Introducing and Operating Efficient Blower Control by Temperature Correction Method

- Promoting Reduction of Greenhouse Gas Emissions from Wastewater Treatment Plants -

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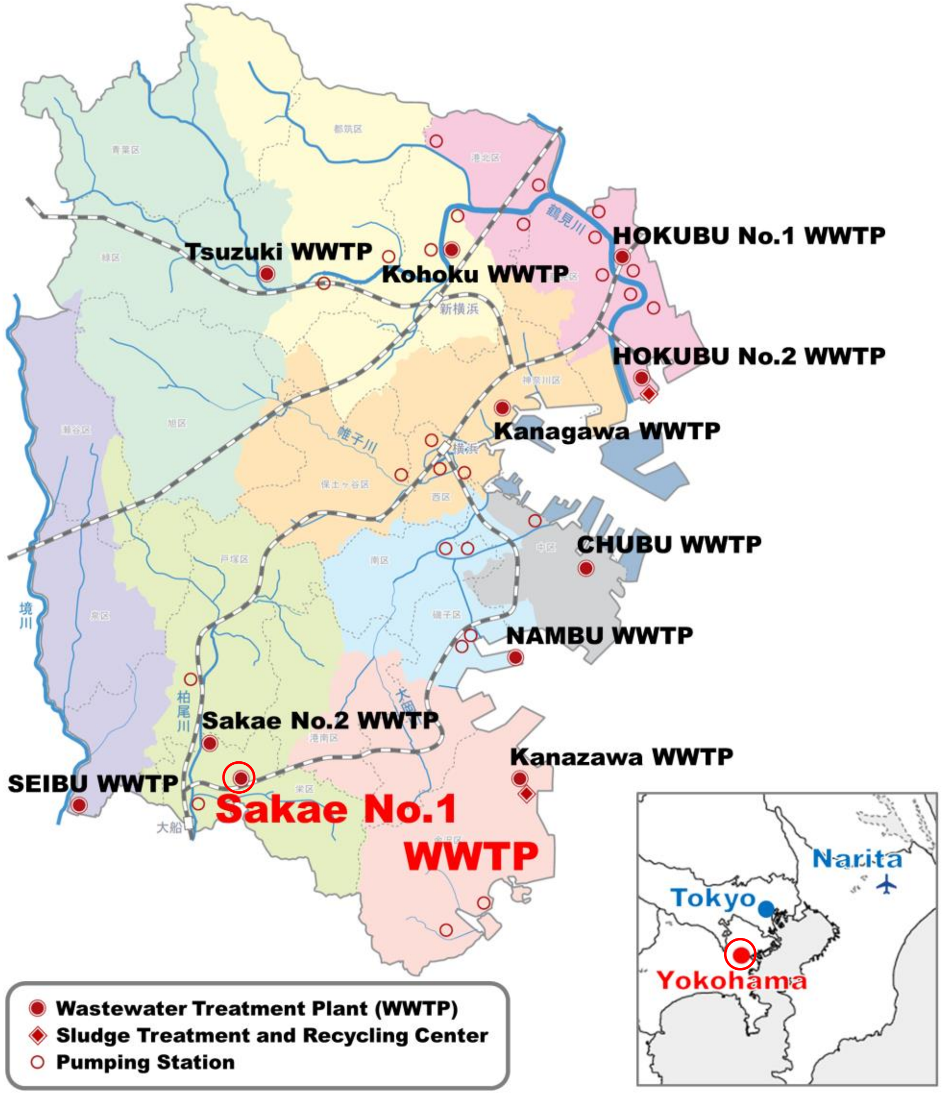
The effects achieved

The operation time of each blower was optimized by efficiently controlling the number of units operating using our method.
As a result, the power consumption of the blowers has been reduced and greenhouse gas emissions decreased.

Key points

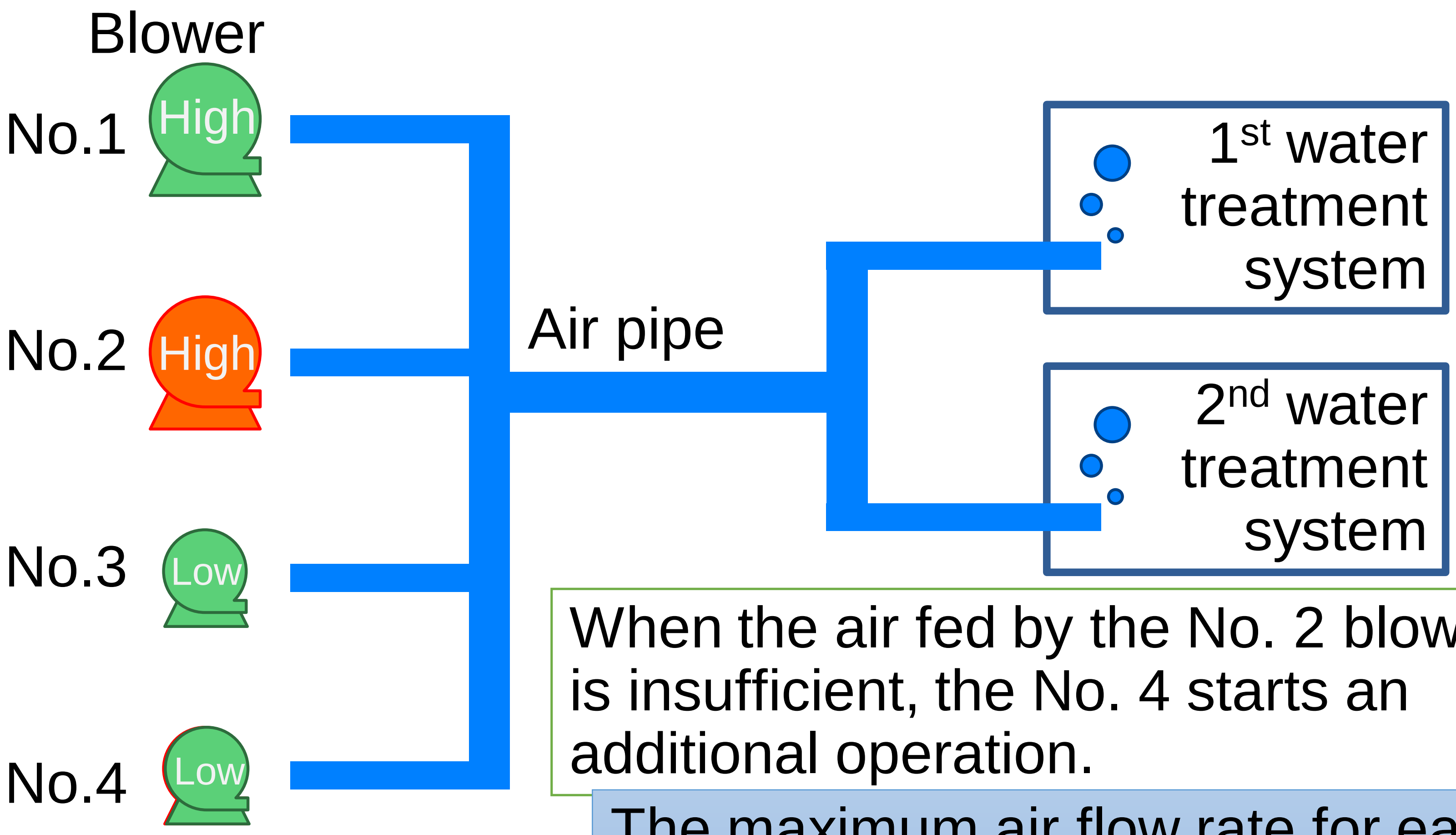
- The software was improved to control the optimal number of units of blowers operating with the addition of atmospheric temperature to the input value.
- No improvements were made to the blowers (hardware).
- The treated wastewater's quality has not worsened.

The activities on greenhouse gas emission reduction by the wastewater treatment plants (WWTPs) in the City of Yokohama



I	Converting lighting to LED	All 11 WWTPs
II	Promoting demand response	9 WWTPs (FY2018) and 10 WWTPs (FY2019) that contracted with a power company
III	Validating the operation of blowers that make use of meteorological conditions	Sakae No.1 WWTP
IV	Validating the control of reactors using ammonia meters	Tsuzuki WWTP
V	Validating introduction of new wastewater treatment method that focuses on treated water quality as well as saving energy	SEIUB WWTP

Overview of the aeration system



When the air fed by the No. 2 blower is insufficient, the No. 4 starts an additional operation.

The maximum air flow rate for each blower (the air flow rate requiring the second blower's additional operation) can be set by the operators as a control value.

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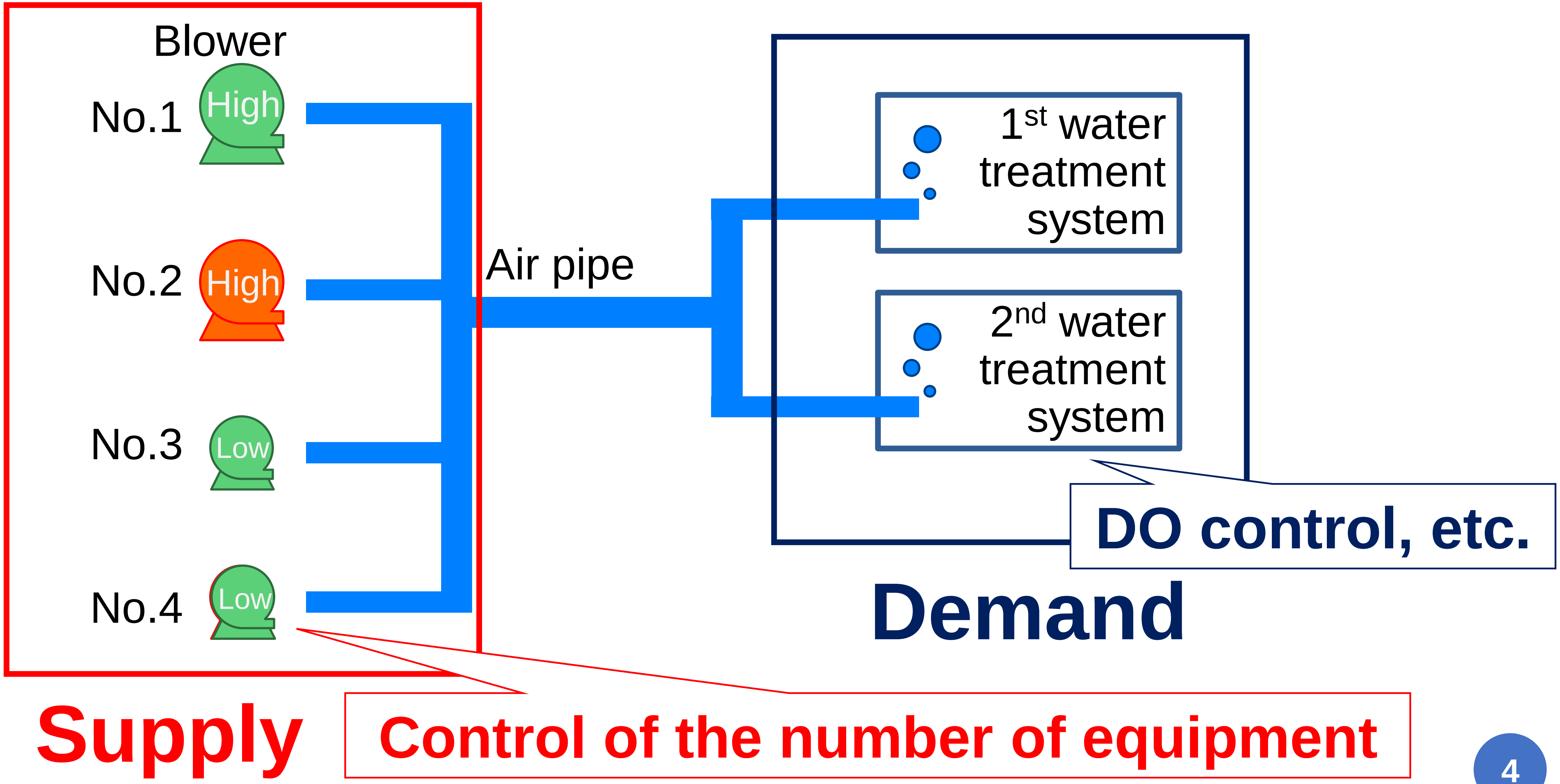
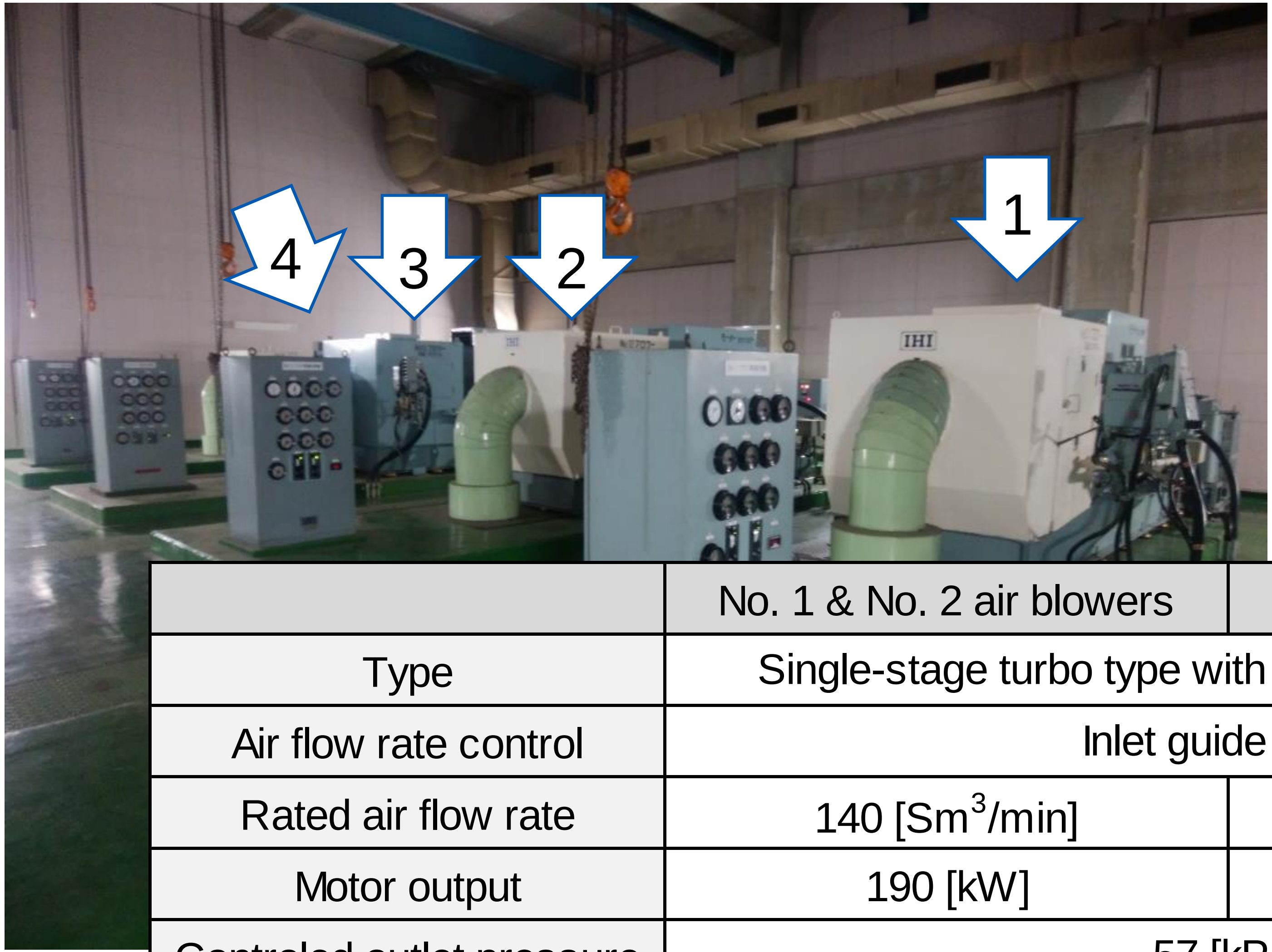
Overview of the aeration system



Overview of the blower



	No. 1 & No. 2 air blowers	No. 3 & No.4 air blowers
Type	Single-stage turbo type with geared speed increase	
Air flow rate control	Inlet guide vane	
Rated air flow rate	140 [Sm^3/min]	70 [Sm^3/min]
Motor output	190 [kW]	110 [kW]
Controled outlet pressure	57 [kPa]	

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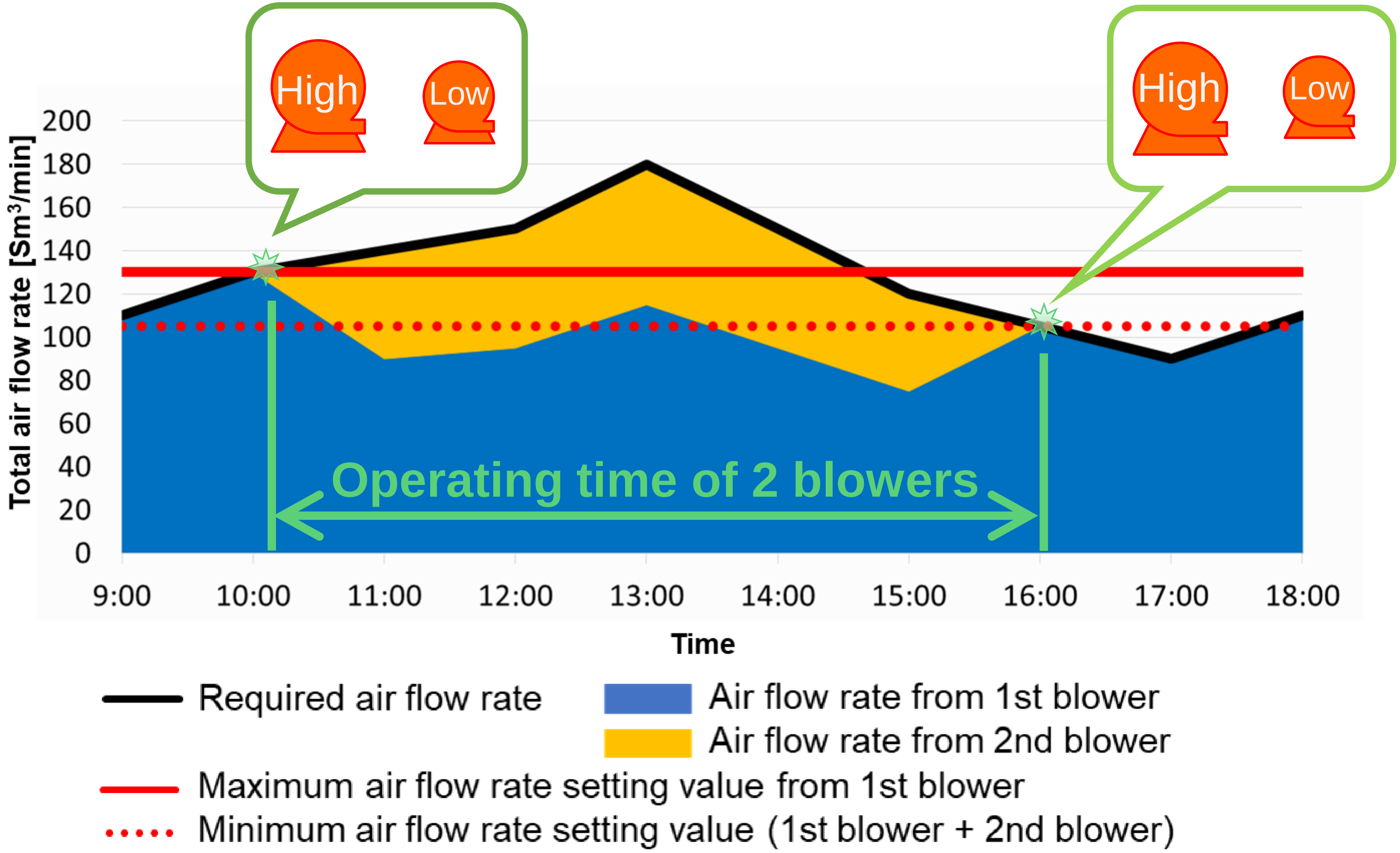
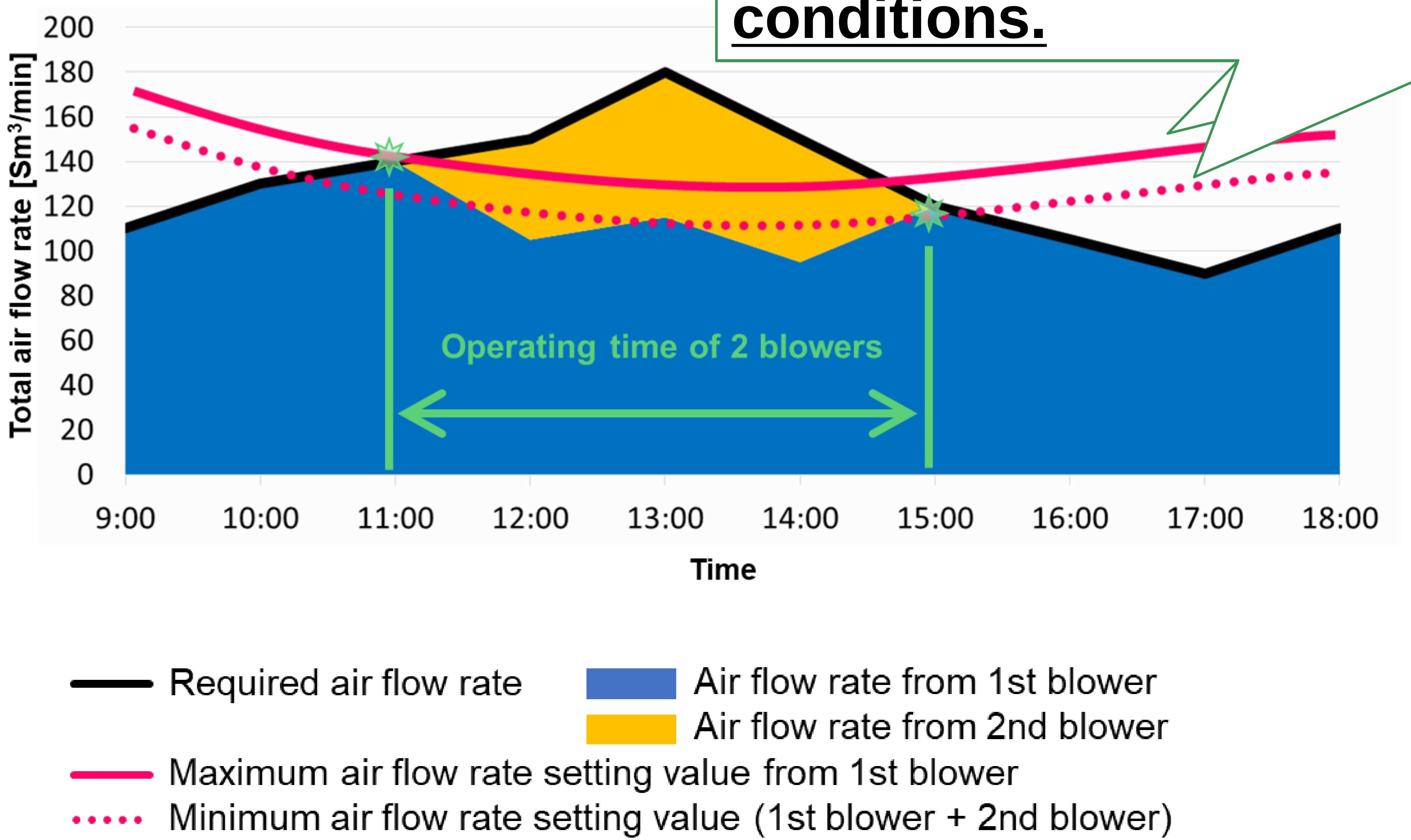
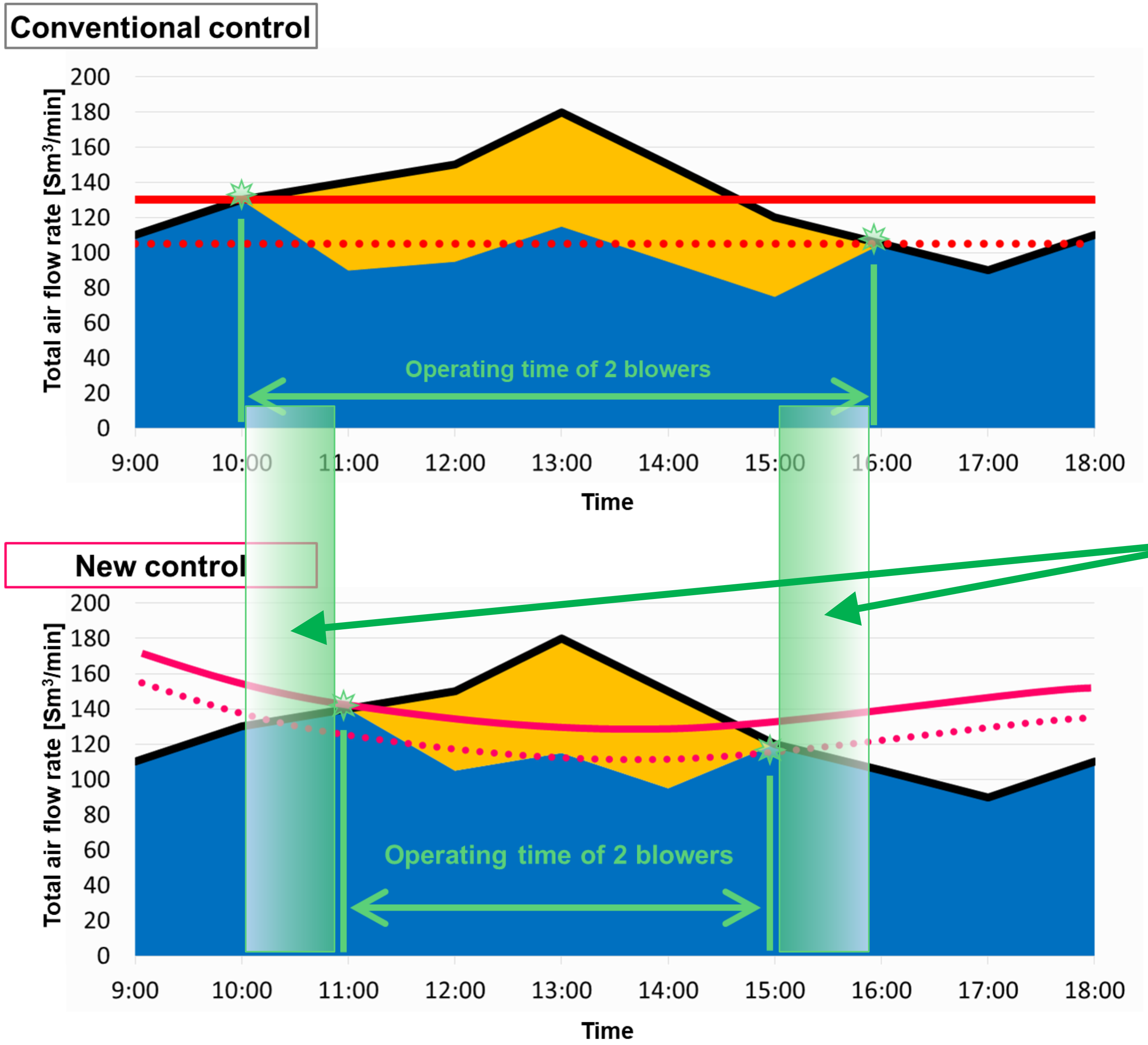
Conventional control



New control

automatically change depending on meteorological conditions.





Reduce the time for the dual operation of multiple blowers.

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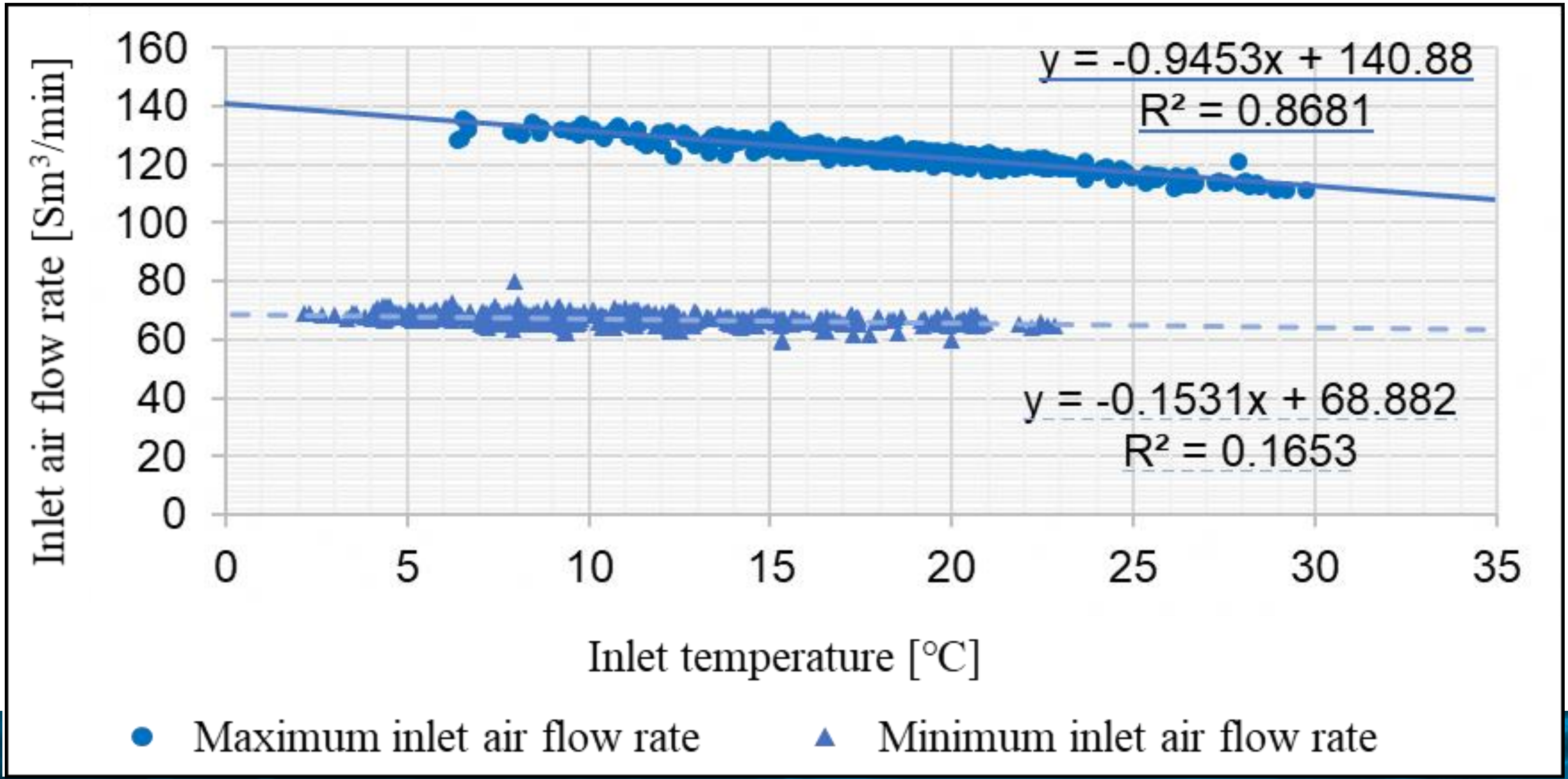
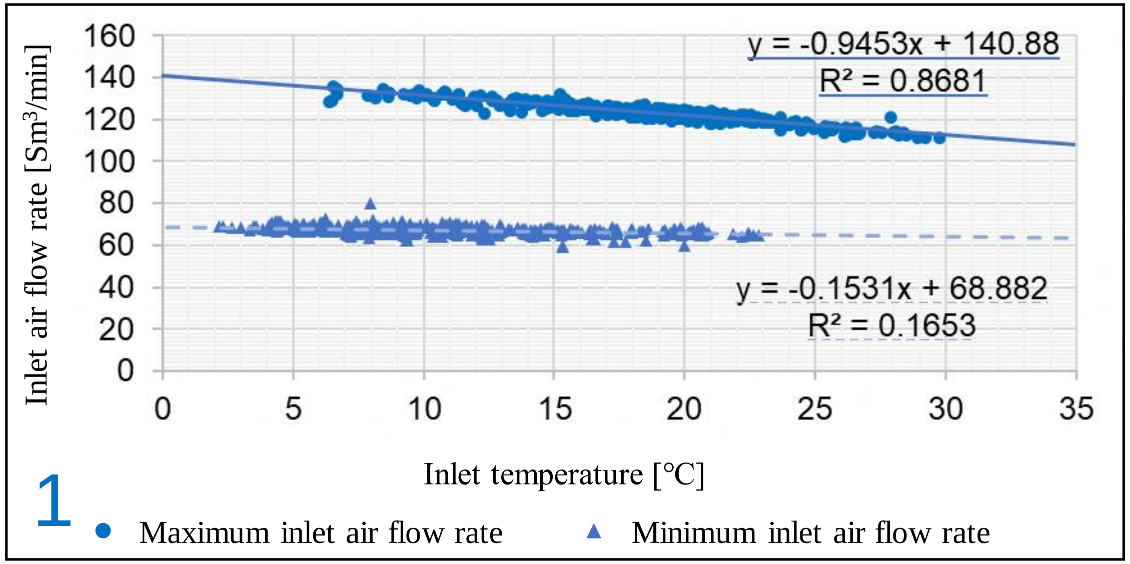
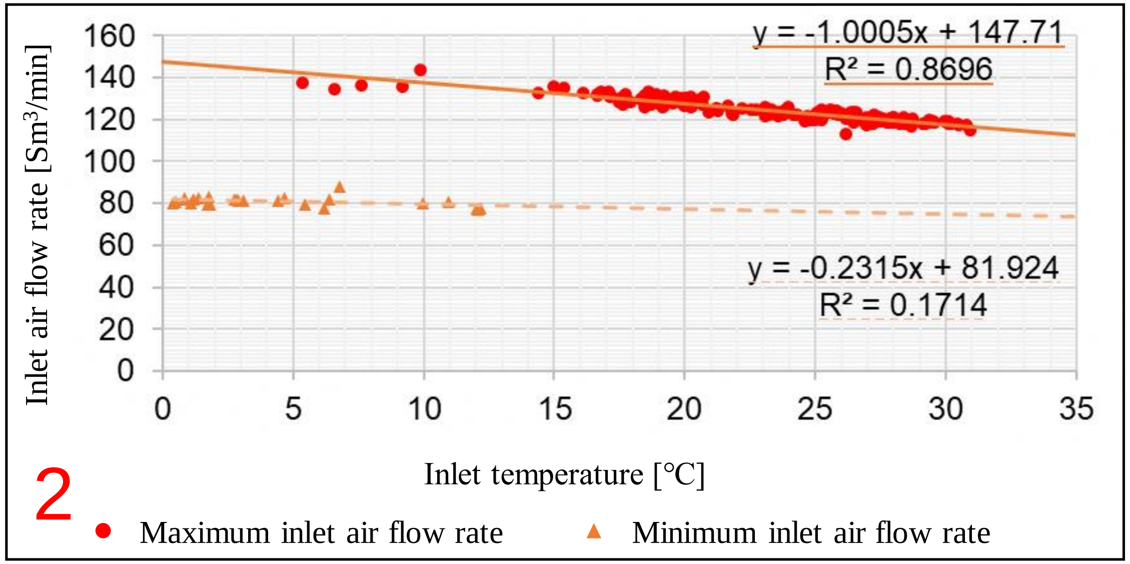
The relationship between the inlet temperature and the inlet air flow rate

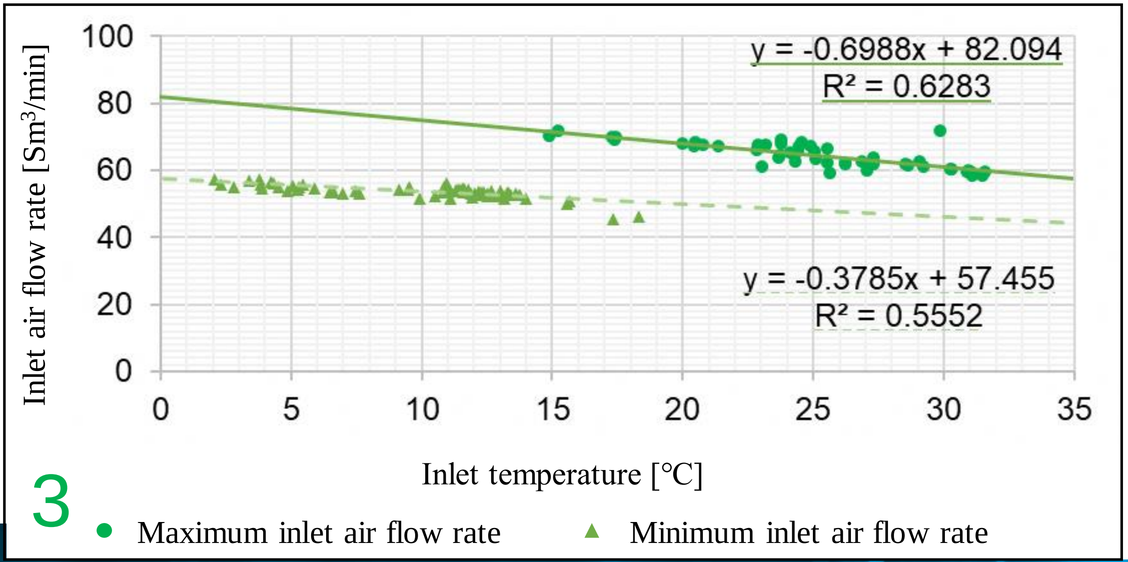
The relationship between the inlet temperature and the inlet air flow rate was checked from the operation record to clarify whether the rule of thumb that an inlet air flow rate increases as the inlet temperature decreases is true.

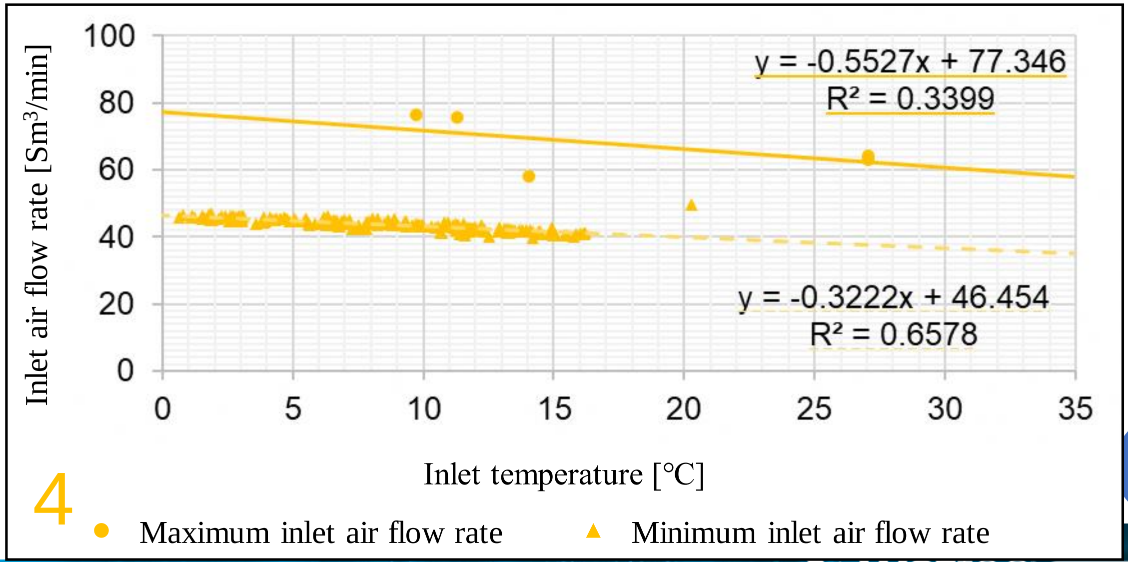


The relationship between the inlet temperature and the inlet air flow rate





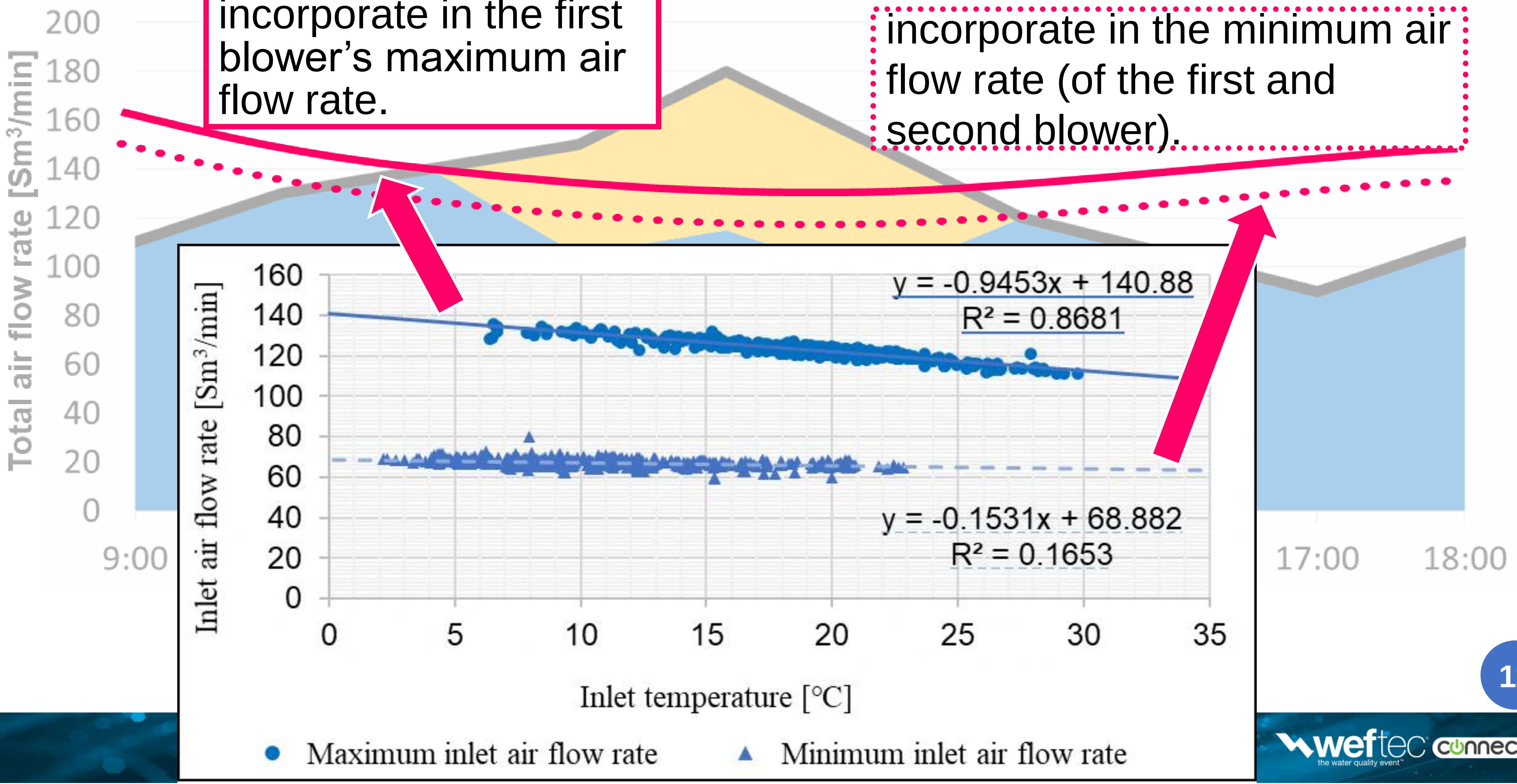




The relationship between the inlet temperature and the inlet air flow rate

incorporate in the first blower's maximum air flow rate.

incorporate in the minimum air flow rate (of the first and second blower).



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The results of the new control operation

	August-2018	August-2017	September-2018	September-2017	October-2018	October-2017
Average temperature [°C]	27.0	25.7	22.2	22.4	18.7	16.5
Air flow / month [Sm^3/month]	4,304,550	4,162,800	4,358,050	4,737,200	4,295,700	4,306,050
Blower power consumption [kWh/month]	126,820	127,550	125,120	138,690	119,050	124,890
Power consumption per air flow [kWh/Sm^3]	0.02946	0.03064	0.02871	0.02928	0.02771	0.02900
Comparison of same month in 2017 [kWh/Sm^3]	**-0.0012**	**(-3.85%)**	**-0.0006**	**(-1.94%)**	**-0.0013**	**(-4.45%)**

The operation using the meteorological data-based corrective control is successful.
The energy-saving effects are also observed despite a variation between the months.
Given that the summer was extremely hot, it can be said that the operation efficiency has been improved.

If the power consumption can be constantly reduced by 4%, the plant can save about $1,400 in electricity a year. This can be estimated to equal a roughly 50-ton reduction in CO_2 emissions a year.

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Issues with operating using a low air flow rate

When new control was introduced

Low air flow rate

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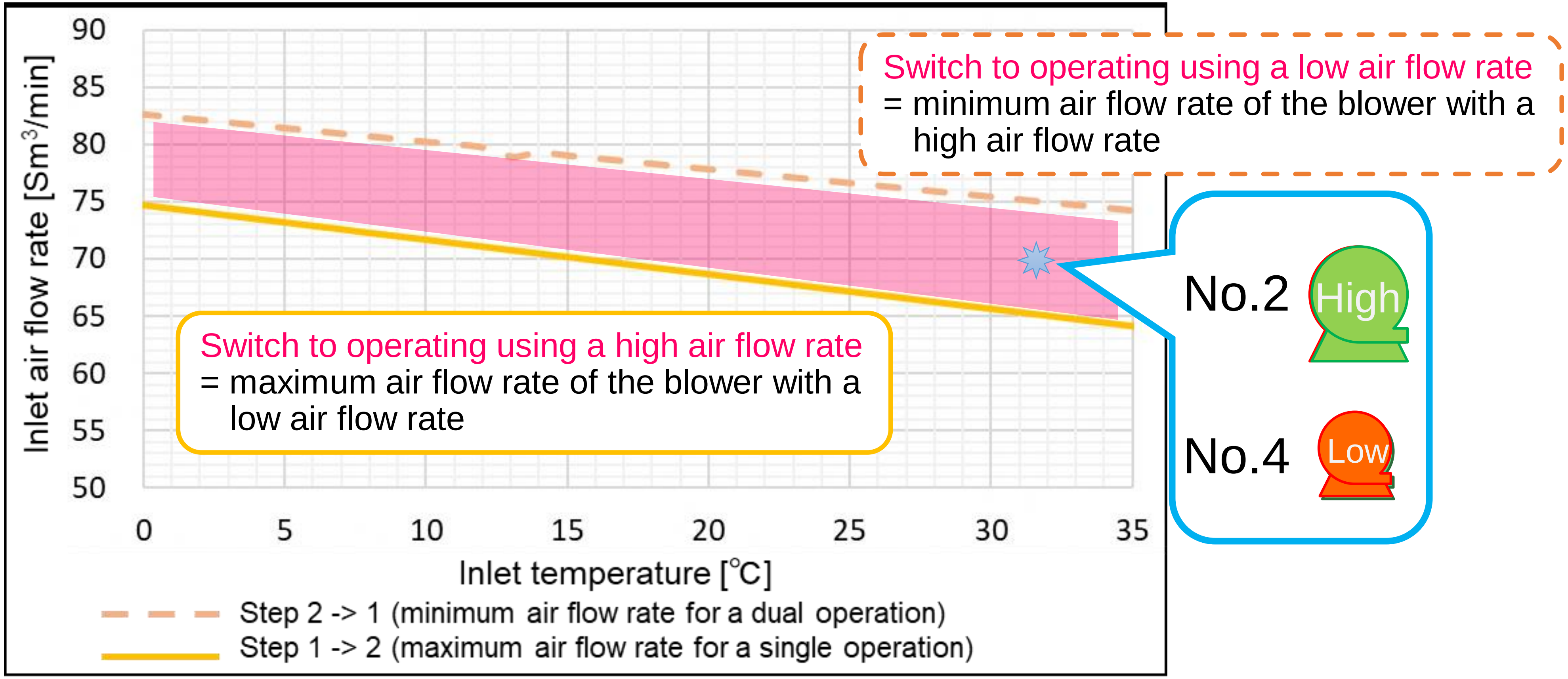
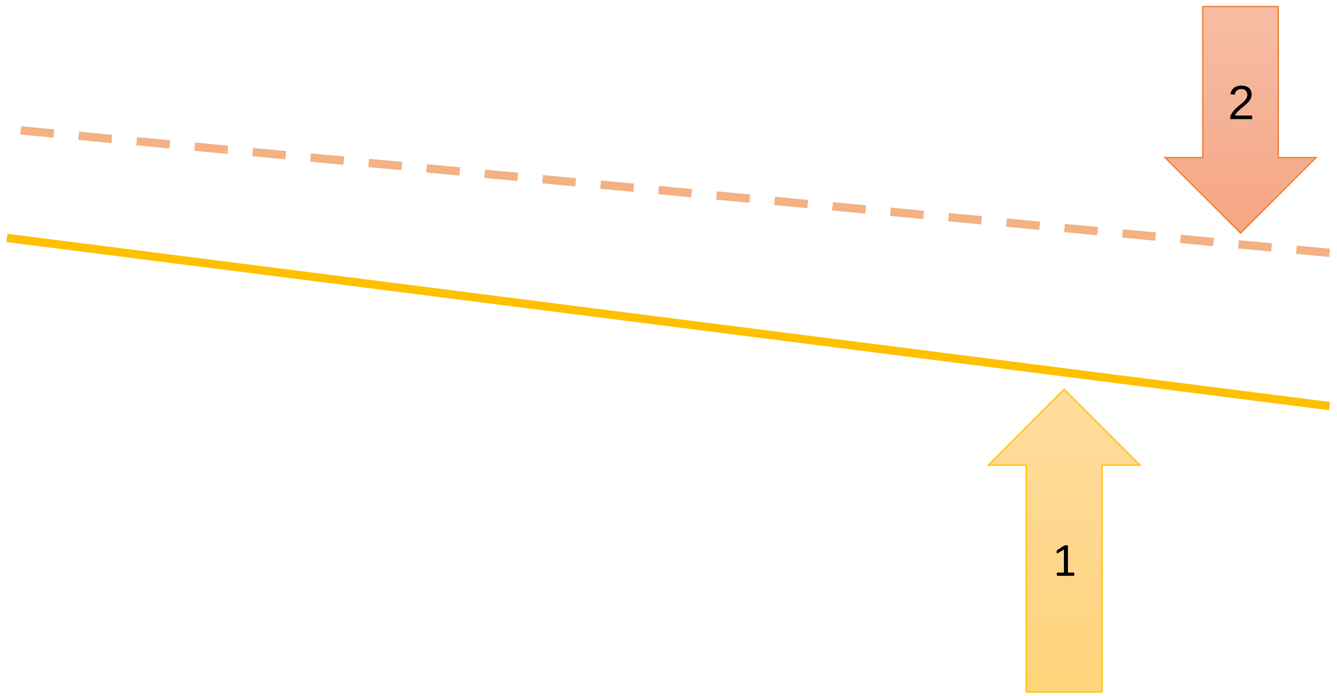
Issues with operating using a low air flow rate



The two blowers started and stopped alternately and repeatedly, and <u>a region where stable operation cannot be obtained</u> was found.

Issues with operating using a low air flow rate



We should have confirmed such overlap.

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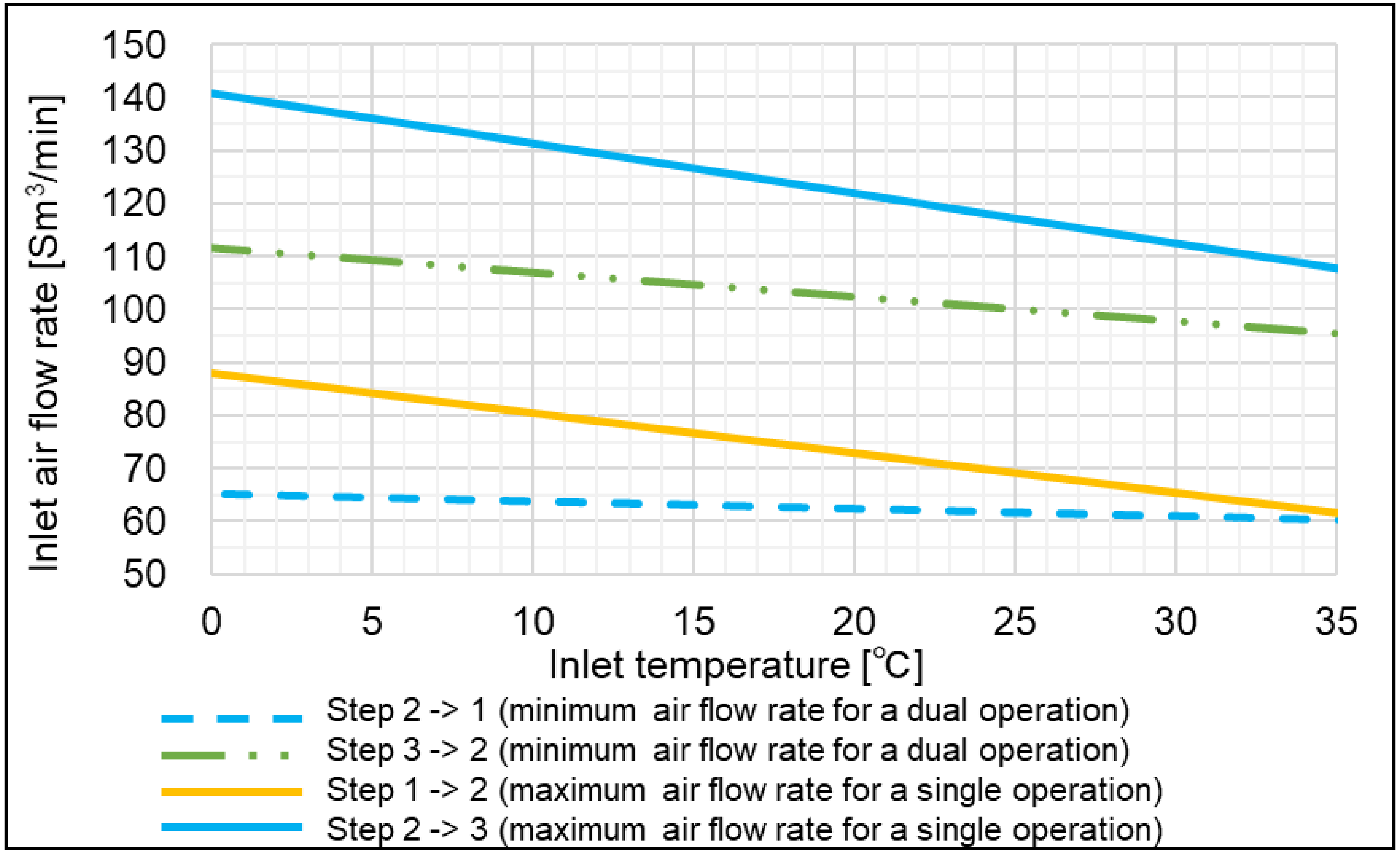
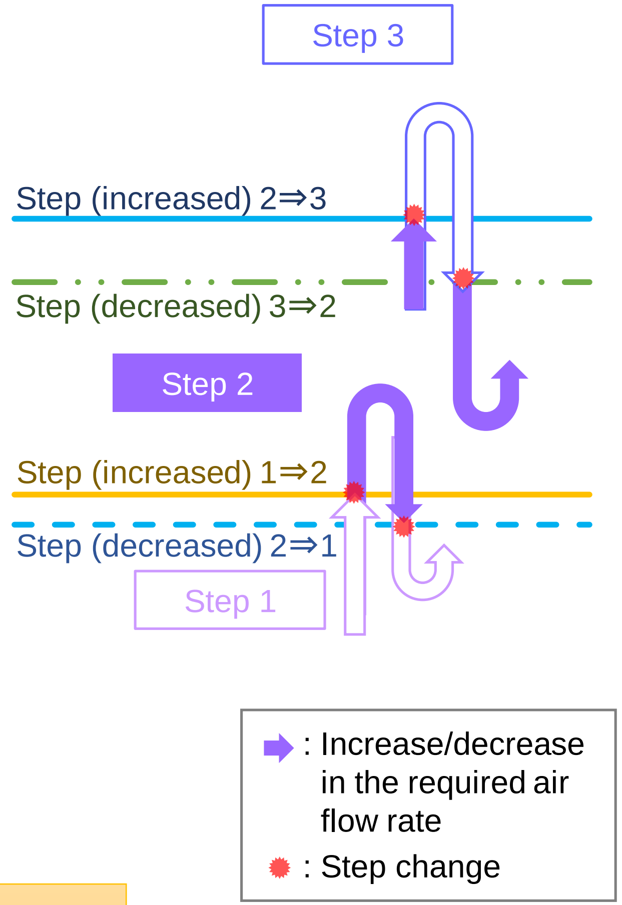
The practical use of operating using a low air flow rate





It was confirmed that the settings for step 1 to 2 and step 2 to 3 can work in the overall temperature range.

This operation is still ongoing without ceasing.

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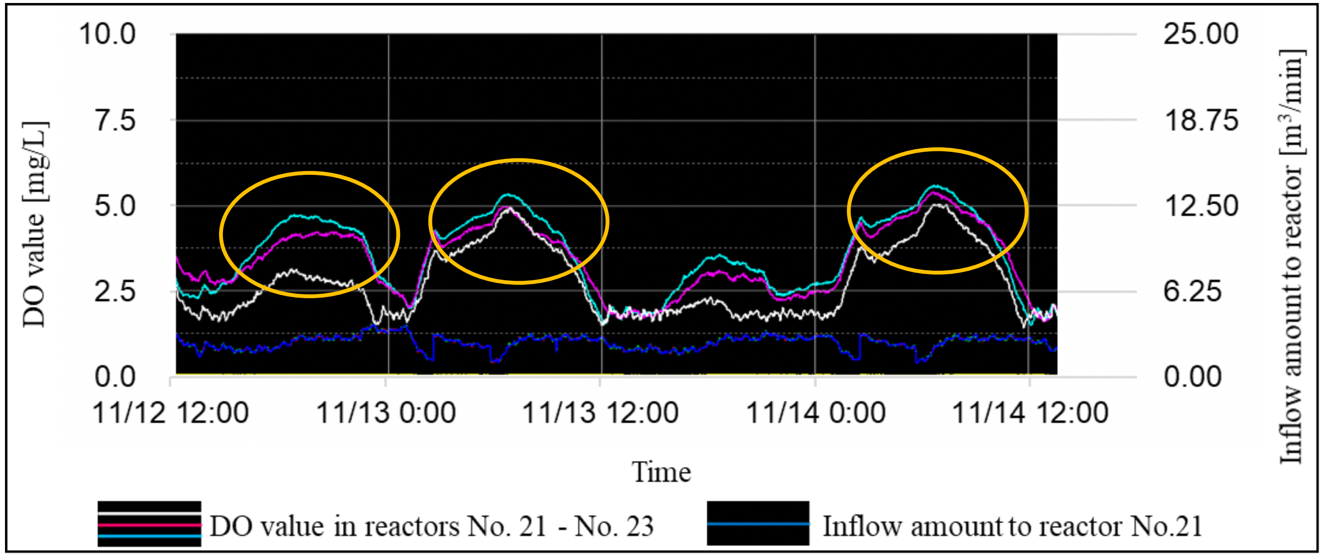
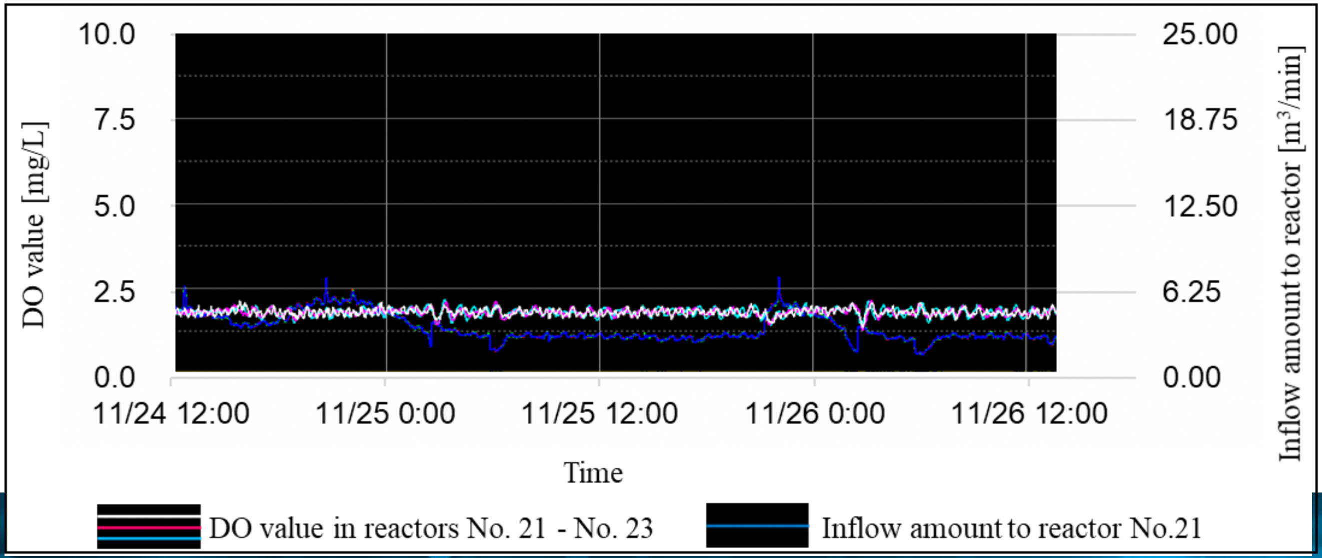
The practical use of operating using a low air flow rate
-Additional effect-



before

DO values during the time of overexposure.



after

We could improve.

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The possibility of using moist air density in the meteorological data-based corrective control

Moist air density: ρ [kg/m^3]

$$\rho = \frac{1.2923}{1 + 0.00366T} \times \frac{P - 0.378e}{1013.25}$$

Water vapor pressure: e [hPa]

$$e = e_S \times \frac{U}{100}$$

Saturation water vapor pressure: e_s [hPa]

$$e_s = 6.1078 \times 10^K$$

$$K = \frac{7.5T}{T + 237.3}$$

The moist air density is an indicator of a state of air. Incorporating atmospheric pressure (P, [hPa]) and humidity (U, [%]) to input values in the meteorological data-based corrective control, in addition to temperature (T, [°C]), may lead to further energy saving.

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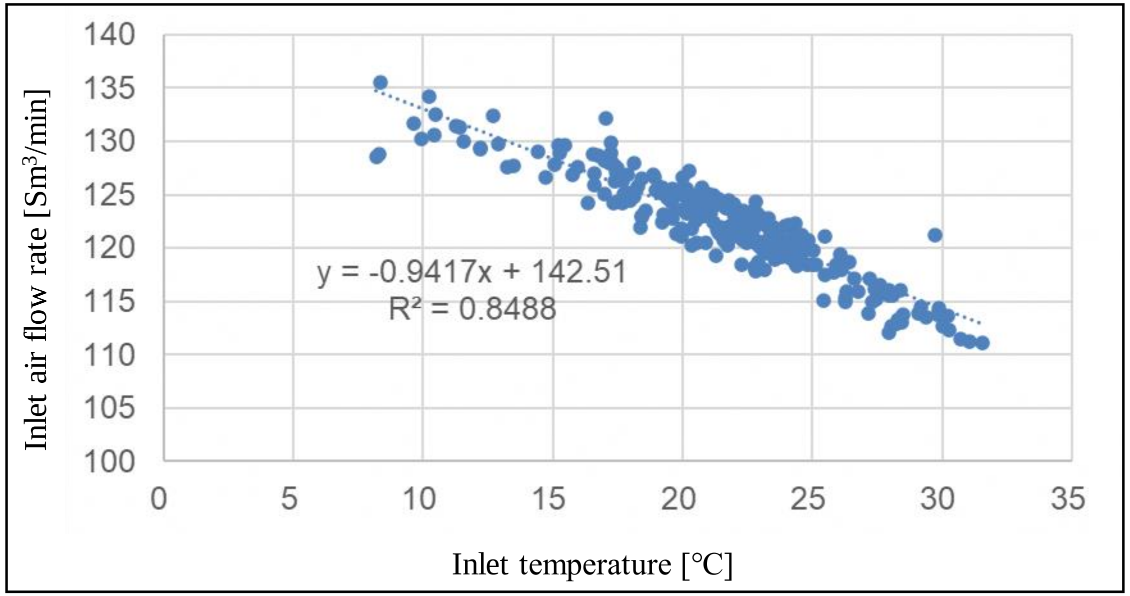
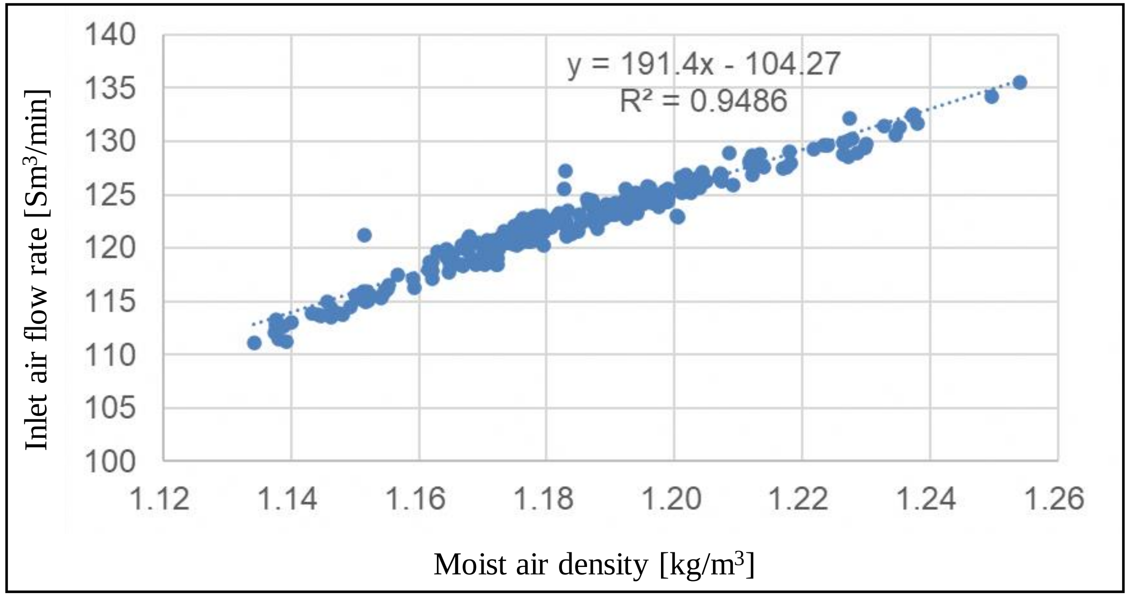
The possibility of using moist air density in the meteorological data-based corrective control





The relationship of the maximum inlet air flow rate with the moist air density (right) has less variation than that of the inlet temperature (left). This means using moist air density can accurately reflect changes in the blowers' operating performance better.

The software is planned to be improved in this fiscal year to incorporate moist air density in the control.

Conclusion

The New control (the meteorological data-based corrective control) is a methodology for energy saving that can prove effective only with software improvement.

- The software was improved to control the optimal number of units of blowers operating with the addition of atmospheric temperature to the input value.
- No improvements were made to the blowers (hardware).
- The treated wastewater’s quality has not been worsened.

The New control can be applicable other WWTPs.

The City of Yokohama is now considering introducing this control to its other WWTPs to contribute to reducing CO_2 emissions (greenhouse gas emissions) further.

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https://www.city.yokohama.lg.jp/lang/overseas/