Diagnosis of Effectiveness of HVAC System and Energy Performance of Osaka-Gas Building through Retro-Commissioning

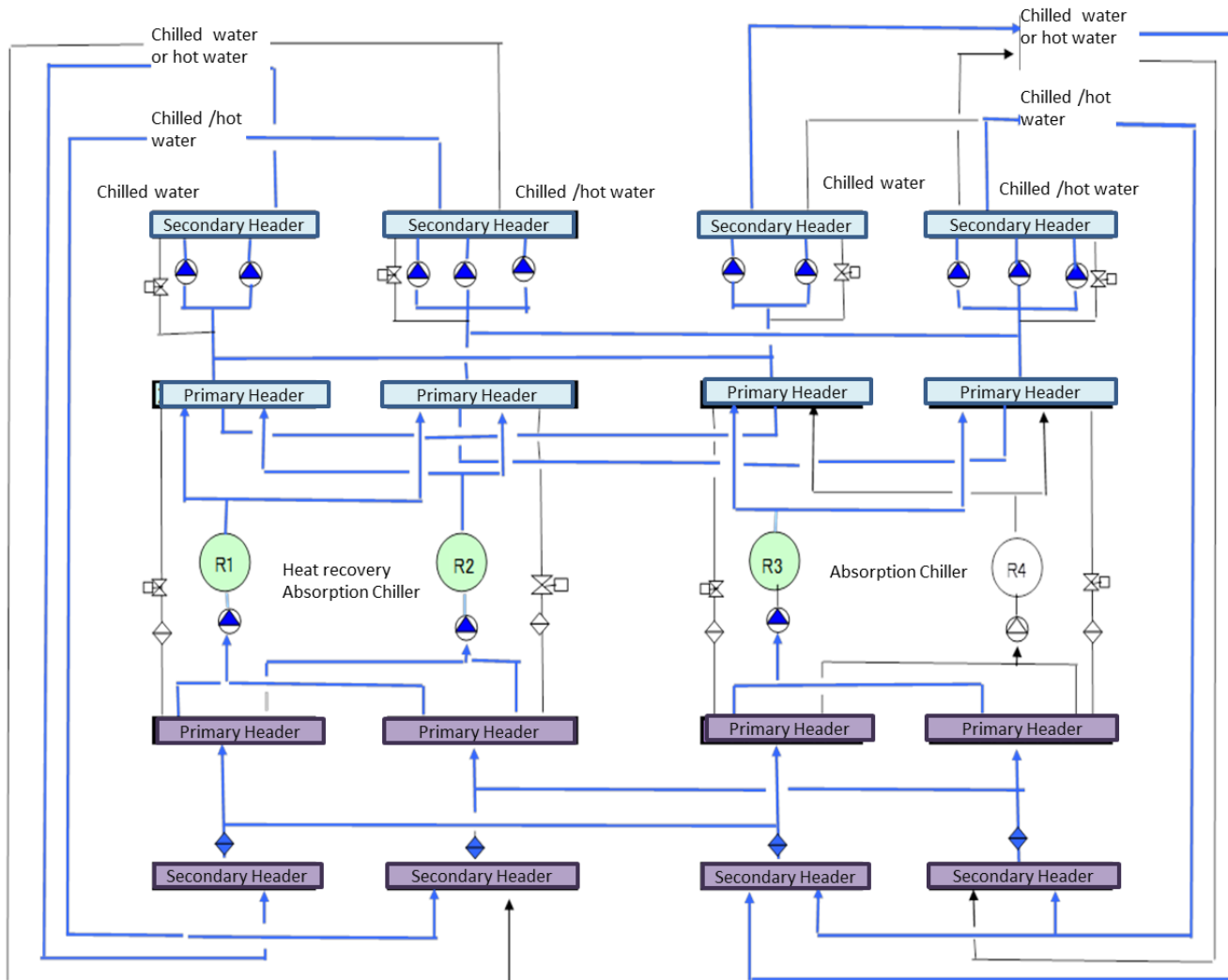## Part 2

Handling the Data Produced by BEMS and Some Results of Analyses

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Outlines

- Description of the system
- Performance indices for co-generation
- Data properties from BEMS
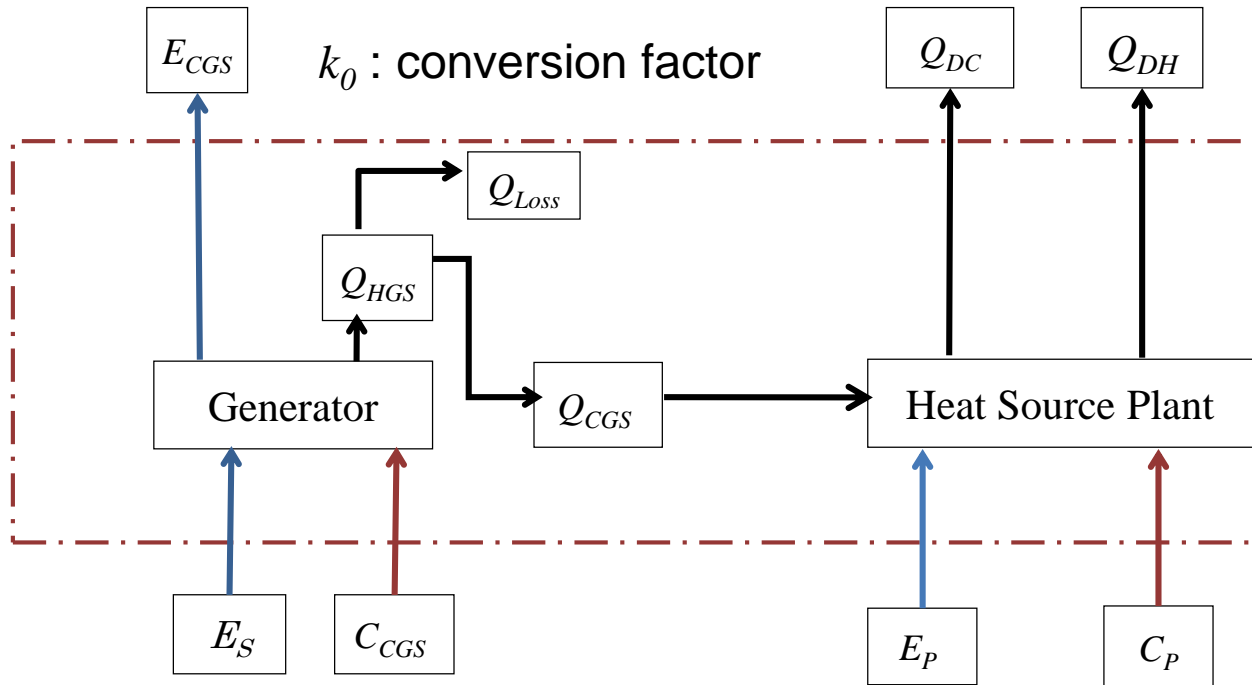- Results
- Conclusions

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Description of the system

R1 R2	Waste heat recovery type absorption chillers
CT-1,2	Cooling towers
R3 R4	Gas combustion Absorption Chillers

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# Performance indices for co-generation

- co-generation system
  - electricity
  - heat
- evaluation of heat
  - first law of thermodynamics
  - heat is equivalent to kinetic and electric energy
  - second law of thermodynamics
  - heat can not be convert to kinetic and electric energy equally

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Primary Energy Based Efficiency

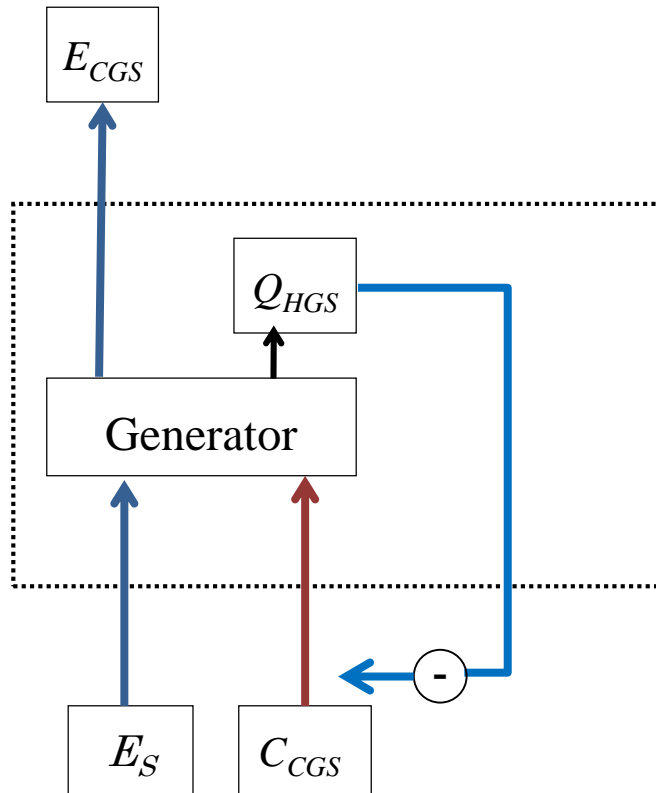$$\frac{Q_{DC} + Q_{DH} + E_{CGS} \cdot k_0}{(E_S + E_P) \cdot k_1 + C_P + C_{CGS}} \quad (1)$$

Equivalent electricity efficiency
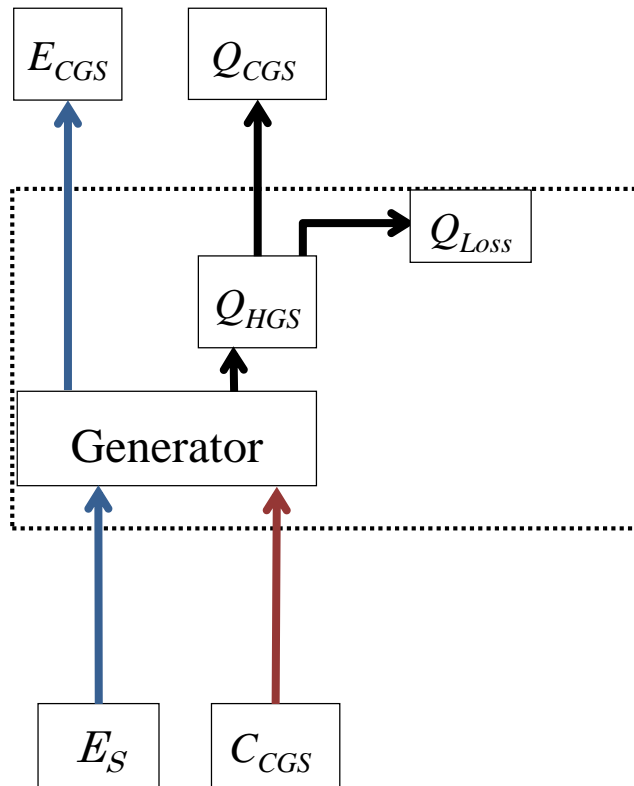
- Considering availability of heat, coefficient X (0 < X <1.0) is adopted to generated heat

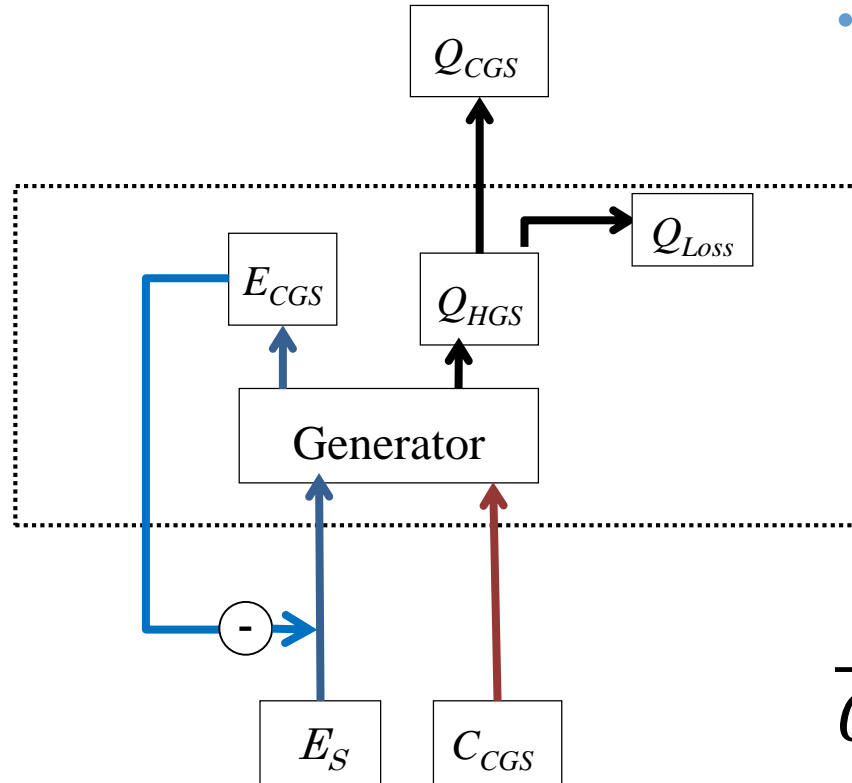$$\frac{E_{CGS} + Q_{CGS} \times X}{E_s + C_{CGS}} \qquad (2)$$

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Equivalent input efficiency

- To assume the system as generator, the heat is extracted from input

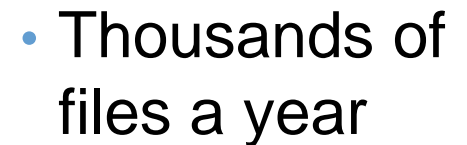$$\frac{E_{CGS}}{E_S + C_{CGS} - Q_{HGS}/\eta_B} \quad (3)$$

Boiler equivalent efficiency

- To assume the system as a boiler, the electricity is extracted from input

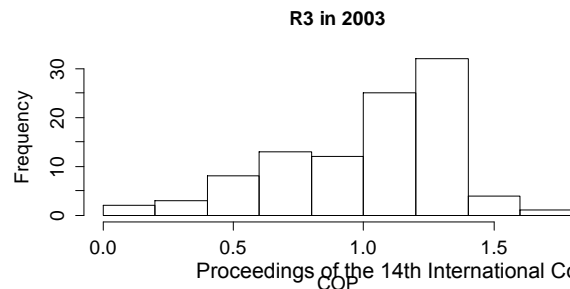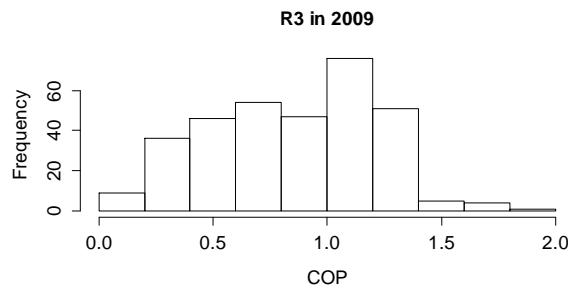$$\frac{Q_{CGS}}{C_{CGS} + E_S - E_{CSG}/\eta_E} \quad (5)$$

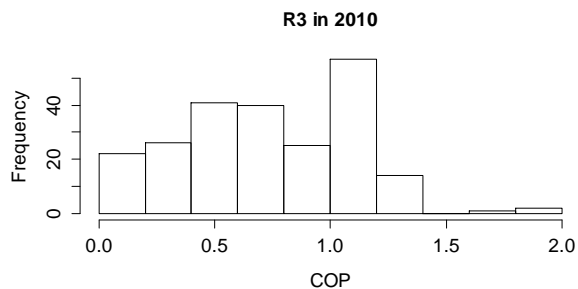Proceedings of the 14th International Conference for Enhanced Building Operations, Beijing, China, September 14-17, 2014

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DATA properties from BEMS

- An excel file per system a day

- Thousands of files a year

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DATA properties from BEMS

Equipments	Temperature	Flow rate	Energy	Others
Chiller	Inlet and outlet	n/a	Gas	Operation Hours
Cooling tower	Inlet and outlet	n/a	n/a	n/a
Primary Pumps	n/a	n/a	n/a	n/a
Secondary Pumps	n/a	n/a	n/a	Inverter output
Heat load	n/a	L/min	kWh	
CGS	n/a	n/a	Gas	kWh

Results

- Estimation of cop of chillers

**R3 in 2010**

R3 in 2009

R3 in 2003

- Heat recovery rate was not know

- COP could be calculated for single chiller operation

- Only R-3 suitable for calculation

- Ever calculation was conducted at small partial load

- Significant difference was not observed

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Results

- Amount of energy used in each equipment was calculated
  - Energy consumption of pumps were estimated from nominal kW and operation hour
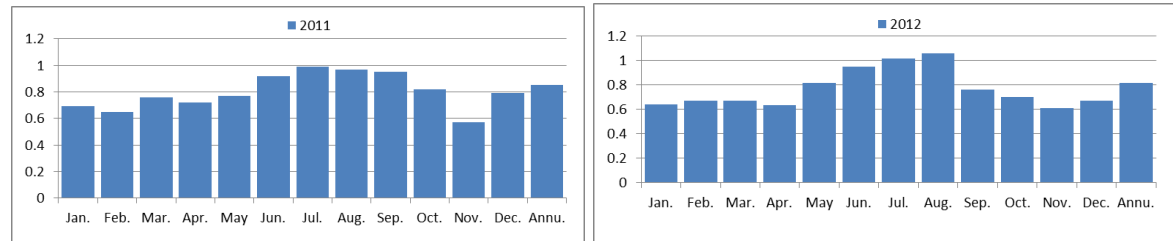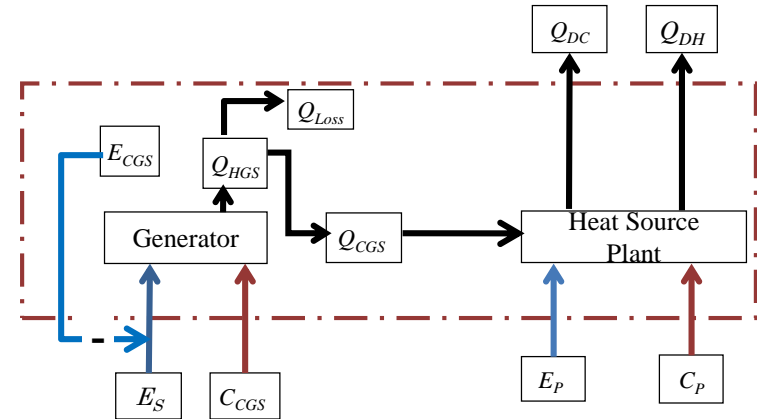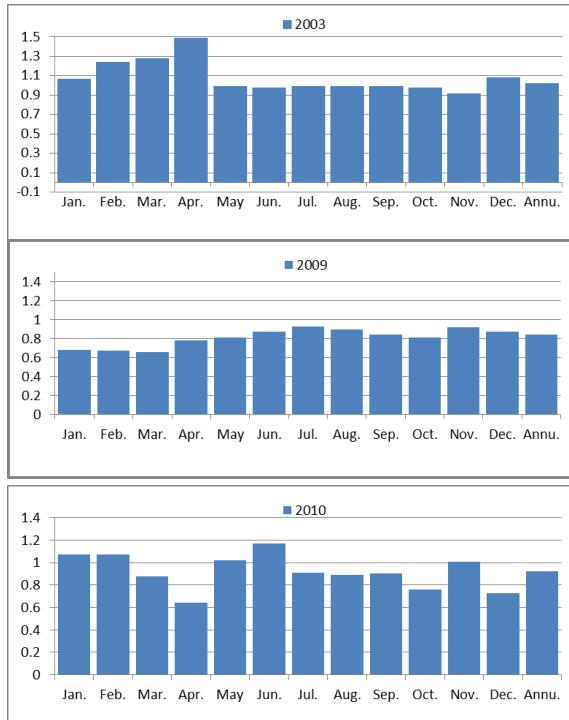- Gas consumption of the generators and chillers was dominant
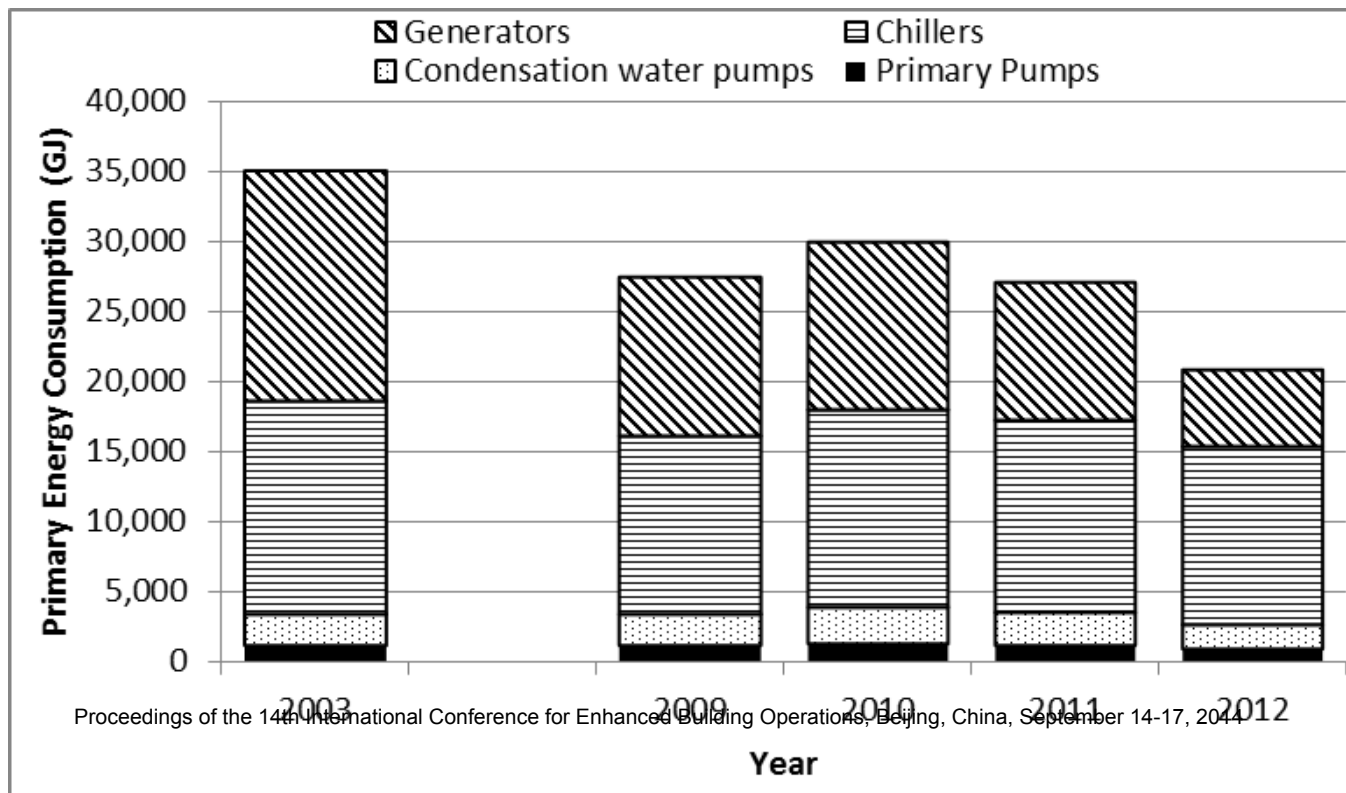
Results: Primary Energy Efficiency
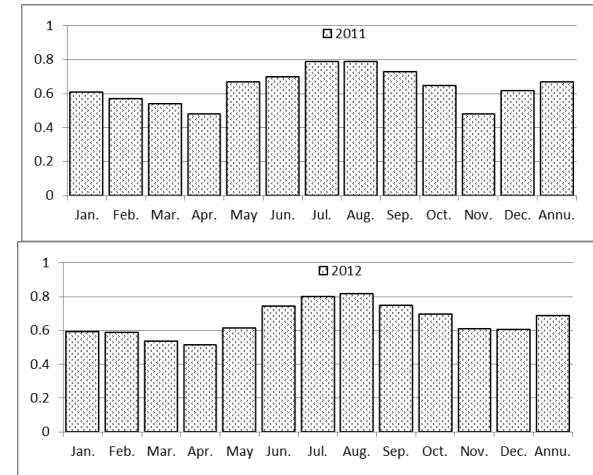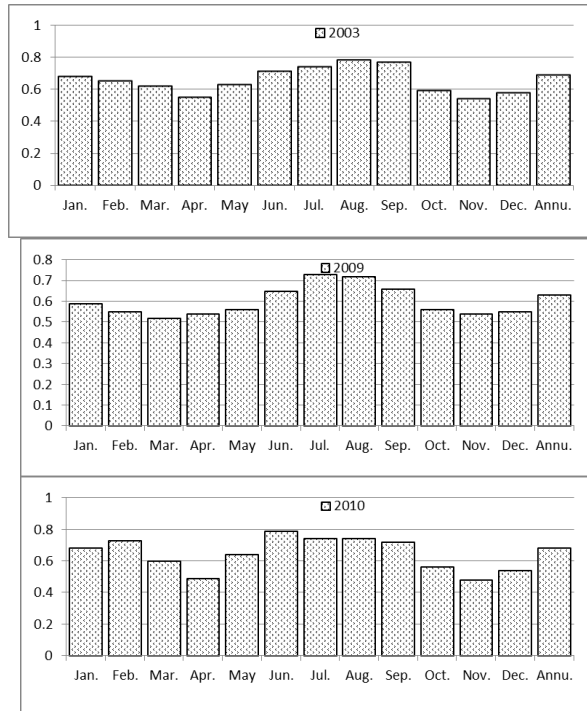
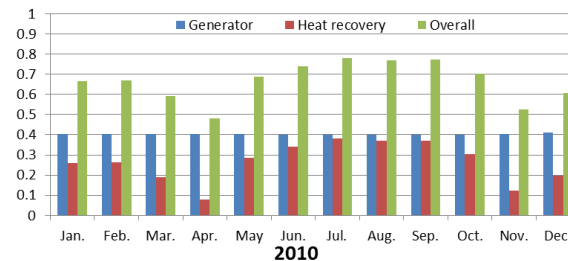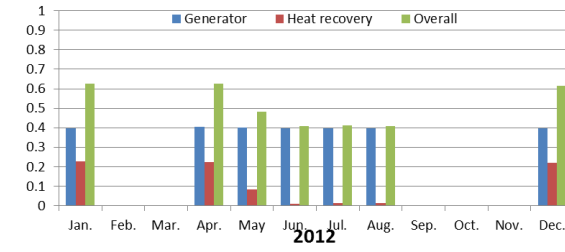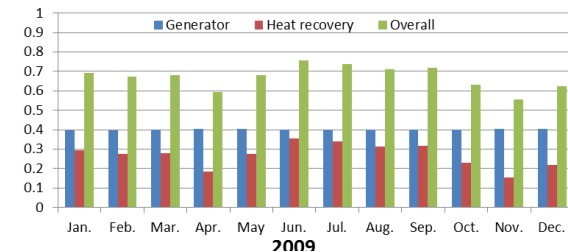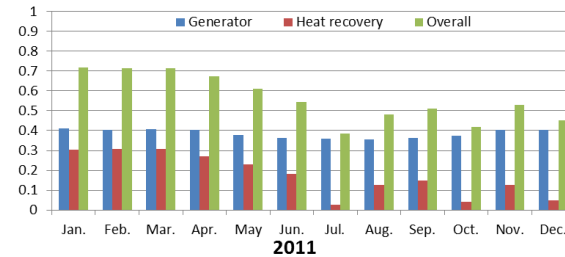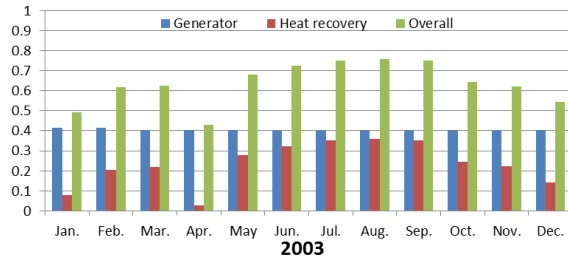$$\frac{Q_{DC} + Q_{DH} + E_{CGS} \cdot k_0}{(E_S + E_P) \cdot k_1 + C_P + C_{CGS}} \quad (1)$$

- Yearly mean values are around 0.7
- The lower heat load become, the smaller efficiency is
- Heat from generators could not be utilized during spring and fall

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Results : Boiler equivalent efficiency

- By definition, value can exceed 1.0
- Operation of Generator has effect on the index

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Results: Efficiency of cogeneration

- ## Generator efficiency has kept constant
- ## Utilization of waste heat from generator confined overall efficiency
  - ### Form 2011, operational condition has been switched to not using waste heat

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Conclusions

- Analysis of the Osaka gas building by BEMS data was conducted

- Performance indices for co-generation system were considered

- The way to utilize huge number of BEMS file was presented

- Average primary energy efficiency was shown around 70 %

- Performance of heat source system was deteriorated during spring and fall due to the electrical out put operation of co-generation, where improvement could be considered