

FREQUENCY CONTROL OF POWER GRID USING GAS COGENERATION

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Daisaku Sato
Osaka Gas

Background

§ Expanding renewable energies

§ High output fluctuation by wind power



High fluctuation in the grid frequency

§ Deviation of frequency may cause serious blackout.



Control of grid requires sensitive operator

Background (cont.,)

- § Power system operators need extra power for control of grid frequency
 - § through their own plants
 - § through power market
- § Shortage in extra power makes it difficult to control the grid frequency by system operators



Restriction of wind power interconnection to the grid



Concern over restriction of gas cogeneration

Purpose

§ Gas cogeneration should play a role in control of the grid frequency

§ Thereby it can contribute to eliminating restriction of interconnection



Governor-free controller for gas cogeneration developed by Osaka Gas

Potential Benefits

- § To encourage use of renewable energies
- § To give gas cogeneration new added value in supply of extra power



Use of gas cogeneration is expected to be further promoted

Grid Frequency Characteristics

§ Relationship between grid frequency and demand-and-supply balance

§ Generation $>$ Demand

è Grid frequency $>$ Standard level

§ Generation $<$ Demand

è Grid frequency $<$ Standard level

§ Grid frequency is **uniform** throughout the power system

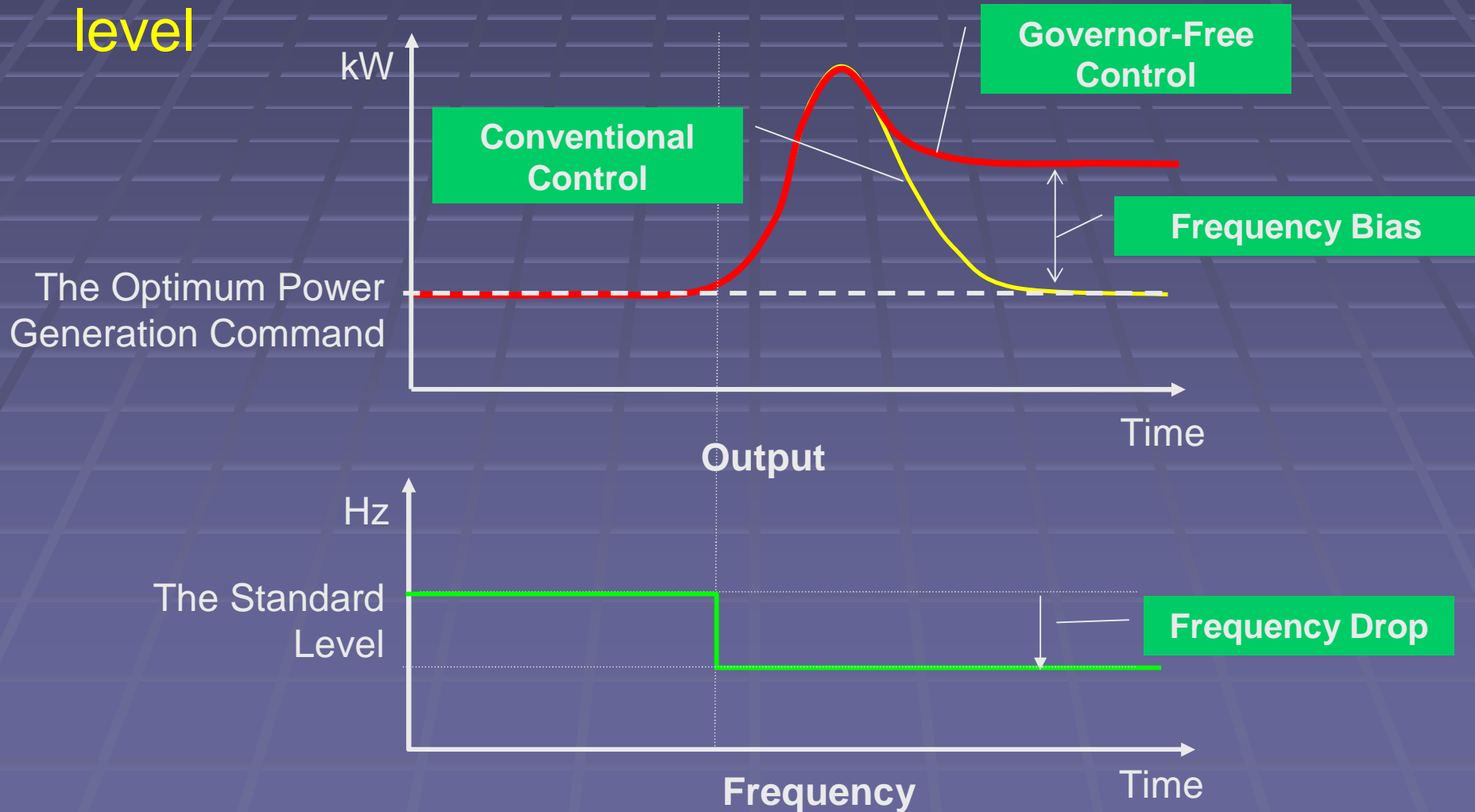
Principle of Frequency Control

§ Grid frequency $>$ Standard level
è **decrease** output of gas cogeneration

§ Grid frequency $<$ Standard level
è **increase** output of gas cogeneration

System Output

§ Governor--Free control makes output **remain at high level**



Proposition

Small-/medium cogeneration should undertake restricted frequency control.



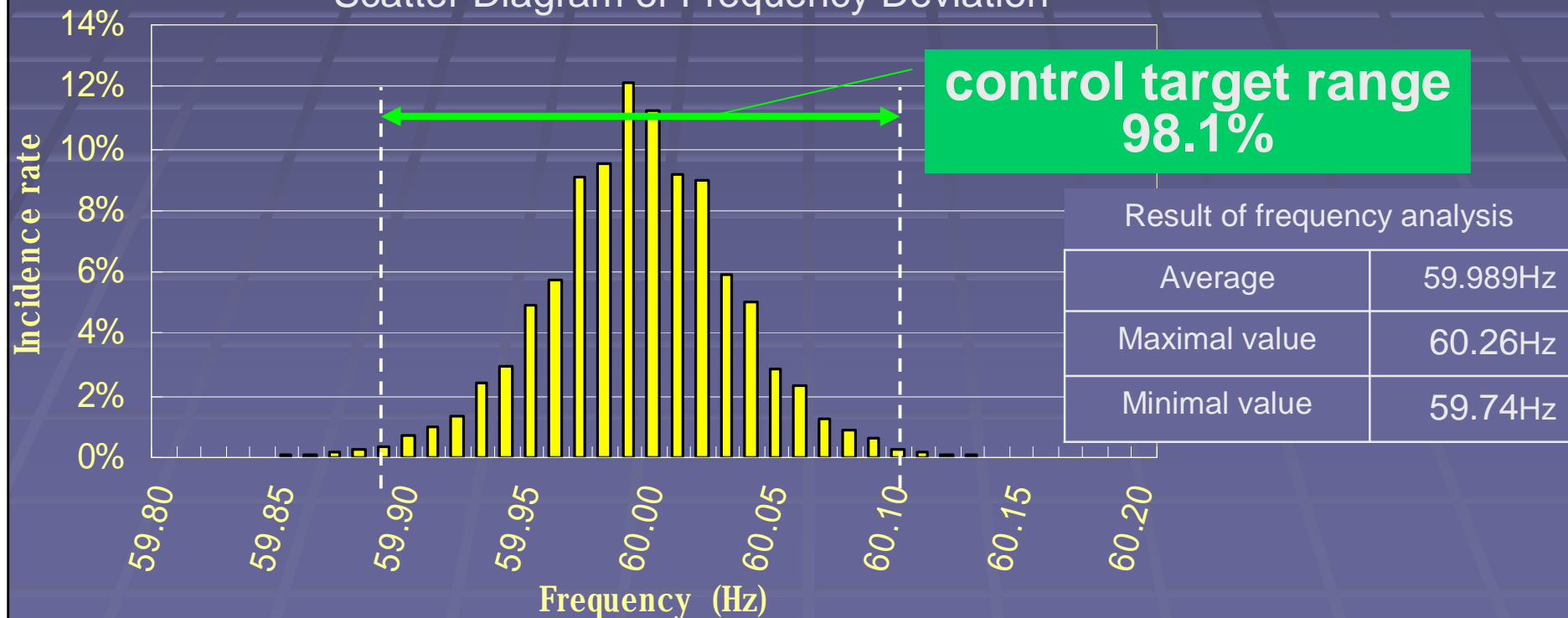
Frequency bias should be restricted to 3% of the rated output.

Grid Frequency Analysis

§ Analysis of statistical data in western Japan

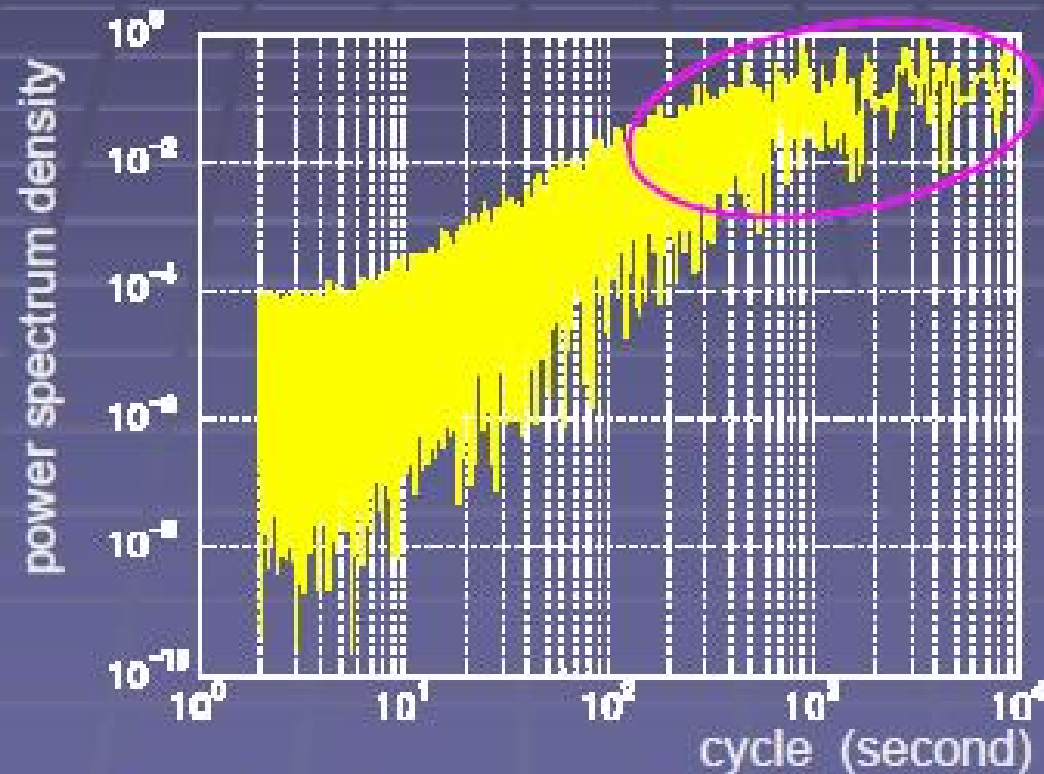
§ A little frequency out of control range

Scatter Diagram of Frequency Deviation



Grid Frequency Analysis (cont.)

§ Frequency fluctuation cycles in a minute order



A sample of power spectrum analysis
on 7th Sep. in 2005

System Evaluation for Grid Frequency

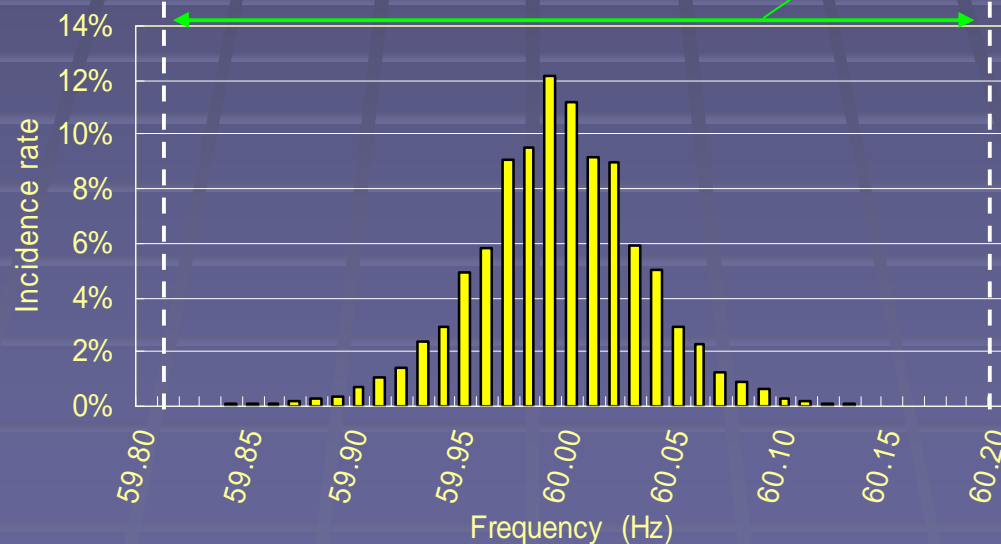
§ Response speed è 0.1 second

(fast enough over frequency change

§ Coverage of control target è

(almost all the frequency is covered

99.9%



Effective for frequency control

Evaluation of Effects on Gas Cogeneration

§ Output fluctuation due to linkage with frequency
è **not affected**

§ Increase in output during rated operation
è **increased output possible
but no adverse effects**



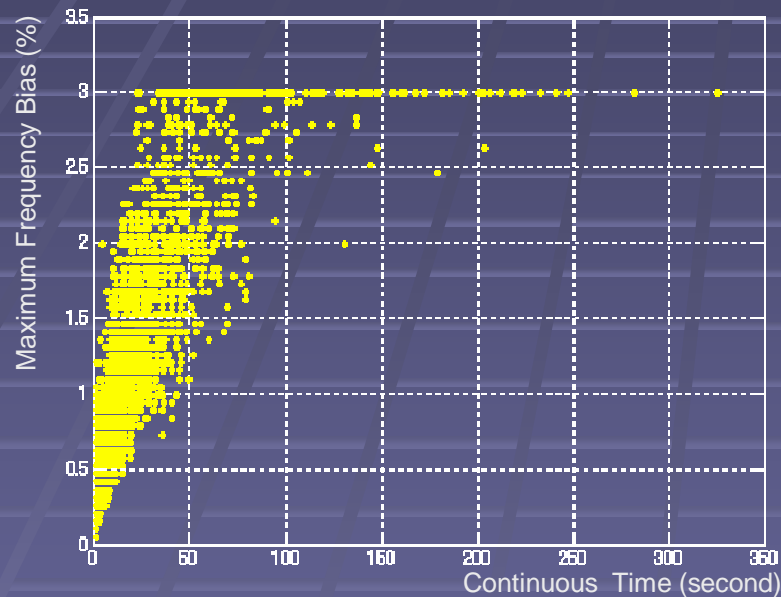
**The controller does not affect gas
cogeneration system**

Evaluation of Effects on Cogeneration Owners

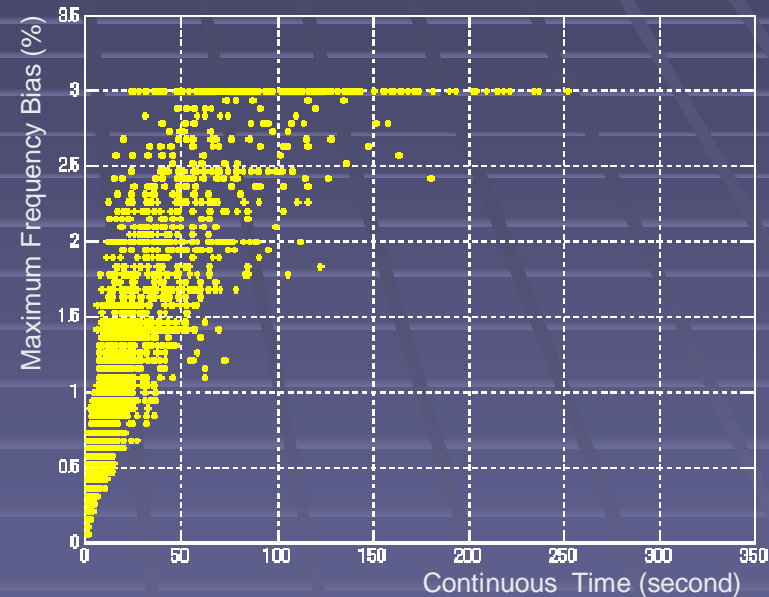
- § Increase in initial costs è **almost none**
- § Increase in maintenance costs è **none**
- § Change in electricity bill è next slide

-- Electricity Bill Simulation --

Little difference between increase and decrease in amount power



<When Decrease Output>



<When Increase Output>

Distribution chart of maximum frequency bias and continuous time period

Result of Electricity Bill Simulation

Electric energy when decrease output	5,871kwh	Purchased power change only 519kwh/year	Electricity Bill US\$/ 51.9 year Decrease (1kwh=US\$0.1)
Electric energy when increase output	5,352kwh		

Evaluation of Effects on Cogeneration Owners (cont.,)

- § Increase in initial costs è **almost none**
- § Increase in maintenance costs è **none**
- § Change in electricity bill è **negligible**



**Our controller performs with negligible
additional costs on owners**

Summary

- § Osaka Gas developed grid frequency controller using a small-/medium-sized gas cogeneration system
- § The system has proved effective for stable operator of power system