fiscal year 2012

Demand response had been collected at peak time 10:00-17:00 on weekdays.

Achievement in 2012	
Days of DR collection	54 days
Total number of transaction	154
Result of DR	159 MWh

Awarded the Energy Conservation Grand Prize for business model.

Authors

Kunihiro Nakao Osaka Gas Co. Ltd.

ku-nakao@osakagas.co.jp

Taiji Ozawa Osaka Gas Co. Ltd.

Akinori Miyamoto Osaka Gas Co. Ltd.

Koji Yakire Osaka Gas Co. Ltd.

Tomoyuki Hirai Osaka Gas Co. Ltd.