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The measure for the effective environmental load reduction in a university campus

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Research Background

- The reasons to advance energy saving and low-carbonization in a university campus
  - Social responsibility of sustainability
  - Energy consumption is gradually increasing and largely going up with the rise of the electric power rate and the gas rate
  - The laws and regulations about energy saving and low carbonization must be observed

- The barriers to energy saving and low-carbonization in a university campus
  - Many old buildings with low performance of air-conditioning system
  - Energy management with no ICT infrastructure because of the various institutions and users
  - Distinction between energy required for research/education and ones wasted

CO2 emission and TSCP

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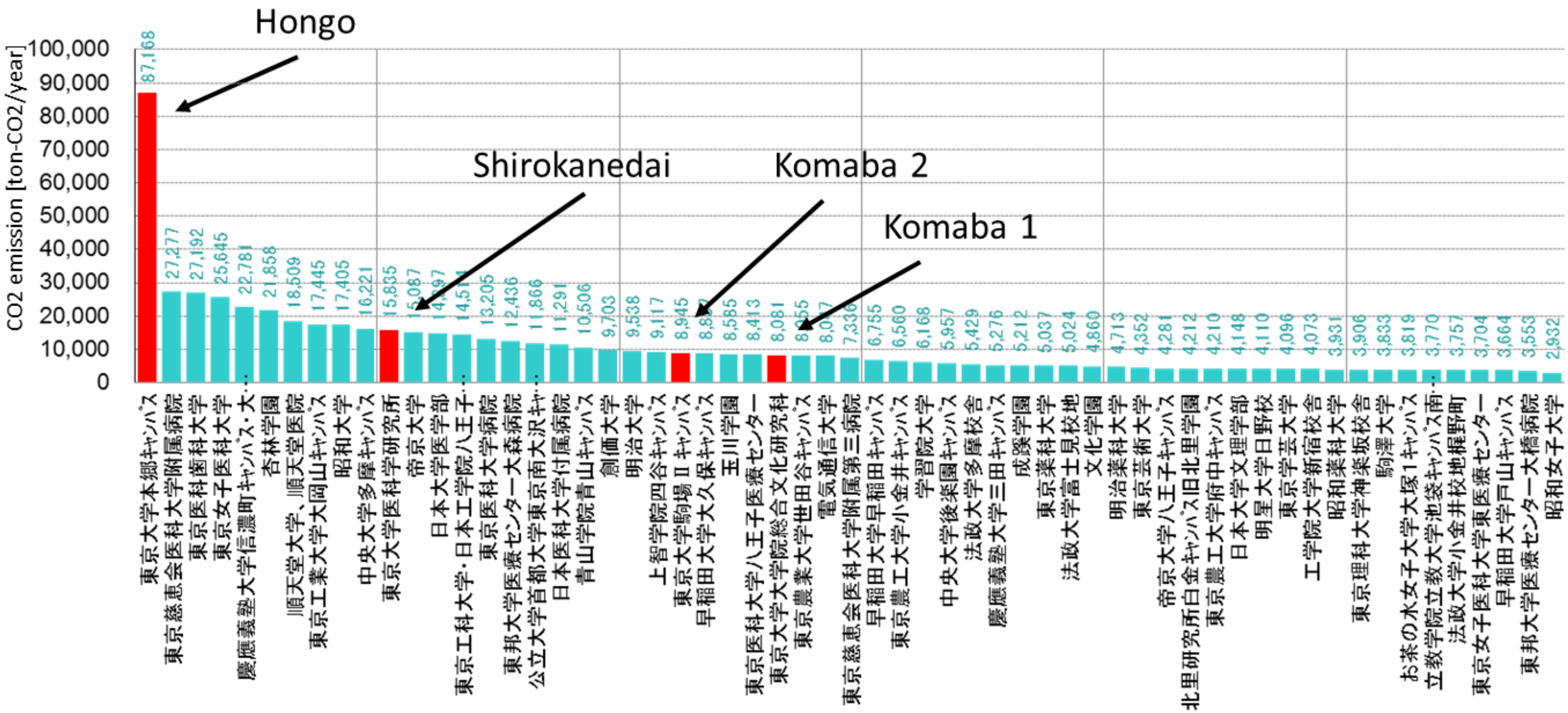
- Very large CO2 emission of the University of Tokyo



- TSCP=Todai Sustainable Campus Project
  – Realization of the low carbonization as the first priority matter
  – 15% reduction by 2012, 50% reduction by 2030 (as compared with 2006)

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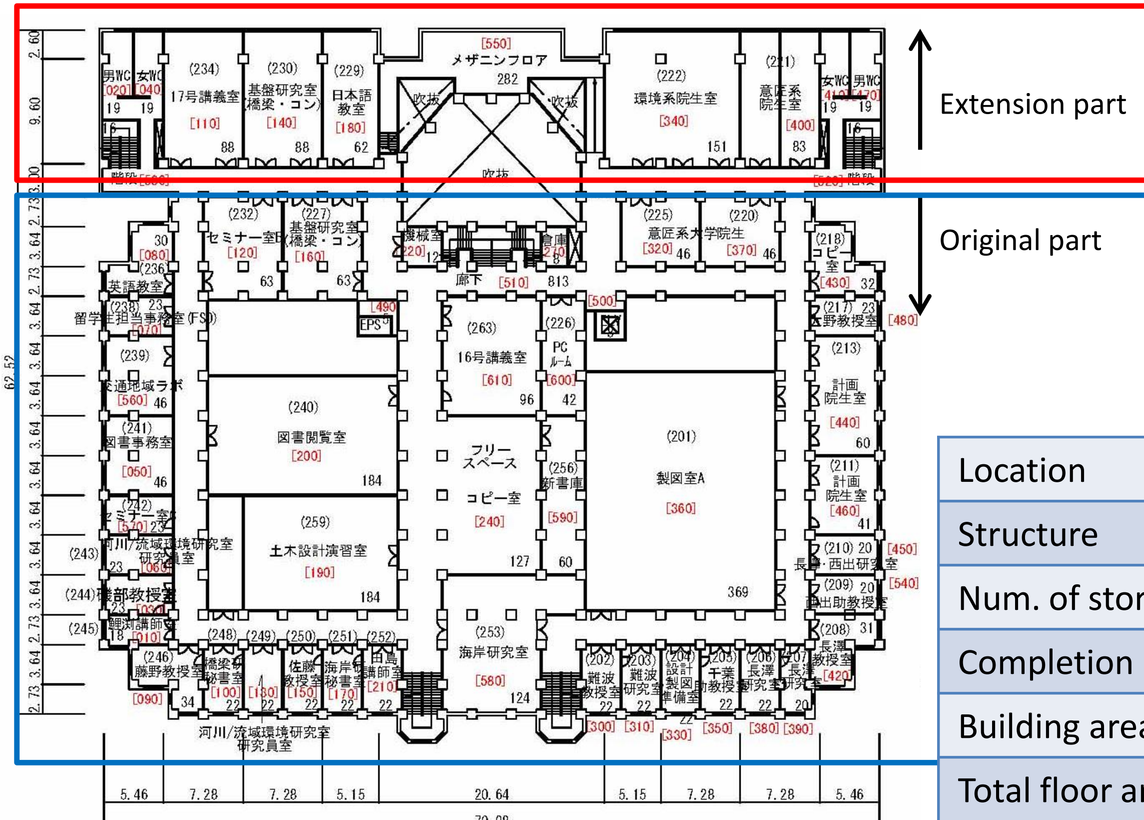
Case study

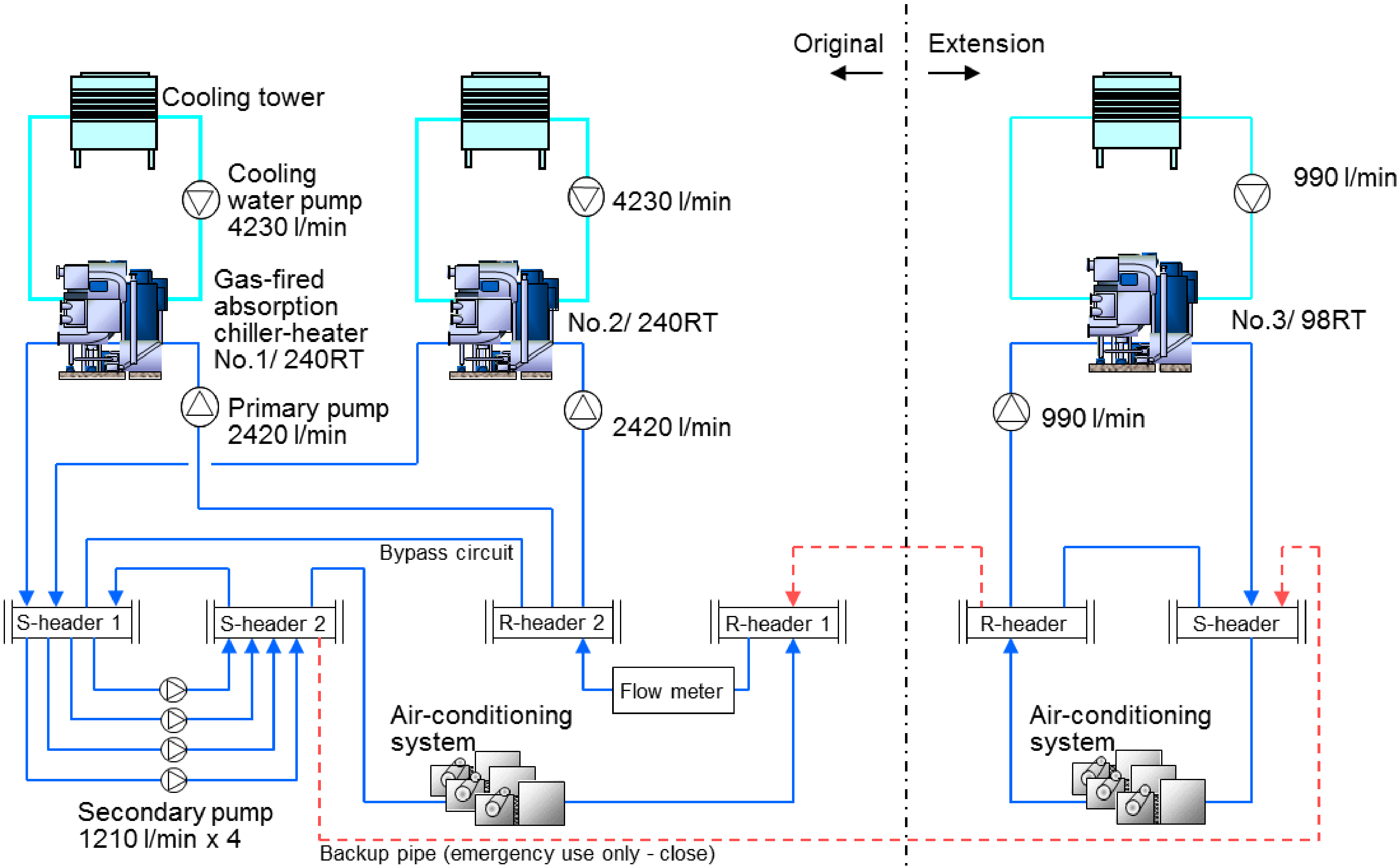
- Building #1 of engineering department
  - Originally completed in 1935 and partly extended in 1995
  - Retrofit of the air-conditioning system in 2011
    - Measurement, analysis, simulation and verification



Standard Floor Plan

Location	Hongo Campus (Bunkyo-ku, Tokyo)
Structure	Reinforced concrete
Num. of stories	Five stories above, one story below
Completion	Original: 1935, Extension: 1995
Building area	3,263 m2
Total floor area	16,510 m2 Original: 10,131 m2, Extension: 6,379 m2

Before the retrofitting #1



Before the retrofitting #2

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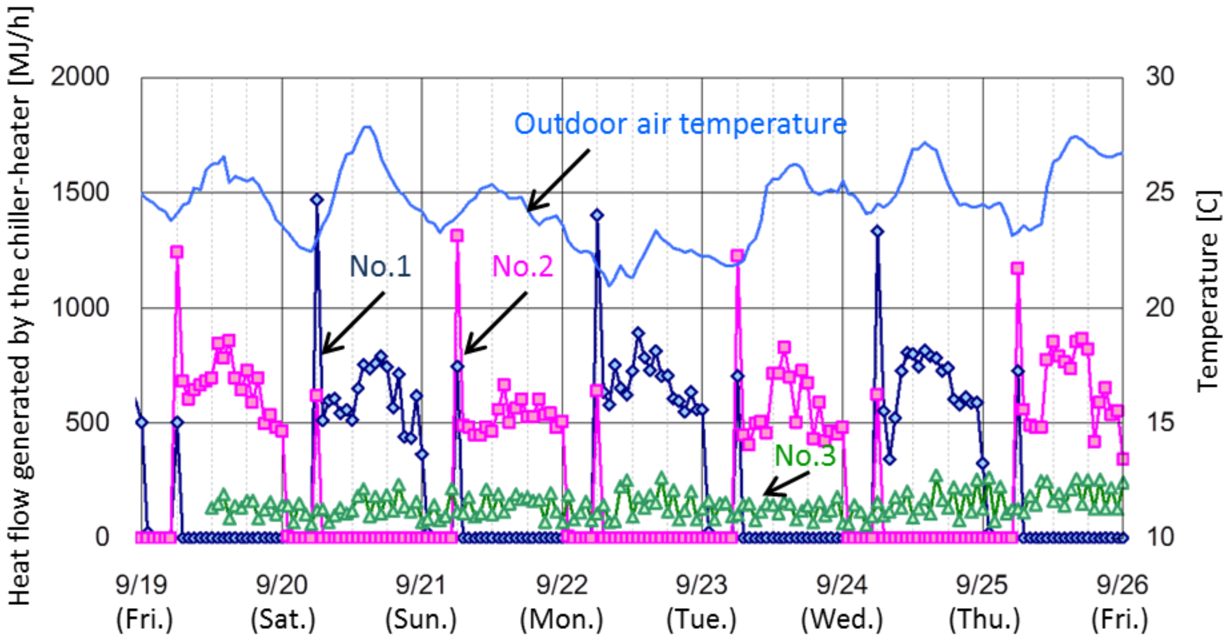
- Problems > System COP was very low
  - The capacity of the absorption chiller-heaters (ACH) were over-seized to the thermal load, and the stop/start in the operation was repeated.
  - The difference between the outlet and inlet water temperature of the ACH was very small.
  - The secondary pumps were operated when the ACHs were stopped.

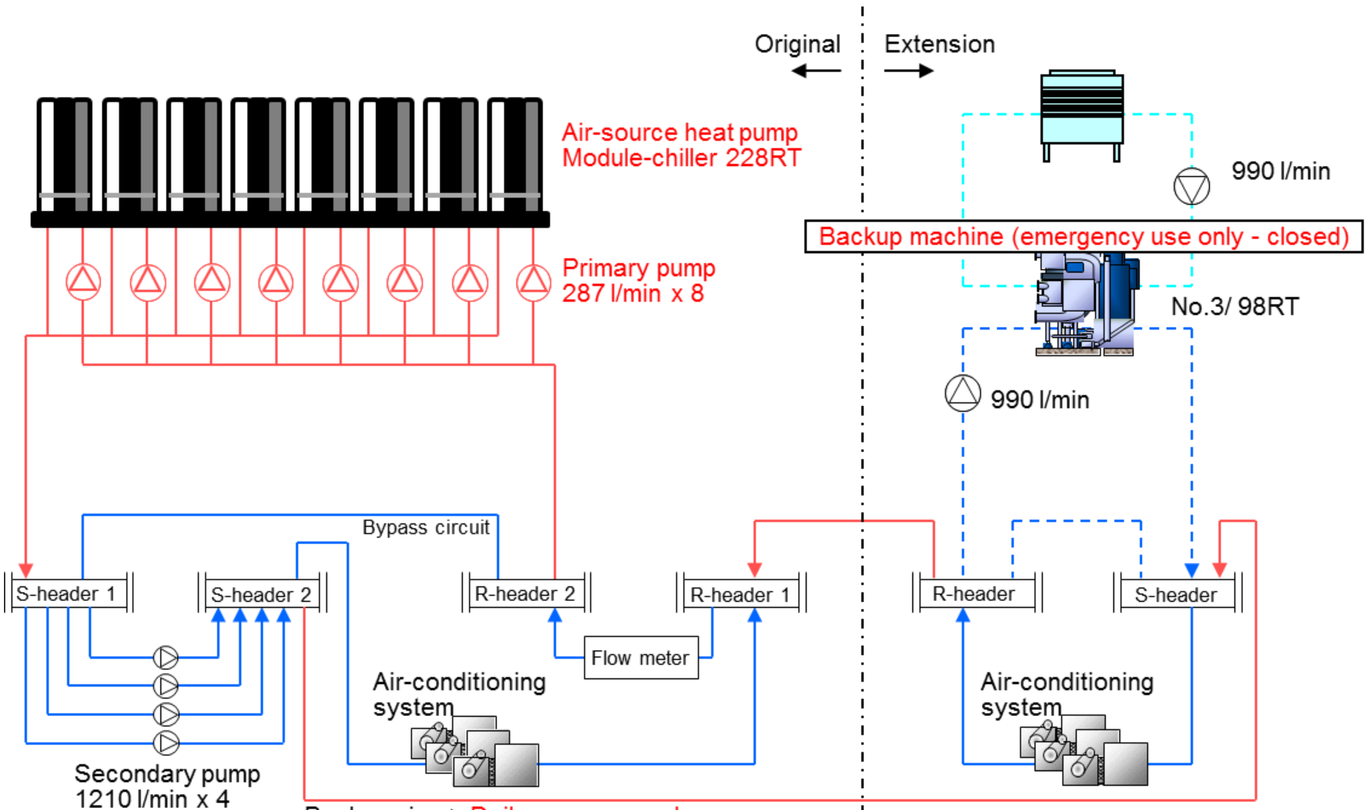


Absorption chiller-heater	Thermal load rate [%]	System COP [-]
No.1	21.1	0.56
No.2	20.1	0.49
No.3	11.4	0.26
Total	9.4	0.37

[Original building]
No.1, No.2: Operated every other day
[Extension building]
No.3: Operated 24 hours

After the retrofitting

- Adopting air-source heat pump module-chiller 228RT
  - Remove the ACHs 240RT x 2 (No.1 and No.2), and remain the ACH 98RT (No.3) for emergency use
- Using the backup pipe as daily use pipe
  - Integrate the air-conditioning systems in the original and extension buildings
- Using inverters to control the secondary pumps



Effects of the retrofitting #1

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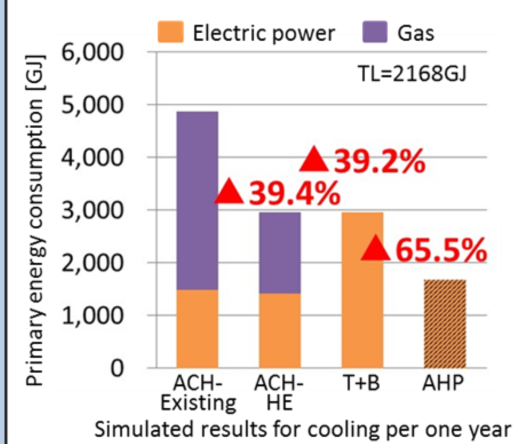
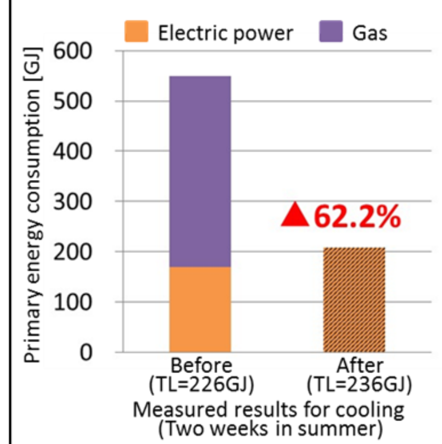
- Simulation
  - One year
  - ACH-Existing
    - Over-sized, 240x2+98=578RT
  - ACH-HE, T+B, AHP
    - Reducing the capacity, 228RT
- Measurement
  - Two weeks in the summer and winter, respectively
- Primary energy savings
  - Cooling: 62%
  - Heating: 47%
  - Almost the same with the simulated results of saving rate

<table>
<tr><th></th><th>Simulated results in the design phase</th><th>Measured results in the verification</th></tr>
<tr><td>Cooling</td><td>
</td><td>
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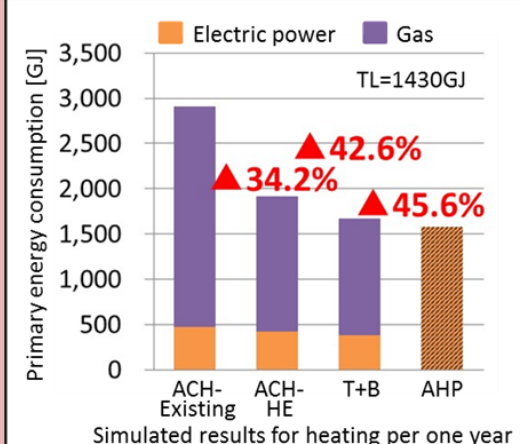
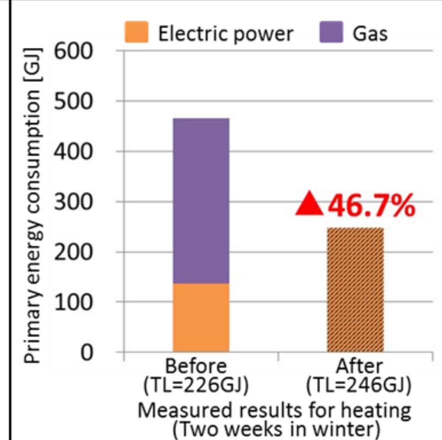
<tr><td>Heating</td><td>
</td><td>
</td></tr>
<tr><td>Note</td><td>ACH-Existing: Existing Absorption chiller-heater (ACH)
ACH-HE: ACH with high efficiency
T+B: Turbo chiller + boiler
AHP: Air-source heat pump module chiller
TL: Thermal load</td><td>Before: Absorption chiller-heater + Cooling tower + Pumps (=ACH-Existing)

After: Air-source heat pump module-chiller + Pumps</td></tr>
</table>

Effects of the retrofitting #2

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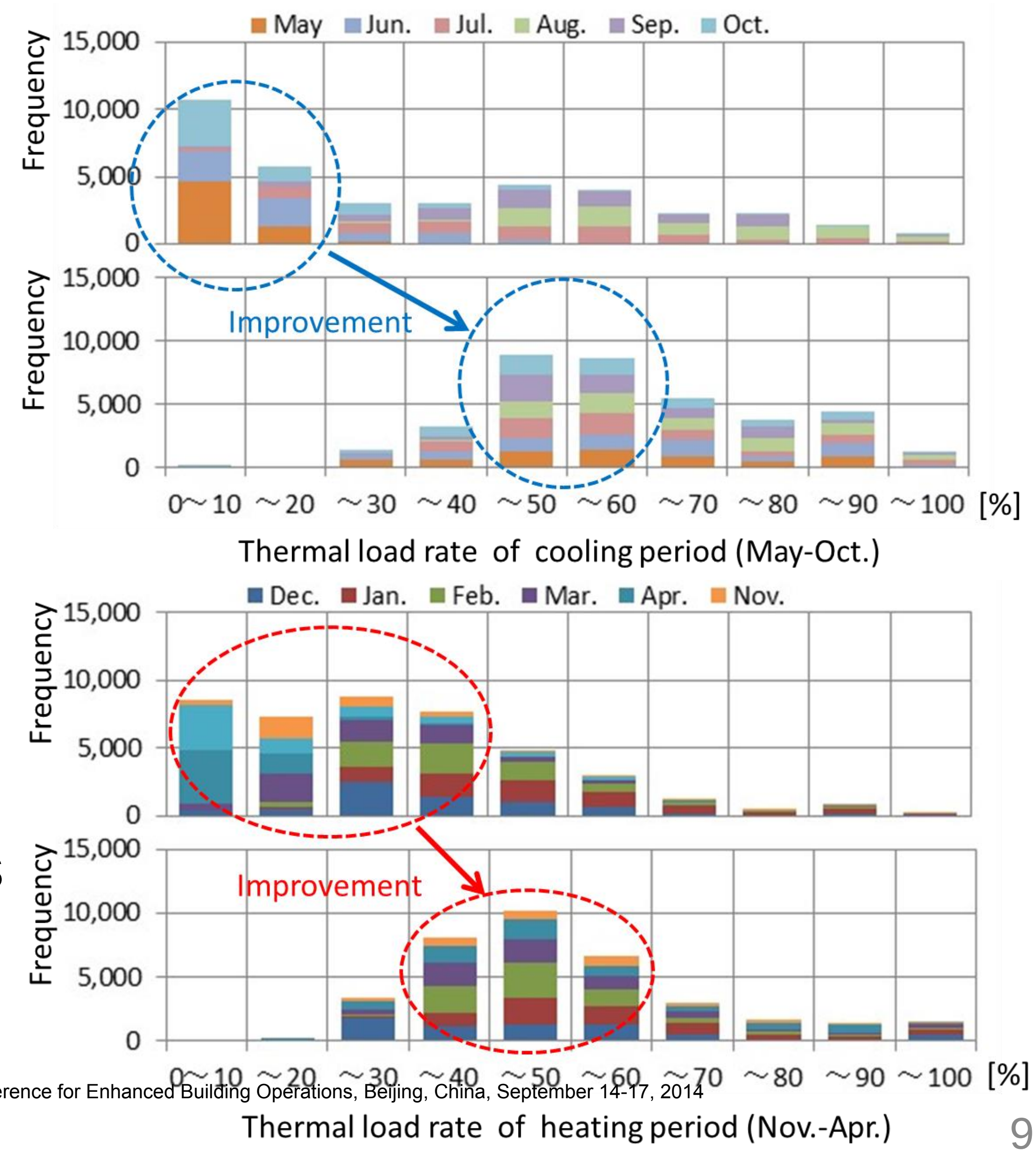
- Improvement of thermal load rate
  - Cooling
    - 0-20% > 50-70%
  - Heating
    - 0-40% > 40-70%

- Confirmed that there is no problem in the reduction of the capacity because the peak of thermal load is less than 228RT.



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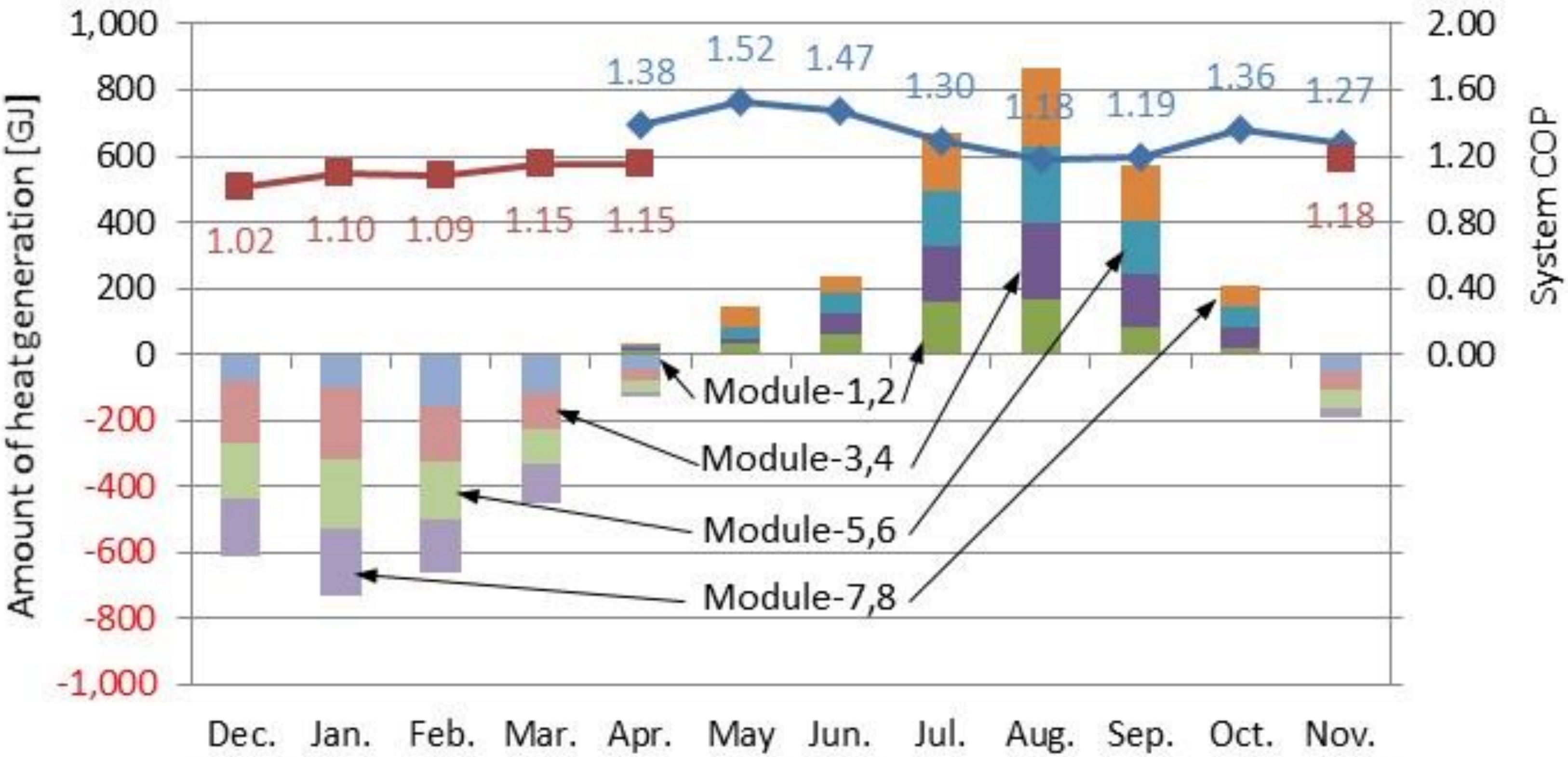
Effects of the retrofitting #3

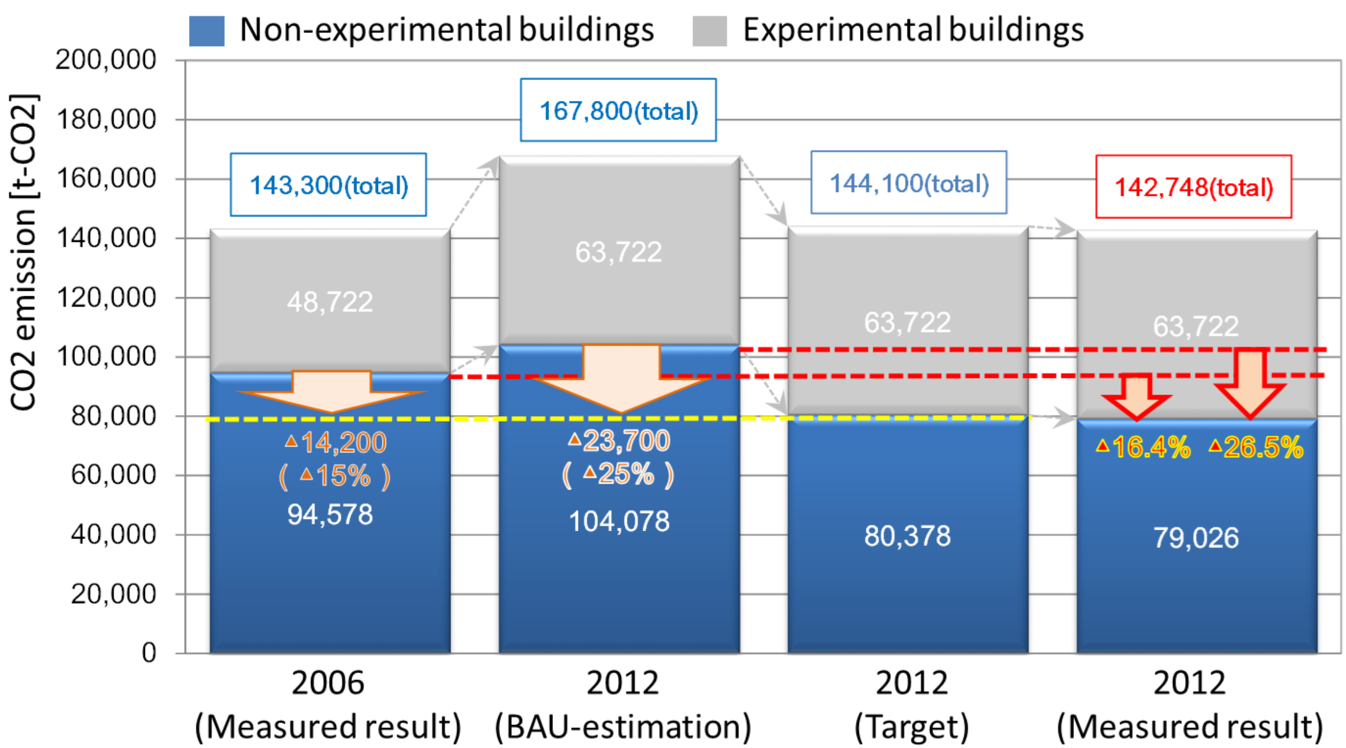
- Improvement of the System COP
  - Cooling: 1.18 - 1.52, Heating: 1.02 - 1.18
  - Largely improved from the system COP=0.37



Monthly changes of the amount of heat generation and system COP (Dec. 2011-Nov. 2012)

CO2 emission reduction by 2012

- 16.4% reduction (achieved 15% of the target) in the UTokyo
  - BAU: estimated by yearly data
    - If the energy consumption increase more than 30% in a building, the increasing is regarded as the natural growth.
  - No use the CO2 emission trading



*CO2 emission co-efficient
[Electricity] 0.368 kg-CO2/kWh, [City gas] 2.31 kg-CO2/nm3, [Heavy oil] 2.71 kg-CO2/litre

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Future development

- Continue the measures by now
  - The first target: 5% reduction by 2017 as compared with 2012
  - Expand the measures to the experimental system which consumes much energy
    - Fume hood, Data center, Ultra-low temperature freezer, etc.
  - Apply the Cx process closely
- Introduce BEMS in each building
  - Analyze and evaluate the CO2 emission easier
  - Develop the guideline for introduction of BEMS
- Use communication and data formats standardized
  - International standard, open architecture, multi vender
- Construct CEMS in a campus
  - CEMS: Campus energy management system
  - Utilize technologies such as the optimization, the fault detection, etc.
  - Realize effective energy management

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Thank you for your kind attention

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