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A Case Study of a Commissioning Process for Demand Side Energy Conservation of the Large Heat Source Plant in Kyoto Station Building

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Outline

1. **Commissioning target**
2. **Performance verification**
3. **Implementation of improvement only by mainly tuning parameters**
4. **Conclusions**

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Commissioning Target

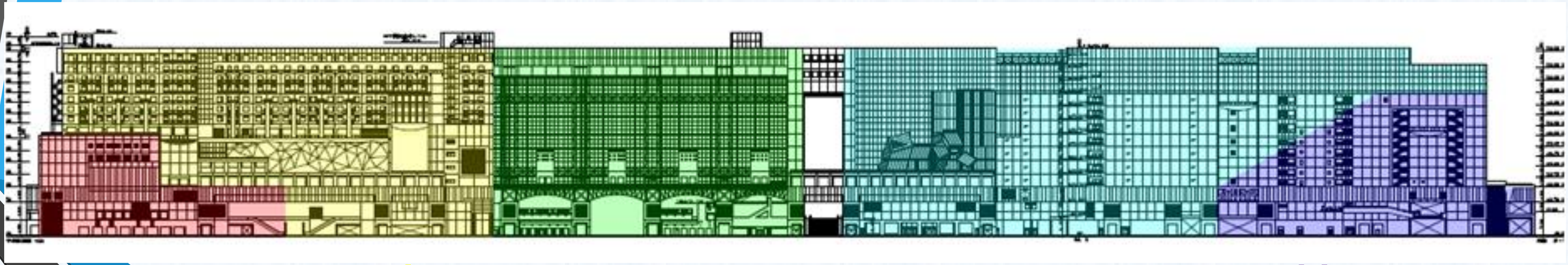
Kyoto station building

A large complex building completed in 1997

The building is used as a
- ✓ **department store**
- ✓ **hotel**
- ✓ **theater**
- ✓ **train station**

and so on.

- ➤ **235,942m^2(total floor area)**



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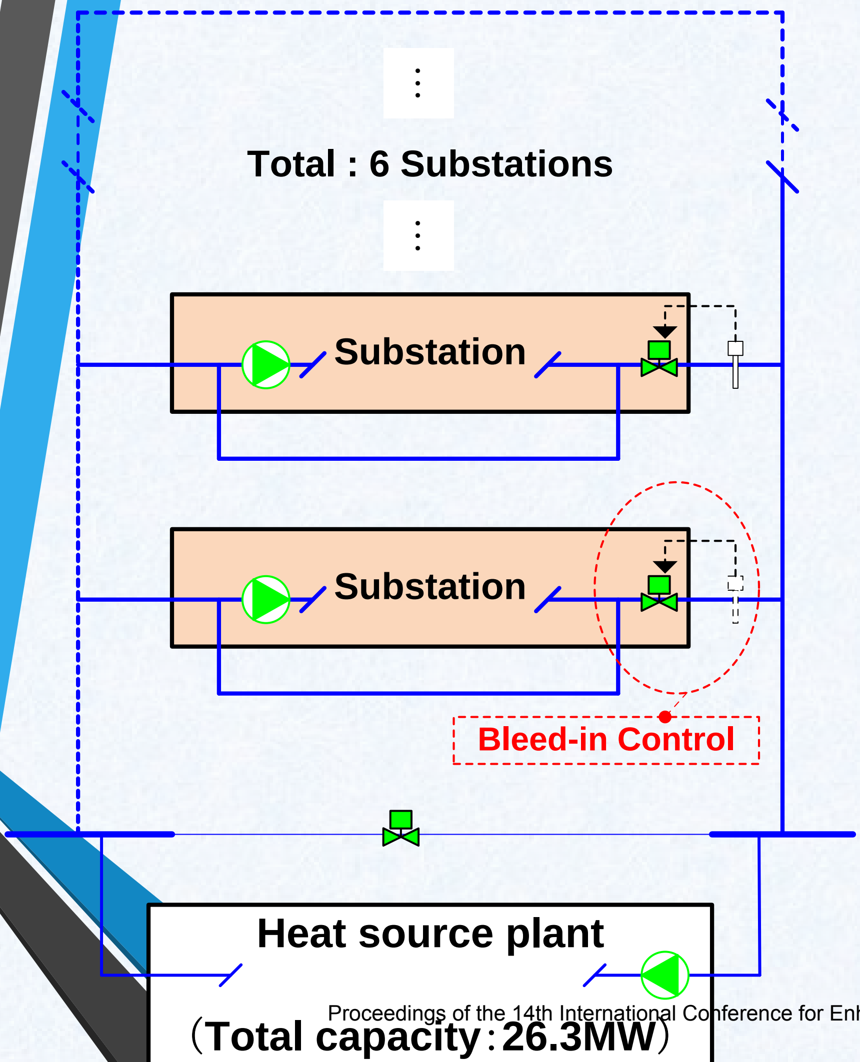
Entire cooling system of Kyoto station building

The chilled water delivery system



Large heat source plant similar to a DHC plant

- Total refrigerator capacity **26.3 MW**
- Chilled water is supplied 6 substations
  - Department store
  - Hotel
  - Theater
  - Train station etc.
- **Bleed-in Control**

✓ Commonly equipped in the substations of DHC plants.

✓ This control maintains the return water temperature to the plant by controlling the bleed-in valve in order to enable efficient operation of the plant.

About the substation system

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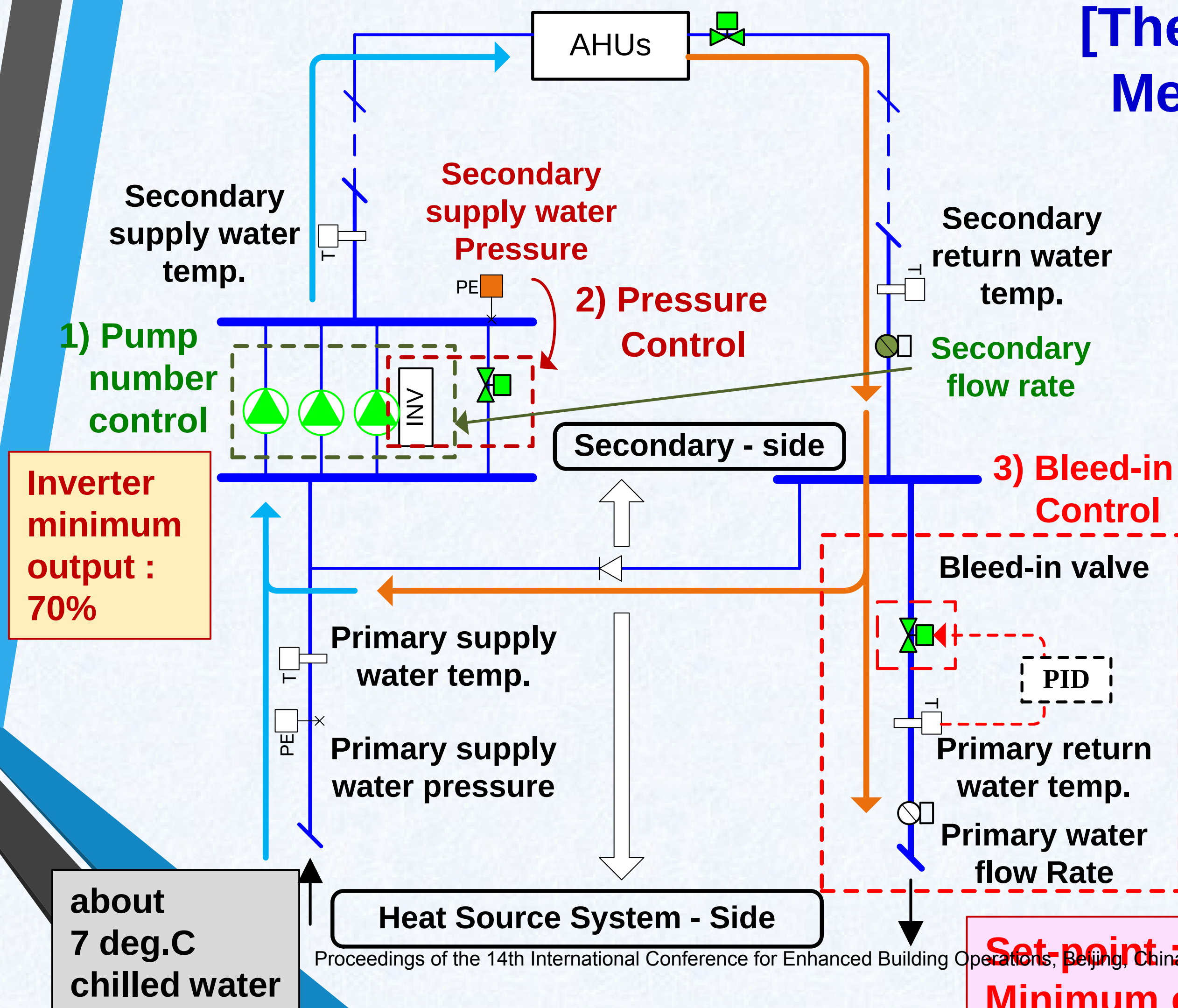
- As an example of the operation verification of the substation, I'll explain that of the department store, which has the most energy consumption of all substations-



[The automatic control Methods of substation]

1) Pump number control by the flow rate
- pumps

2) Supply water pressure constant control with
- the pump Inverter
- the bypass valve

3) Bleed-in control by the return water temperature
- bleed-in Valve

Set-point : 12.8 deg.C
Minimum opening position :16%

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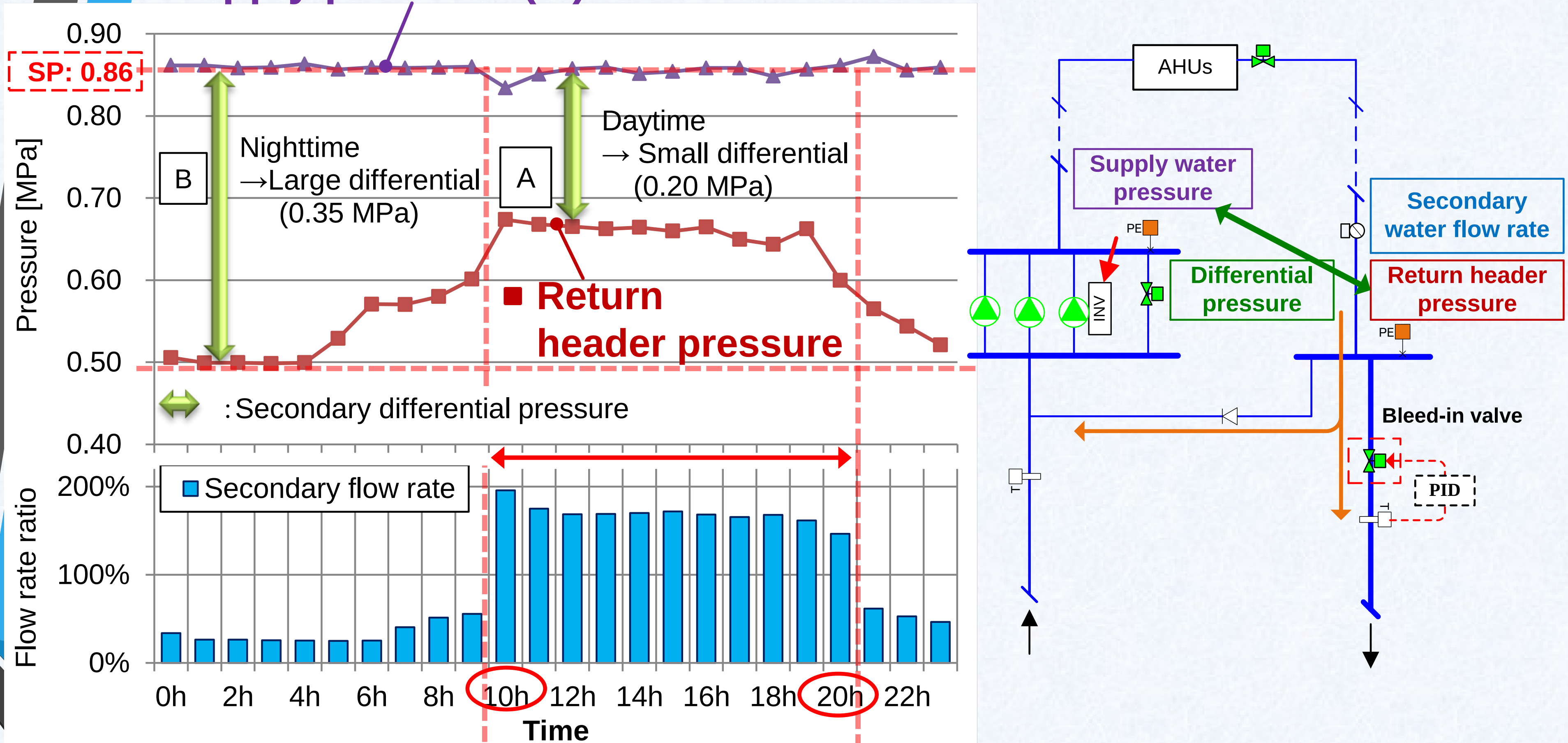
Water pressure analysis(1)

This chart shows the data of hourly averages in July

Supply pressure (▲)is controlled to be constant



The supply pressure becomes excessive except during daytime of a high demand period in summer

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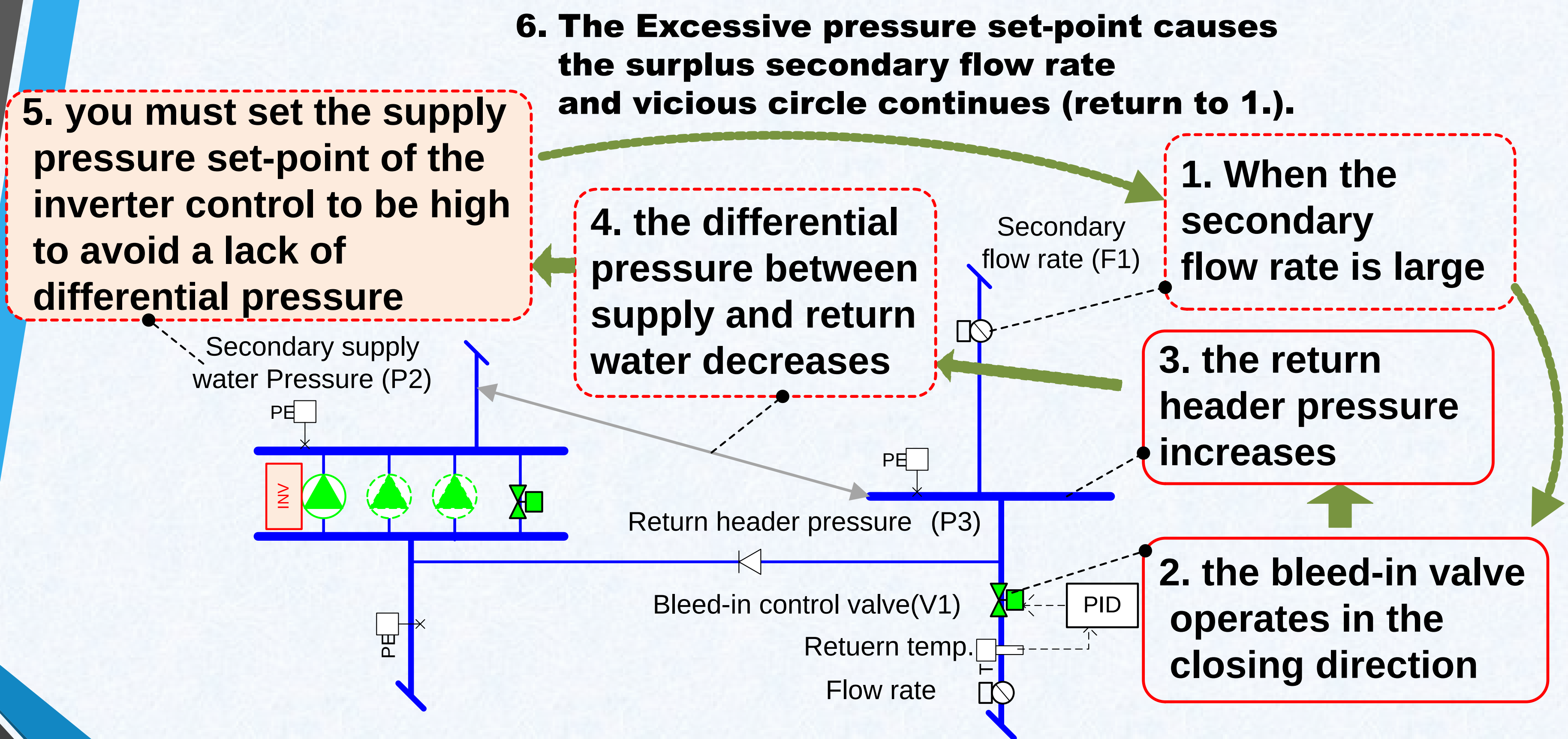
Water pressure analysis(2)

- **The possible mechanism that causes the pressure control of the substation with bleed-in control to be become appropriate.**
  - Why is the existing set point of supply pressure very high?



Due to the very high pressure set value, the excessive secondary flow rate occurs easily throughout the year

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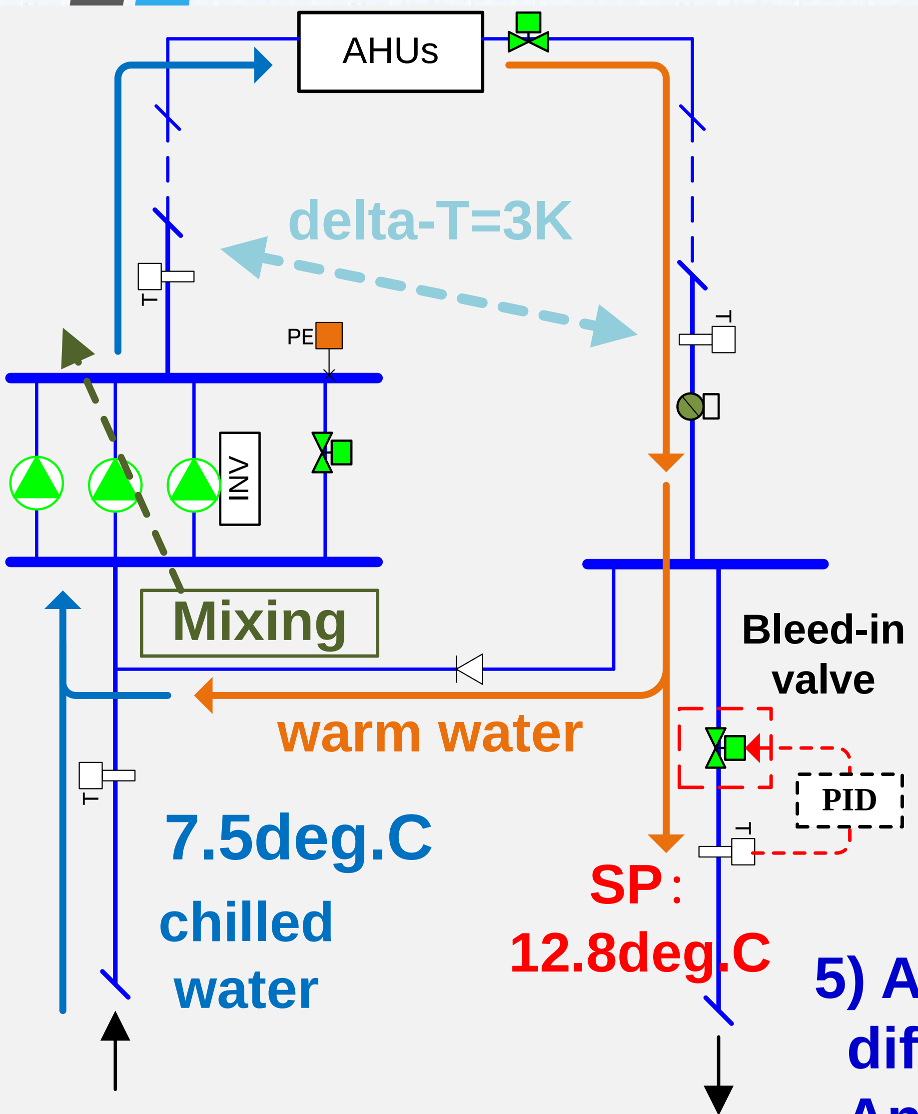
Water temperature analysis(1)



1) Because the bleed-in valve is closed,

2) a large amount of warm return water flows back into the supply side,

3) this warm return water and primary chilled water are mixed,

4) The secondary supply water temperature frequently becomes higher than the primary water temperature.

5) As a result, the temperature difference is small, about 3 K.
An additional increase in the demand flow rate for AHUs occurs

Water temperature analysis(2)

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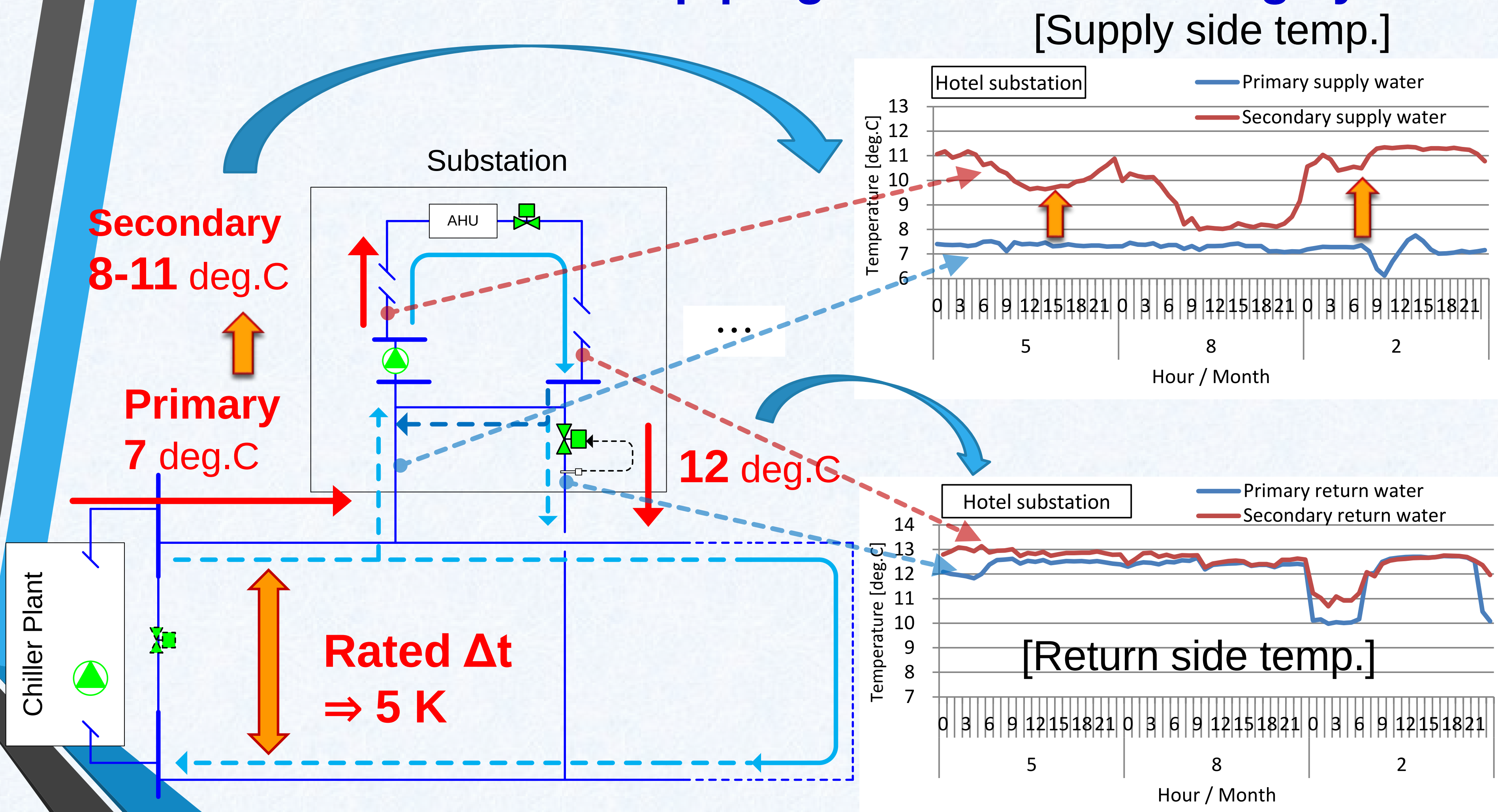
- This chart shows the situation of the temperature distributions in the piping of the total cooling system



The secondary supply water temperature becomes higher, to around 8-11 degrees C, due to controlling the substation at an inappropriate.

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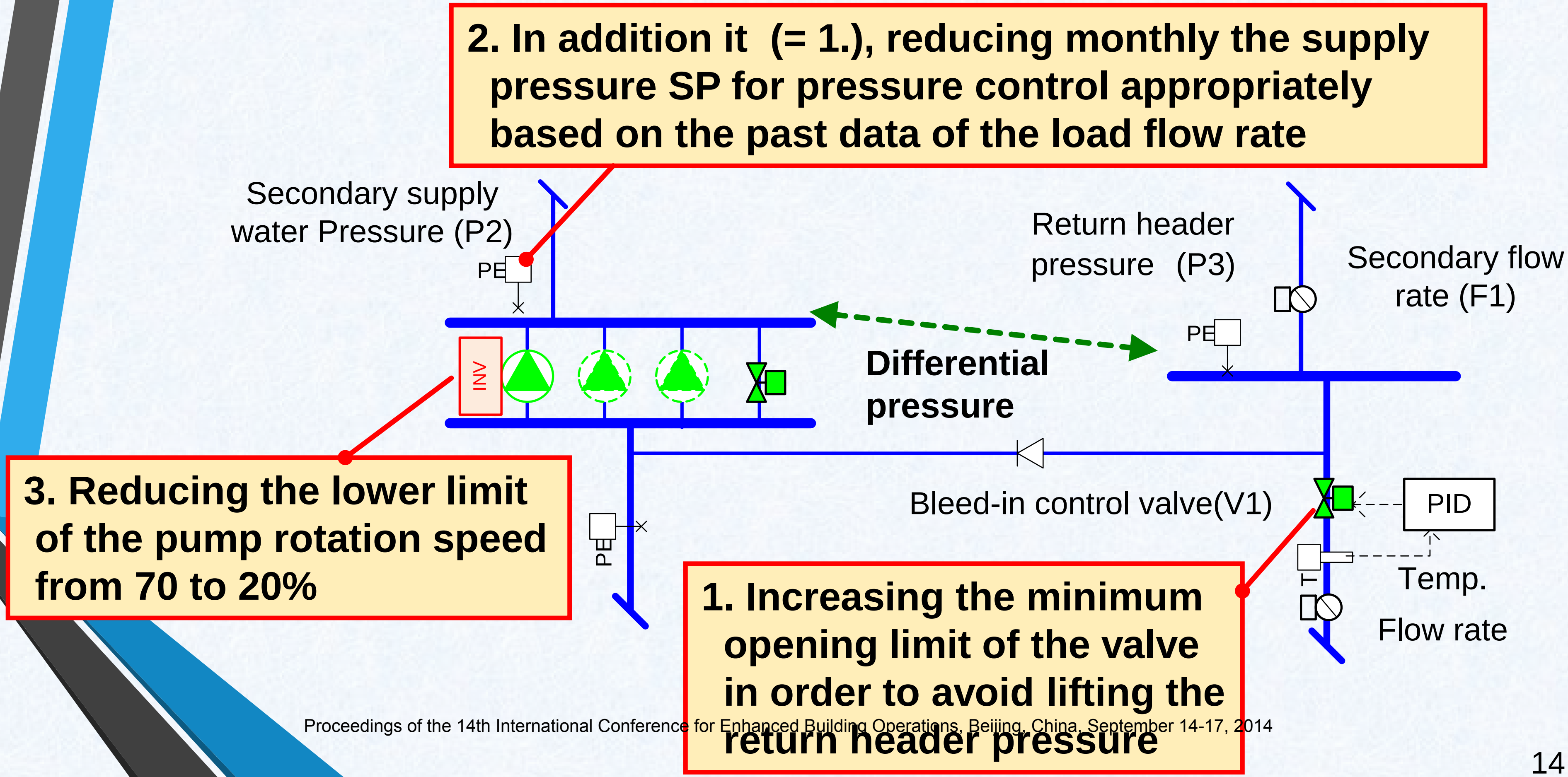
A Policy and implementation of Energy Saving Countermeasures

- **Taking easy energy saving countermeasures that are low cost and can be performed by only tuning the controller parameter and program.**
- **The countermeasures were performed during low cooling load operation, from October to March, in Y2012 and FY2013. The reason that this period was chosen is the low risk for air conditioning of the cooling mode.**
- **In the first year (FY2012), we carried out only the parameter tuning for substation control based on the data analysis.**
- **In the second year (FY2013), we carried out the control parameter tuning of the heat source side in addition to the tuning for substation controls.**

Summary of the turning for substation controls in the first year, 2012

- **We implemented the improvement measures that are easily carried out with regular tuning of the control parameter manually.**



Result of the turning for substation control

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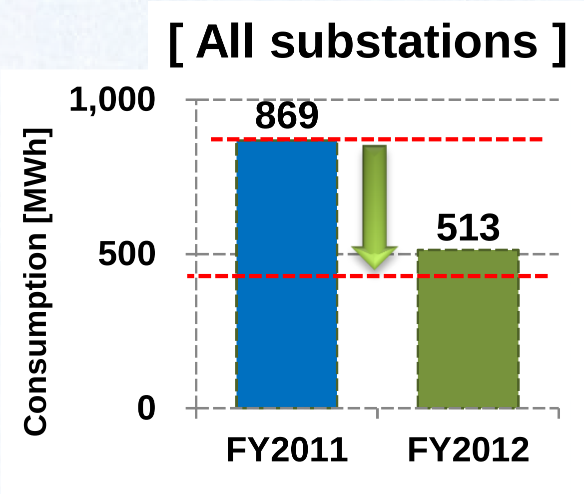
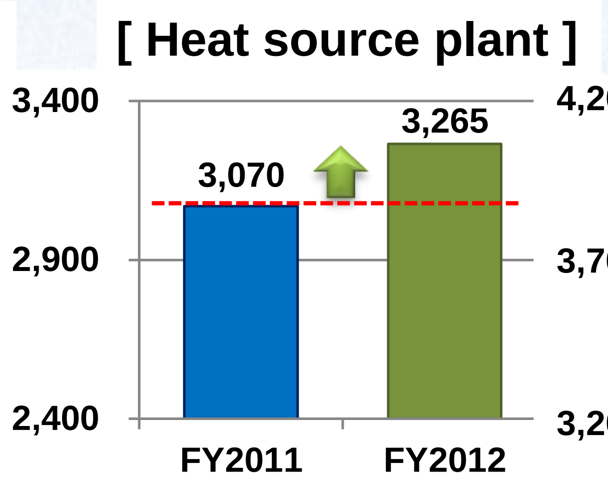
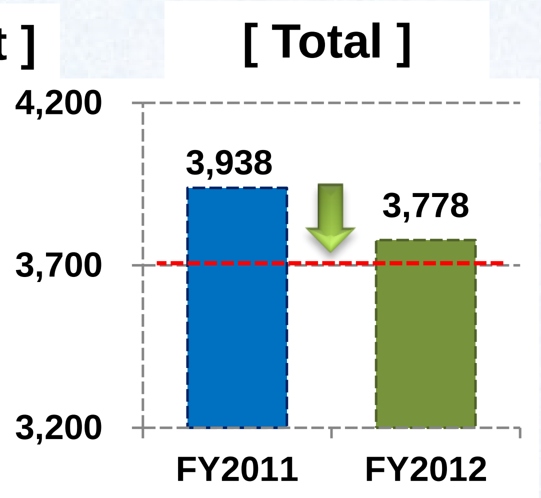
➢ A comparison of power consumption before and after the improvement measures (before; 2011, after; 2012)



41% decrease
(- 356 MWh)



6% increase
(+ 195 MWh)



4% decrease
(- 161 MWh)

Decrease in substations and total system both substation and plant, but increase in heat source plant.
--- As the chiller type of the plant is an absorption chiller, the increase depends on the chilled and cooling pump of the chiller with the increase in the driving chiller number.

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There is room for improvement on the chiller plant side.

Cause of increase in the electric power consumption of the heat source plant (1)

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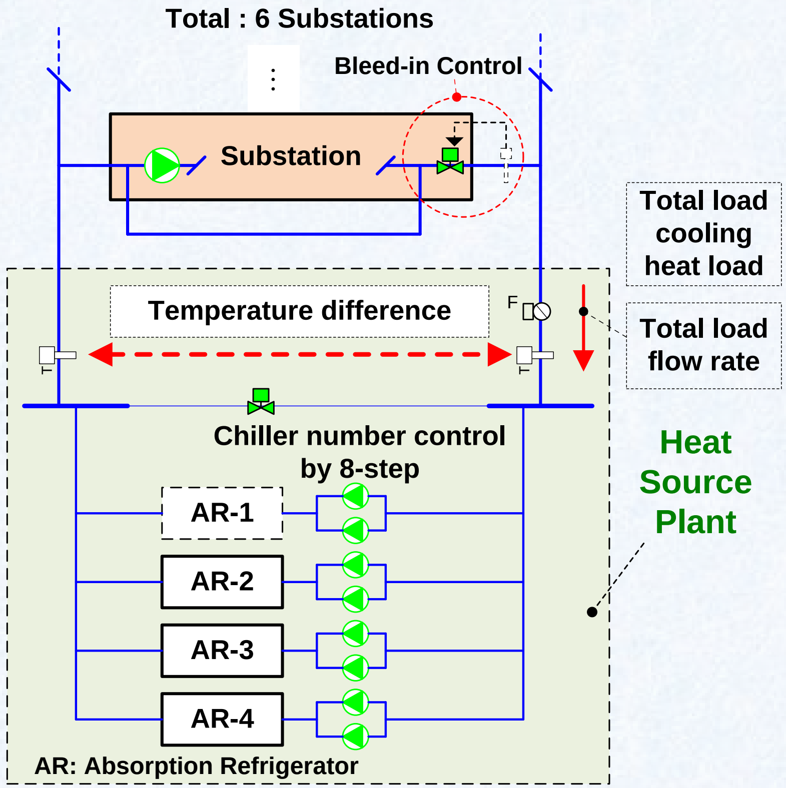
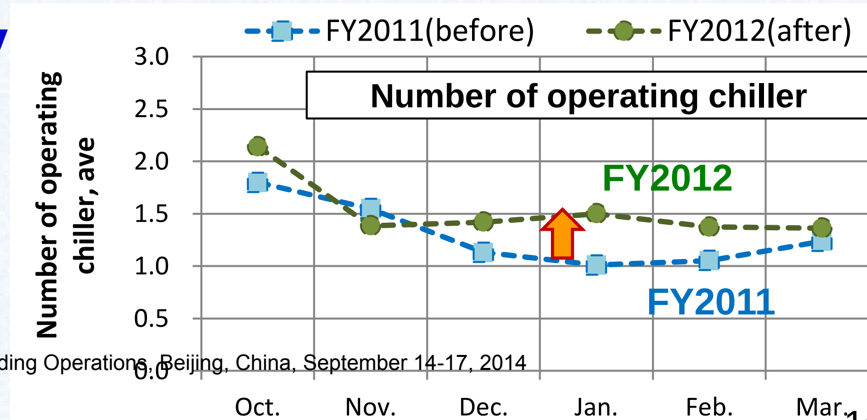
- **The method of the chiller number control of 8-step in increments of half a chiller**
  - Two number judgments, by total cooling heat and by total flow rate.
  - The actual operated number is selected to be high.
  - The chiller type is steam absorption chiller.



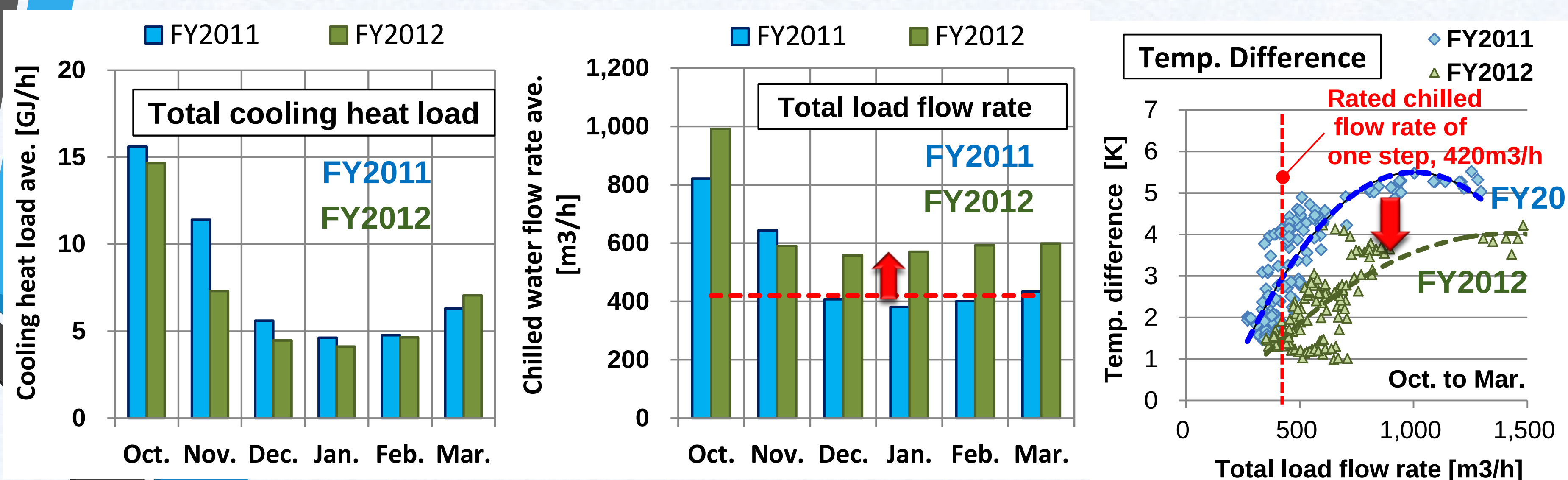
- **The comparison of monthly average operating number**
  - the operating number in 2012 (after) increased compared with that in 2011 (before)



Cause of increase in the electric power consumption of the heat source plant (2)

➢ Cause of increase in the chiller operating number

- Total heat load was almost same, but the total load flow rate increased and the temperature difference decreased.
- The reason is that the chilled water became easy to return to the heat source plant from substations, because of increasing the minimum opening limit set-value of the bleed-in valve.
- And, the number of chillers increased by judgment of the flow rate

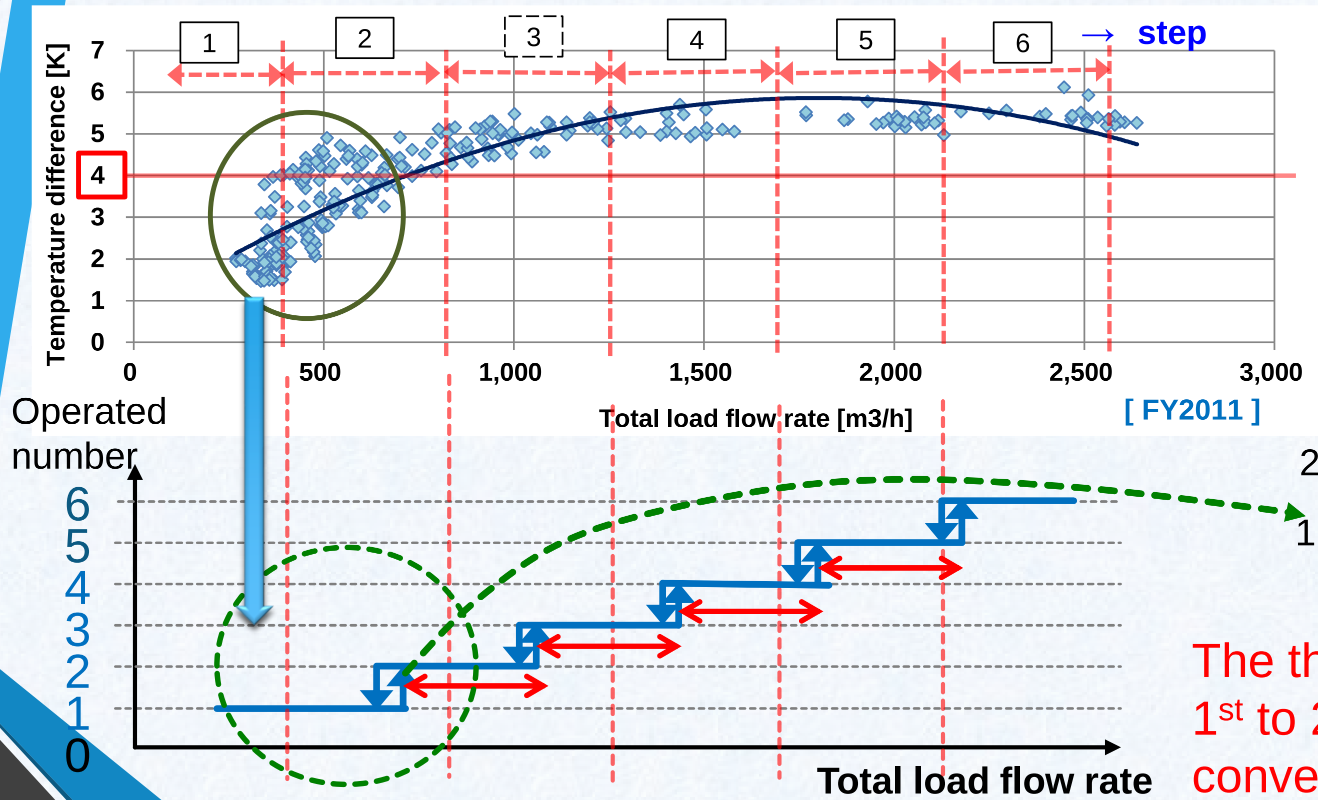


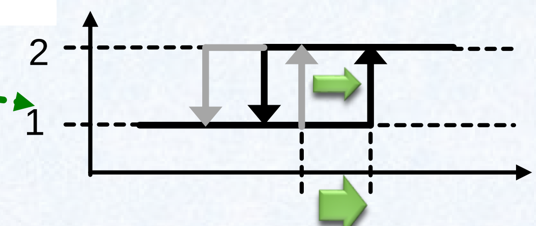
Comparison bar graphs of monthly heat load and flow rate average

Additional turning for the heat source plant control in FY2013 (1) Countermeasure-1

[The correlation chart of the total load flow rate and the temperature difference . These plots are hourly data before all measures.]

In a low flow rate range, the temperature difference tends to become low because of surplus flow rate by some by-pass in the whole piping.





The threshold set value from 1st to 2nd step is **1.3 times** of conventional set-value

➢ **Increasing the threshold flow rate value of the number control judgment by the total flow rate from 1st to 2nd step.**

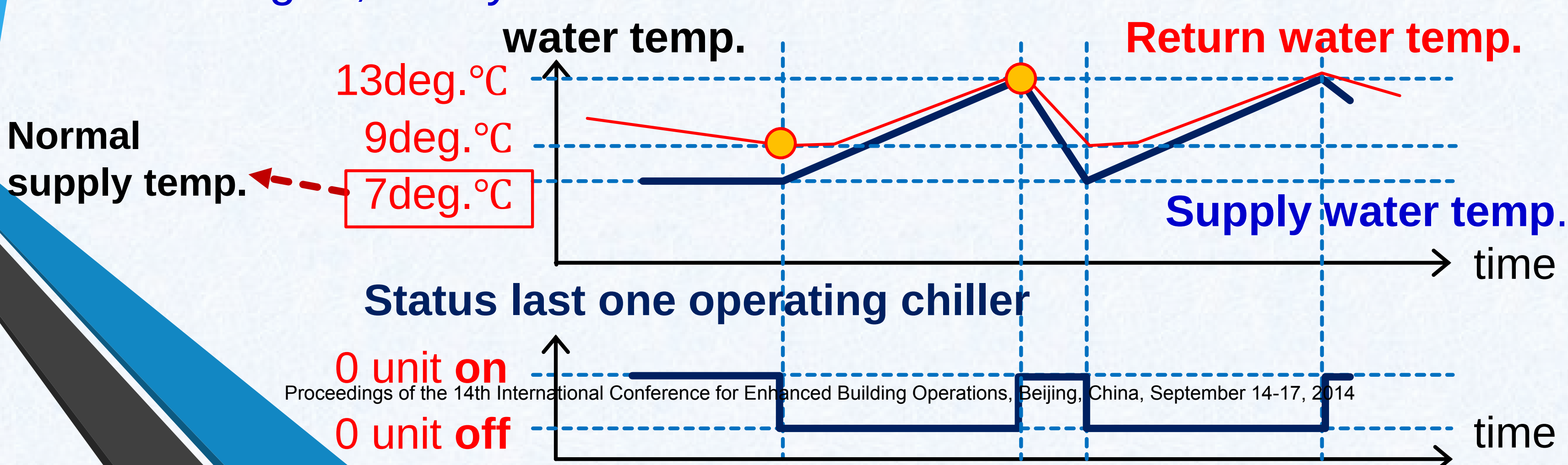
Additional turning for the heat source plant control in FY2013(2), Countermeasure-2

➢ Implementation of Chillers "0" unit operation control

- Shut down all chillers and only circulate chilled water.
  This control method is the measure **for the extremely low load**.

- **[Chillers 0 unit operation start] – shut down all chillers**
  When the return header water temp. becomes lower than the set-point, for example, 9 deg.℃, which means the low load situation, this control starts. After all chillers stop, the supply temp. is rising with a value almost same as the return temp.

- **[Chillers 0 unit operation stop and return to the normal control]**
  When the supply temp. becomes higher than the set-point, for example, 13 deg.℃, the system returns to normal number control.



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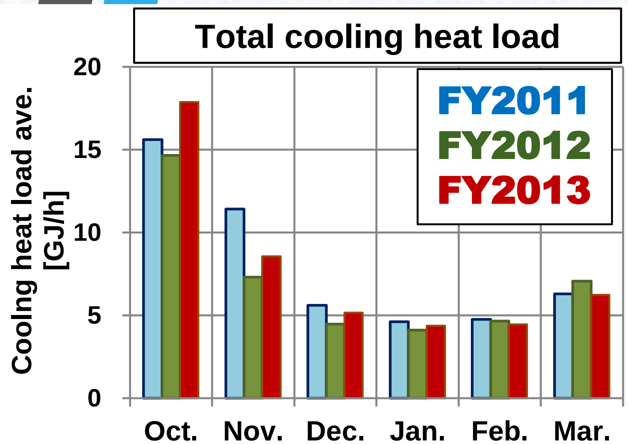
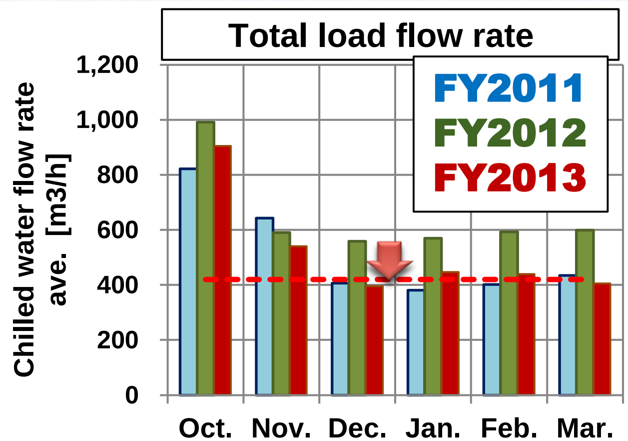
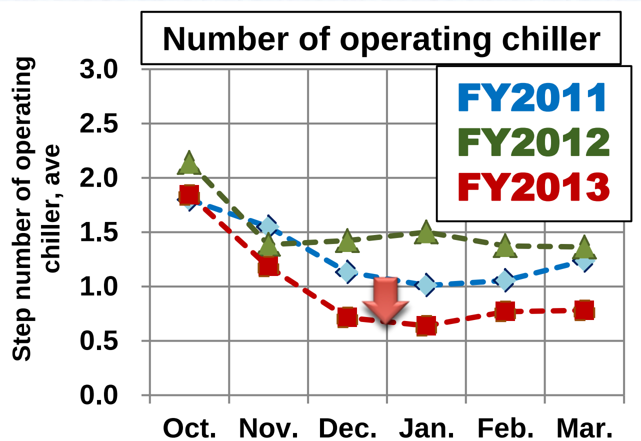
Additional turning for heat source plant controls in FY2013 (3) Result-1

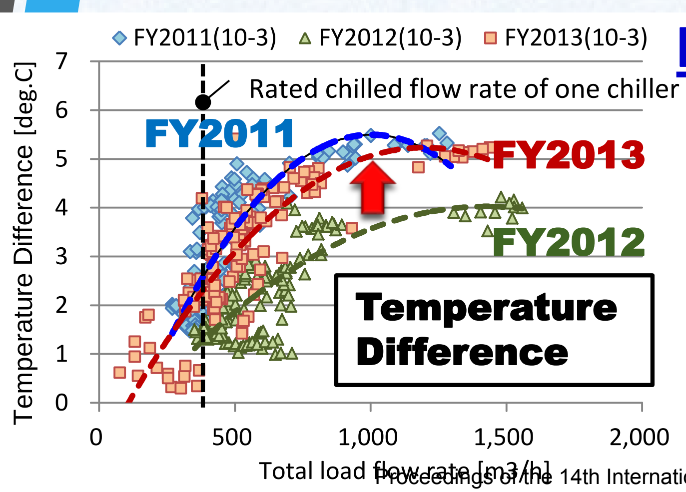
➢ Result of additional tuning for the plant controls

- Comparison of 3 year, **2011(before)**, **2012 (only substation tuning)**, and **2013 (both heat source plant and substation tuning)**.







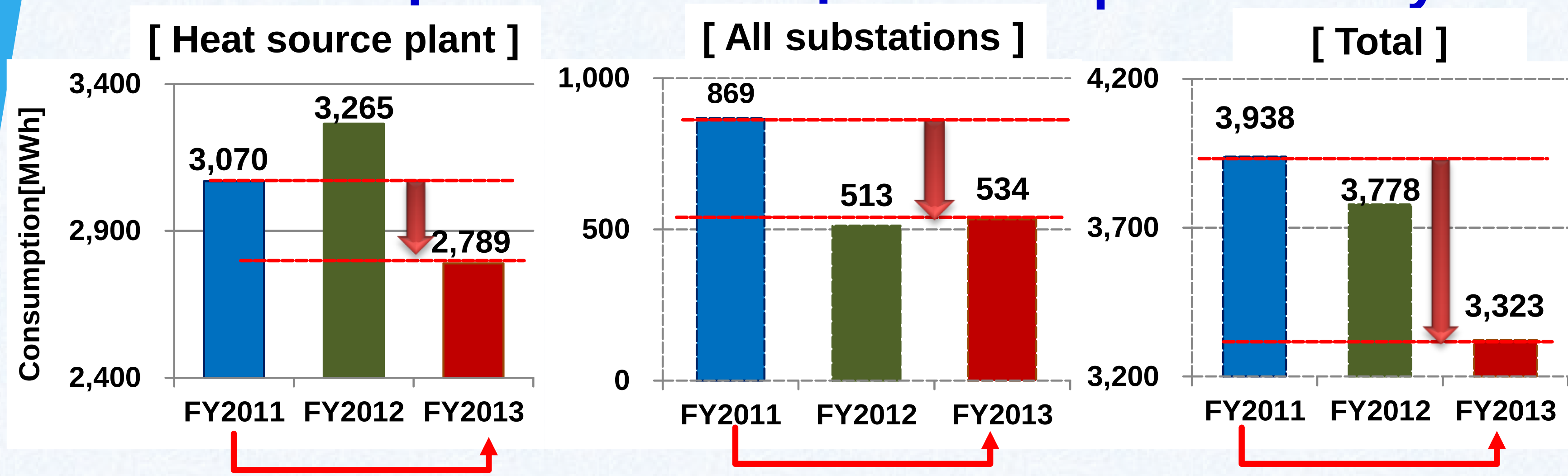


From Oct. to Mar. in 2011, 2012, 2013

- **Heat load : almost same each year**
- **Flow rate : 2013 decrease from 2012 and so it becomes same as 2011 level**
- **Number of operating chillers: 2013 is the least number.**
- **Temp. Dif. : 2013 becomes larger than 2012, and so becomes the same as 2011**

Total effect by turning for both substation and plant control (FY2011 vs FY2013)

➢ The electric power consumption compared for 3 years



➢ The reduction compared with FY2011 before all the improvements

- Substation: 335MWh decrease (down 39 %)
- Heat source plant: 281MWh decrease (down 9%)
- Total: 615MWh decrease (down 17%)

(down *%) → Compared with FY2011

➢ Achieving the big energy saving effect by tuning the control parameters of both the substation side and the heat source plant side is based on an operational analysis

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Conclusions(1) Outline

- Bleed-in control is commonly equipped in the substations of the DHC plant in order to enable efficient operation of the plant.
- According to the data analysis, it is found that useless energy consumption of substation- side occurred due to unsuitable control parameters including bleed-in control.
- Taking easy energy saving measures that are low cost and performed by only tuning the controller parameter during low cooling load operation.
- The improvement of wasteful energy consumption of the substation is insufficient by only tuning of the substation control. At the same time, tuning of the heat source plant side is also necessary.
- As the result, in the low cooling load from Oct. to Mar., a total 615 MWh decrease (down 17%) was achieved.

Conclusions(2) Concrete tuning technique

➢ *Turning for substation-side*

- **Reducing supply pressure SP for the pressure control of pump inverter and by-pass valve properly while increasing the minimum opening limit set-value of the bleed-in valve to avoid a drop of the differential pressure properly.**
- **Reducing the lower limit of the pump rotation speed to about 20%.**

(Of course, we should change the differential pressure control instead of supply pressure control, but because it was premised that we did not change the existing hardware at all, we couldn't do that in this time.)

➢ *Turing for heat source plant-side*

Because it is unavoidable that the load flow rate is more than the proper volume in low heat load, we take two measures as follows;

- **Increasing the threshold of the flow rate value for the number control judgment by the total flow rate in the low load flow rate range.**
- **Implementing Chillers "0" unit operation control for extremely low load**

Thank you!