Outline explanation of Enepro21 World Edition

U.S. Patent No. US 8,396,605 B2

Overseas version simulation software that contributes to the prevention of global warming.

E.I. Engineering Co., Ltd.

1. Overview of Enepro21WE

<u>Distributed power generation facility and centralized thermoelectric facility</u>

- New design
- Analysis of existing facility
- Energy saving analysis
- Equipment renewal

Software that can be examined efficiently with high accuracy

Energy simulation Software

Enepro21 WE

【Basic development philosophy】

① Enepro21WE can flexibly respond to high-efficiency system design that matches the energy load characteristics of the region.

② The annual operation of existing facility can be accurately reproduced, and this is used as the base case. Being able to make accurate energy-saving diagnoses and propose renewals.

③ It should be "general-purpose technology software" that is easy for anyone involved in energy to use.

④ Enrich Online-Help, publish formulas, and eliminate black boxes.

【Basic structure】

Thermoelectric Facility

Set requirements

Electric power, chilled water, hot water, Steam and Warm water load and the temperature difference of heat medium

Perform a simulation →

Output

Energy consumption , operating cost, Environmental load of CO_2, NOx, System COP, etc.

Setting main requirements

① Thermoelectric load, outside air temp., outside air wet bulb temp., chilled / hot water supply temperature and return temperature.
② Setting of equipment configuration of thermoelectric facility
③ Setting of equipment performance data, environmental load evaluation data, charge data, weather data
④ Setting the operation pattern (operation priority) of the equipment

Based on these settings, you can run the simulation accurately on any system built with a typical system flow.

2. Features of Enepro21WE

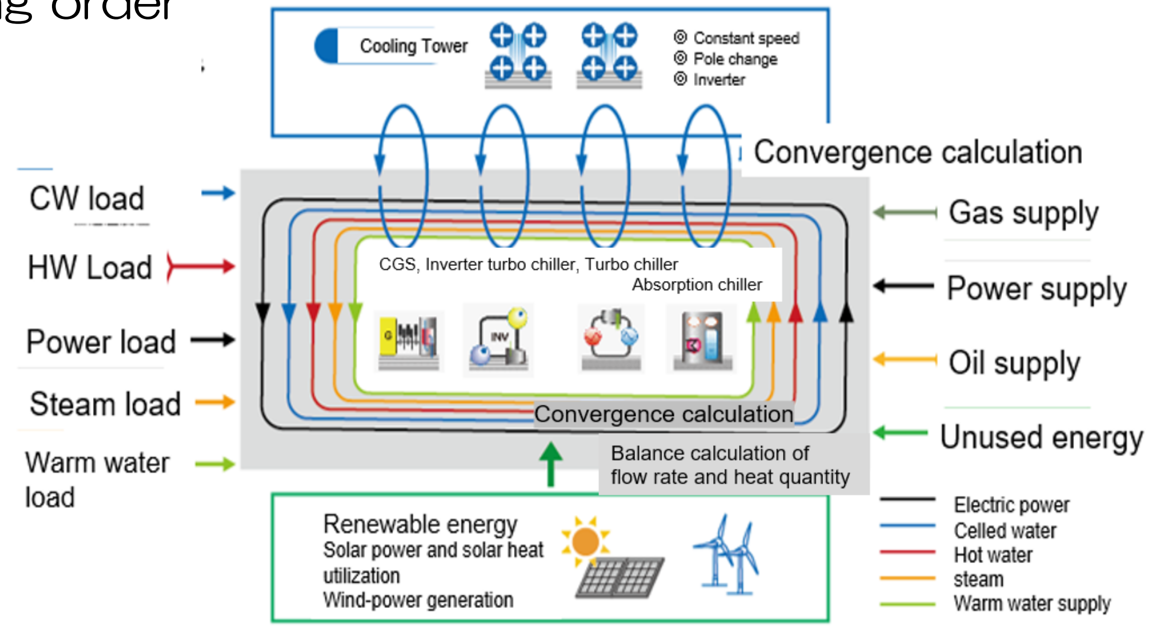
Features 1. Accurately reproduce existing facility

The annual operation record of existing facility can be reproduced with high accuracy, and the difference between the energy consumption by simulation and the energy consumption of actual facility can be within an error range of 1 to 2%. This can be achieved because the balance calculation of power, heat and flow rate can accurately reproduce the operating state.
In the balance calculation, each energy balance influences each other's equipment, so the balance point is found by the iterative calculation of each balance and the whole iterative calculation through all the balances at the same time.

Balance calculation is calculated in the following order

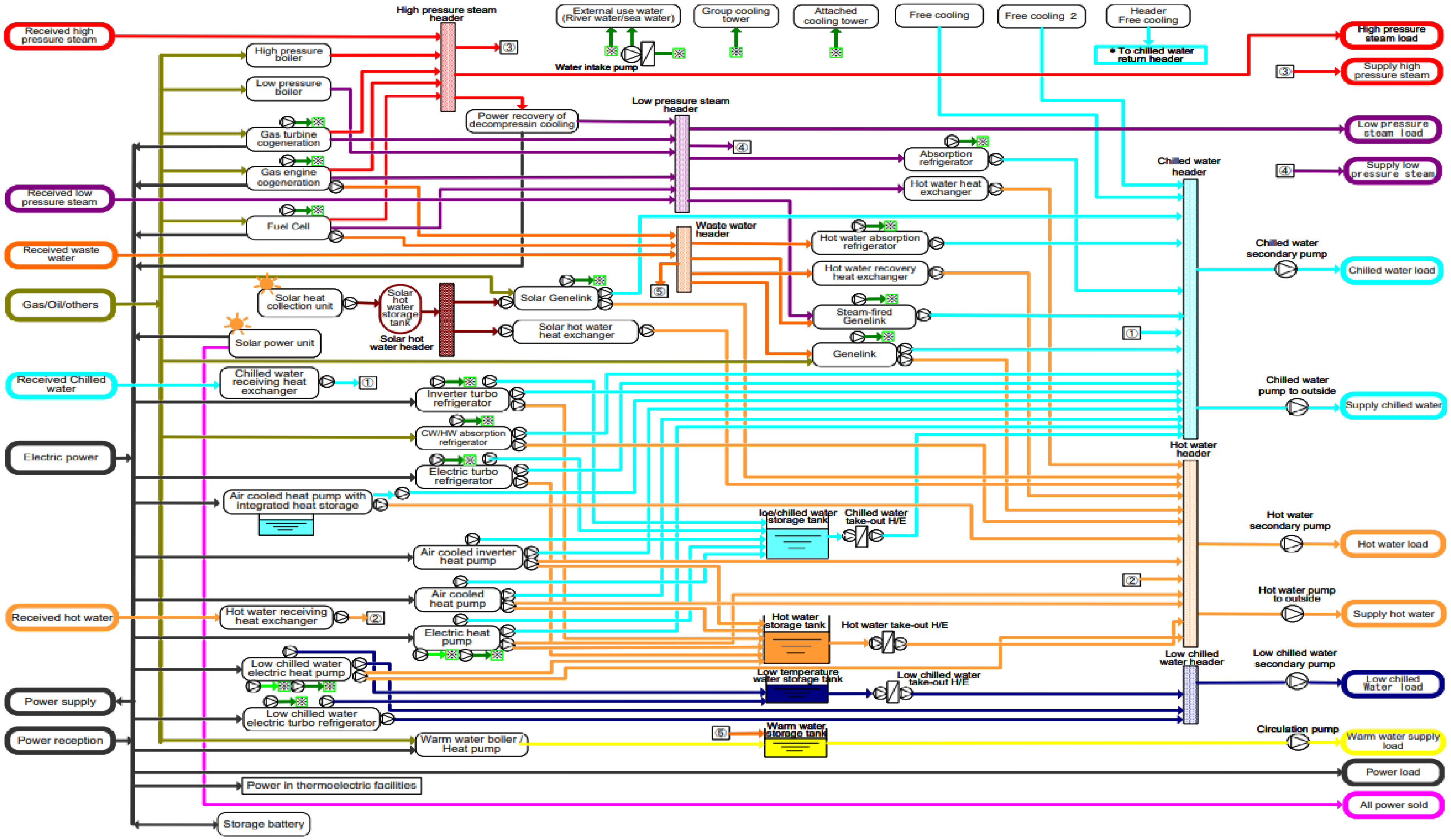
① Chilled water balance ② Hot water balance
③ Low chilled water balance ④ Low Pressure balance
⑤ High pressure steam balance ⑥ Warm water balance
⑦ Power balance ⑧ Exhaust heat balance

Regarding the balance of chilled water and hot water, not only the heat balance but also the balance of the "flow rate" of chilled water and hot water required for the secondary air conditioner on the building side is calculated to determine the number of chillers required and the load factor.



Features 2. Easily build the optimal thermoelectric system

By incorporating equipment into the general-purpose system flow, you can easily build an optimal system for thermoelectric loads.



In addition, the following items can be freely incorporated into the thermoelectric system to accurately calculate the energy balance.

① Incorporate primary pump system, secondary pump system, free cooling system

② Use seawater, river water, sewage, and groundwater as heat source water or cooling water

③ Accepts and balances electricity, chilled water, hot water, steam and hot water from other facilities

④ Calculation by incorporating photovoltaic power generation and solar heat utilization into thermoelectric facility

⑤ Flexible operating that combines GE cogeneration and GT cogeneration
- Power purchase control that does not cause reverse power flow
- Maximum power operation for the purpose of selling power
- Thermal main operation according to steam load

⑥ Arbitrarily set the priority of equipment that uses the exhaust hot water discharged from GE
You can freely set the heat utilization priority according to the load of Genelink, waste hot water recovery HE, and hot water supply unit.

⑦ Flexible operation of heat storage system
- Can handle heat storage and heat dissipation at the same time
- Heat storage operation during nighttime and daytime hours
- Set the operation of the heat storage unit to 6 patterns of time zones
- In principle, heat dissipation is the highest priority.
- You can also perform heat dissipation operation according to the setting of operation priority.

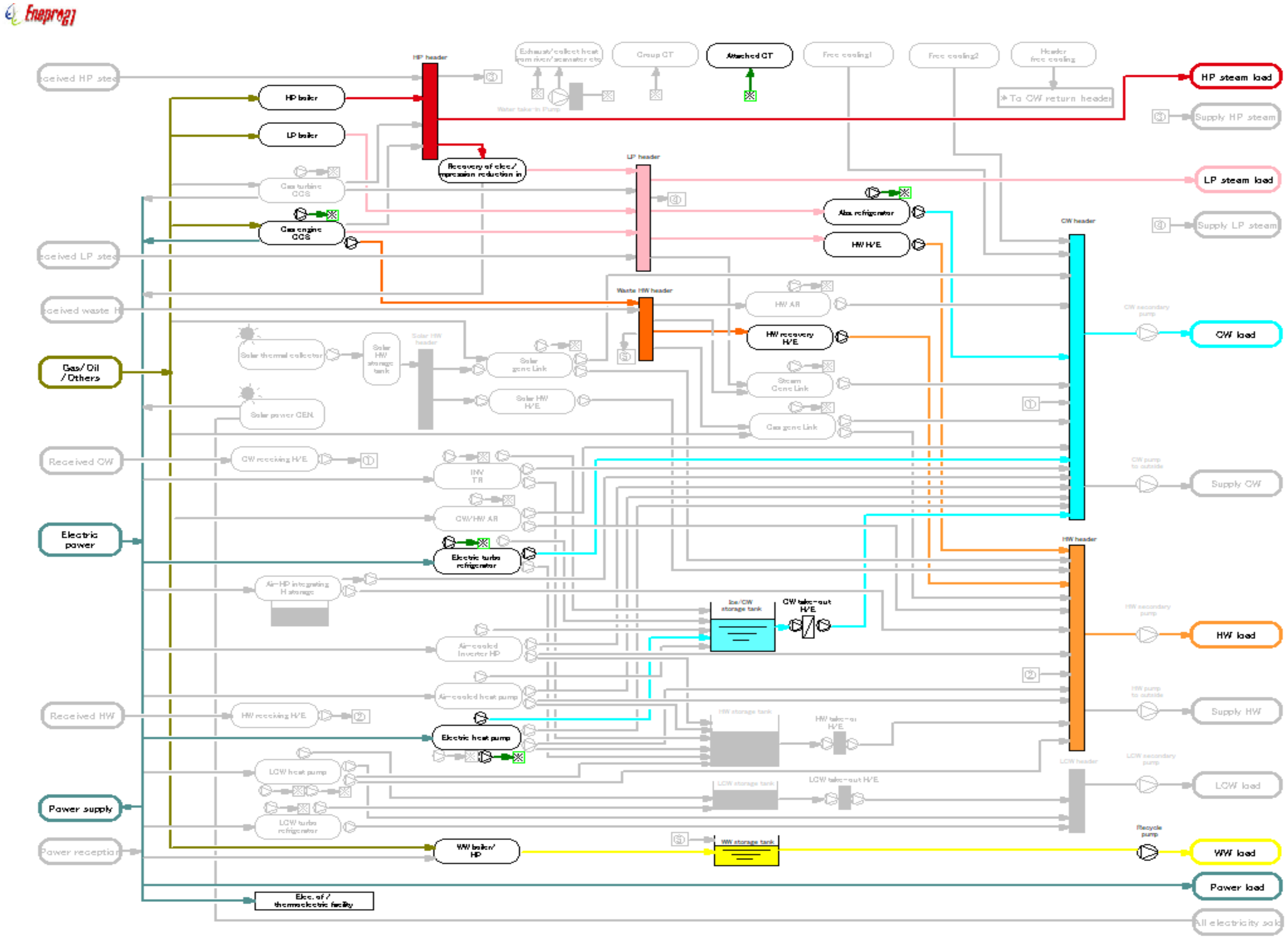
Features 3. Since the operating conditions can be set flexibly, the operation of existing facilities can be accurately reproduced.

① Set the operation priority of the equipment for each time zone according to the load pattern.
② The generated power can be set to the following supply destinations.
- Supply only to the power load of thermoelectric facility
- Supply only to the consumer's power load
- Supply both the consumer's power load in addition to thermoelectric facility

③ Automatic COP correction when the chilled water outlet temperature is changed for each refrigerator
④ Reflection of capacity decline and COP deterioration due to aging of chiller
⑤ Set the cooling water outlet temp. of the cooling tower monthly
⑥ Set monthly load factor for heat storage of heat storage inverter turbo chiller
⑦ Set the heat storage efficiency of the heat storage tank monthly
⑧ Cooling tower fan control settings: constant speed, pole conversion (4P⇔6P, 4P⇔8P), inverter control
⑨ Pump control method settings: constant flow rate control, constant pressure control, control valve control and inverter control
⑩ Combined operation of constant flow pump and inverter control pump

Features 4. General-purpose technology software that can be easily used by anyone involved in energy

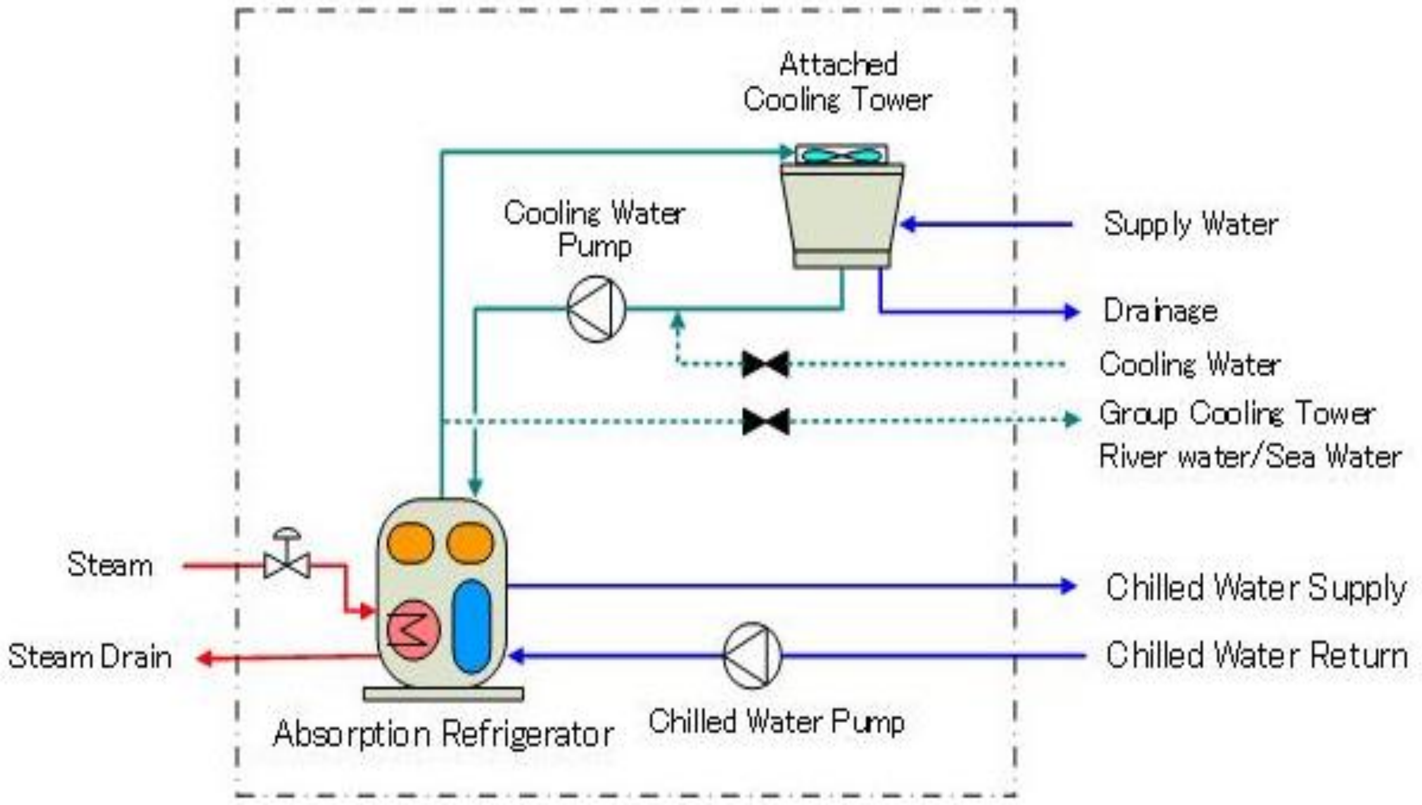
① System flow diagram enables visual system construction



② Automatic connection of device data related to the main equipment

The related equipment within the dotted line are automatically connected.

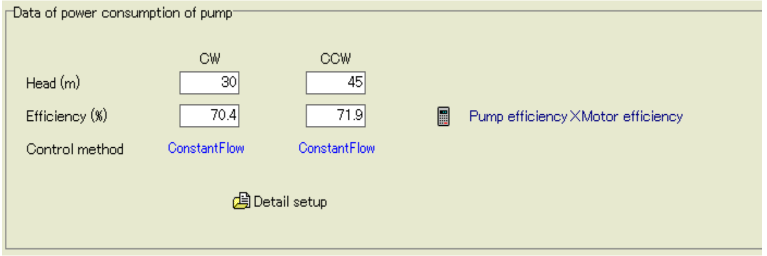
- chilled water pump, cooling water pump, and attached cooling tower



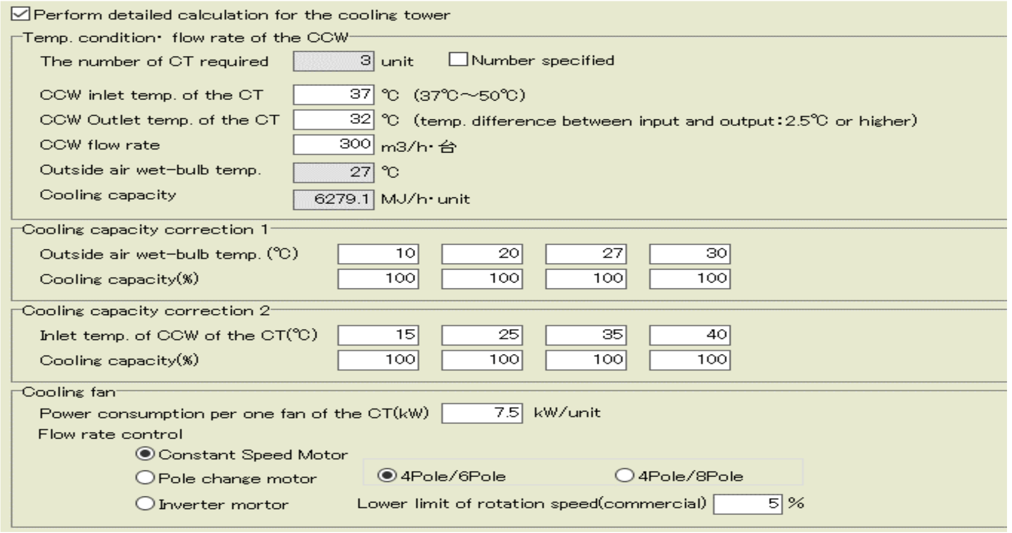
Automatic pump setting, automatic setting function of attached cooling tower → Further reduce user's trouble

- Automatic pump setting: Automatic calculation of pump capacity and data input assist function for pump efficiency based on JIS.

JIS＝Japanese Industrial Standards

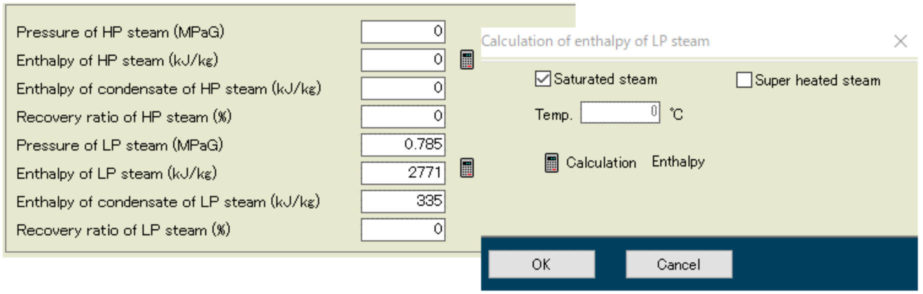


- Automatic settings for the included cooling tower: Can be set automatically based on equipment download data from the Enepro21 database.



③ Other auxiliary functions are also enriched

- Automatic input function of enthalpy from steam pressure



- Output the calculation result in Excel format → Create a report together with the output of the graph
- There are many other useful features. For details, see "Enepro 21 operation explanation video".

④ Enepro21 database

It is prepared so that the equipment performance data required for simulation can be easily set.

WEB — Enepro21 utilization data

A huge amount of performance data of more than 8,000 units has been collected from various equipment manufacturers.

⑤ Detailed online help function

Detailed online help is displayed for each window screen, and input methods and calculation methods are also disclosed.

Gas engine help screen: Display flow model and calculation formula

Content

4.3 Gas Engine cogenerator

4.3.1 Model System diagram

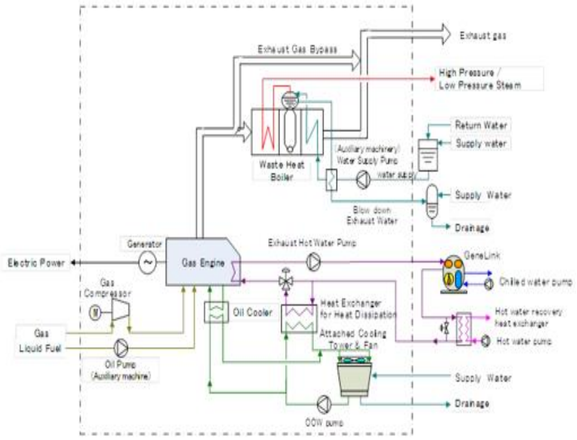


FIG. 4.3.1

4.3.6 Calculation expression

1) Fuel consumption

From Expression 4. 3. 2

$$\text{Fuel consumption [Nm3/h]} = \frac{\text{kW [kW]} \times 3.6 \text{ [MJ/kWh]}}{\text{Lower fuel heating value [MJ/Nm3]} \times \text{kW [\%]}} \times 100$$

Expressio

2) Actual vaporization amount of waste heat boiler

Combining Expression 4.3.2, Expression 4.3.3, and Expression 4.3.6, the rated actual vaporization amount of the waste heat boiler can be obtained as follows:

$$\text{Actual vaporization amount [kg/h]} = \frac{\text{kW [kW]} \times 3600 \text{ [kJ/kWh]}}{\Delta H_S \text{ [kJ/kg]} + \Delta H_B \text{ [kJ/kg]} \times \text{Blow rate [\%]}/100} \times \frac{\text{Steam heat recovery rate [\%]}}{\text{kW [\%]}}$$

Expression

where

$$\Delta H_S \text{ [kJ/kg]} = \text{Steam enthalpy [kJ/kg]} - \text{water supply enthalpy [kJ/kg]}$$

$$\Delta H_B \text{ [kJ/kg]} = \text{Blowdown water enthalpy [kJ/kg]} - \text{water supply enthalpy [kJ/kg]}$$

At a certain electricity generation output (kW), the power generation efficiency and the waste hot water heat recovery ratio can be determined from the load factor and the performance data.

3) First, the fuel consumption (Nm3/h) is determined by Expression 4.3.9, and the amount of heat recovery from waste hot water is calculated by the following expression.

Amount of heat recovery from waste hot water First, the fuel consumption (Nm3/h) is determined by Expression 4.3.9, and the amount of heat recovery from waste hot water is calculated by the following expression.

First, the fuel consumption (Nm3
/h) is determined by Expression 4.3.9, and the amount of heat recovery from waste hot water is calculated by the following expression. [MJ/h]

$$= \text{Lower fuel heating value [MJ/Nm3]} \times \text{Fuel consumption [Nm3/h]} \times \frac{\text{Waste HW heat recovery ratio [\%]}}{100}$$

3. Introducing the Enepro21 database

Enepro21 utilization data collection
Equipment performance data

Energy Integration Engineering
Energy Simulation Software
Enepro21 WE Equipment utilization data collection
Logout

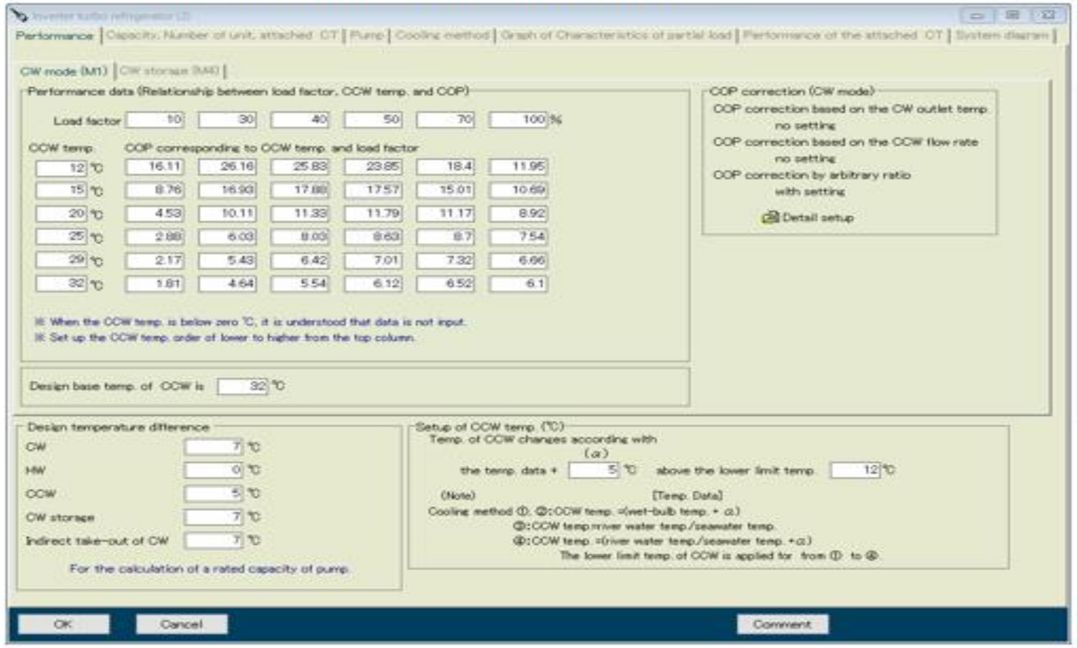
Breakthrough system

When you download the necessary data from "Enepro21 Utilization Data Collection" and import it into Enepro21WE, various equipment data are automatically set.

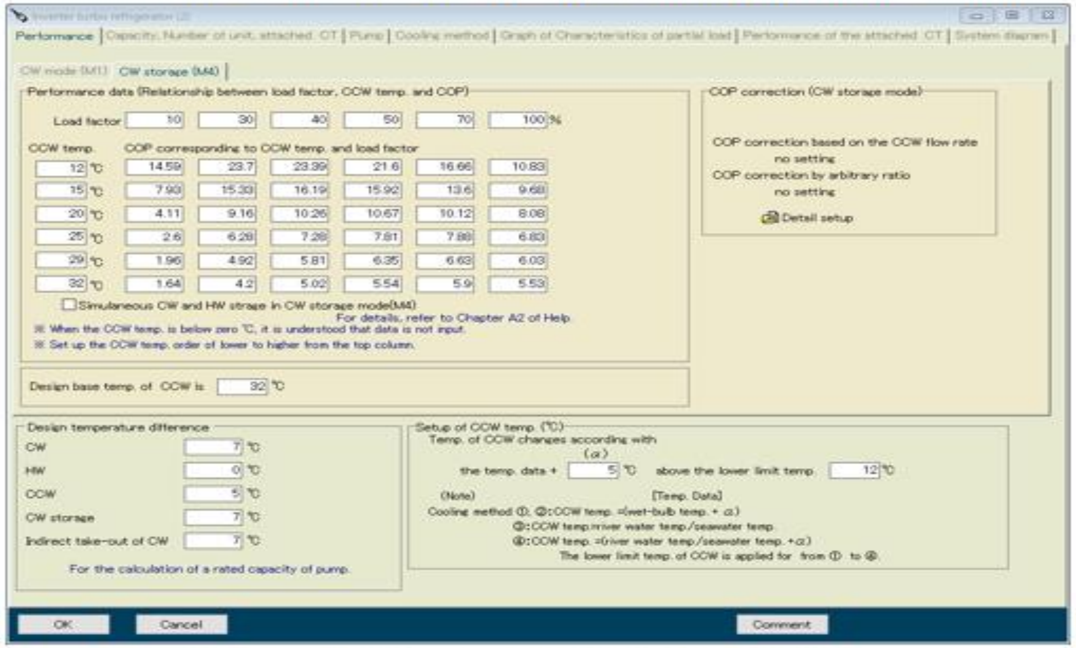
When adopting Japanese equipment, it can be used as it is.
When using U.S. equipment, you can download similar equipment, build a system, and use it for prior consideration of what kind of system is good before obtaining accurate equipment performance data from the manufacturer. Once the user obtains the performance data from the equipment manufacturer, the performance data can be overwritten and corrected for simulation to obtain accurate simulation results.
In addition, since the required performance data is overwritten, input errors are eliminated.
<u>It radically solves the difficulty for users to obtain data and the time involved in entering data.</u>

【Equipment performance screen of inverter turbo chiller data imported to Enepro21WE】

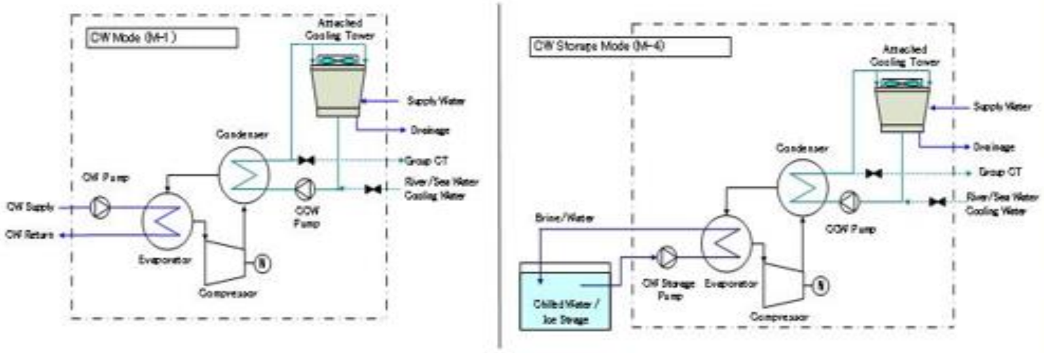
Chilled water supply temperature 7 °C



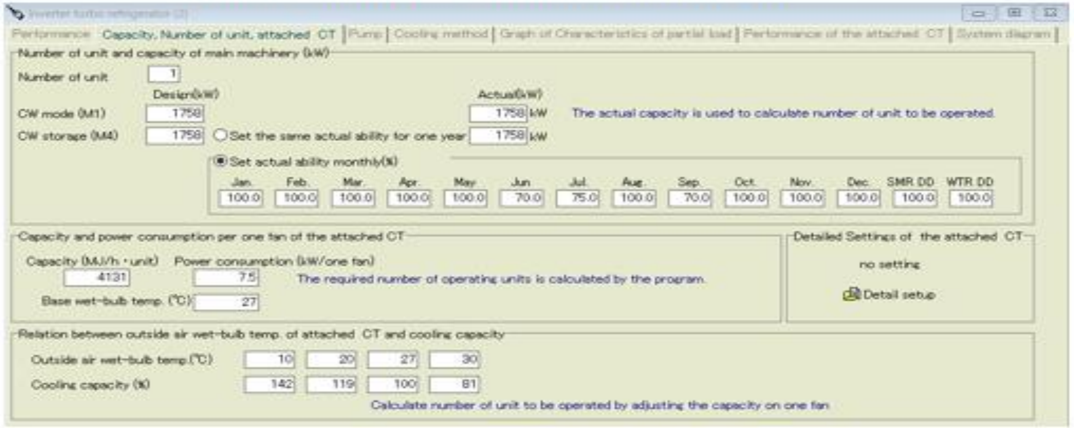
Chilled water 5 °C heat storage mode performance data



Download data flow chart



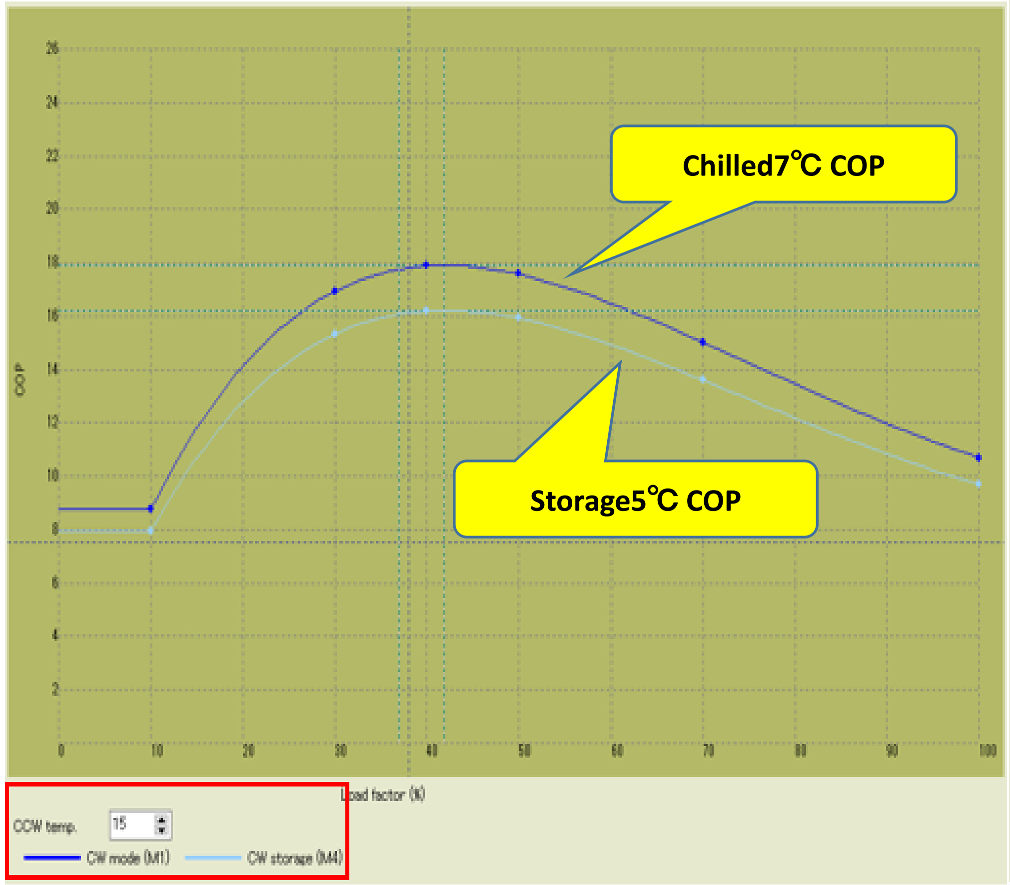
Capacity / number / attached cooling tower



#【Inverter turbo chiller load factor and COP graph】

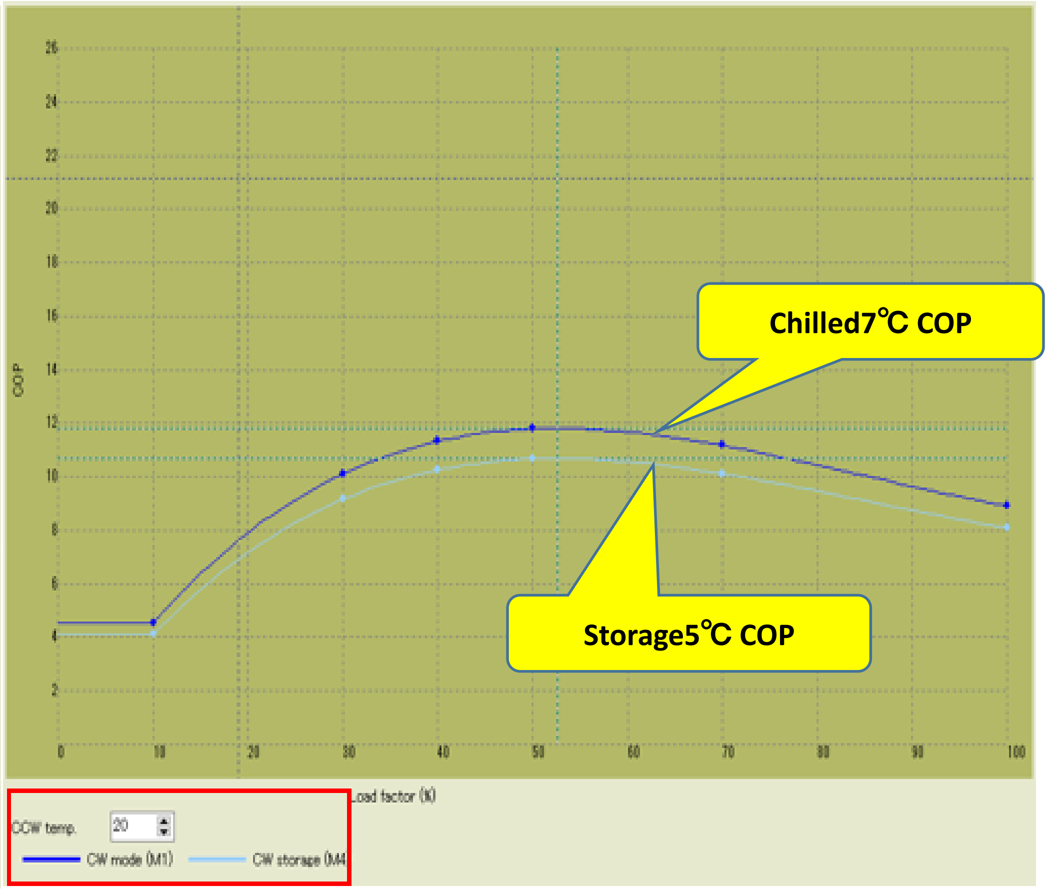
Partial load COP characteristics of chilled water 7 ℃ supply mode and chilled water 5 ℃ heat storage mode

Cooling water temperature 15 ℃



Cooling water set to 15℃
(Chilled water 7 ℃ mode, heat storage 5 ℃ mode)

Cooling water temperature 20 ℃



Cooling water set to 20 ℃
(Chilled water 7 ℃ mode, heat storage 5 ℃ mode)

①COP characteristics of inverter turbo chiller

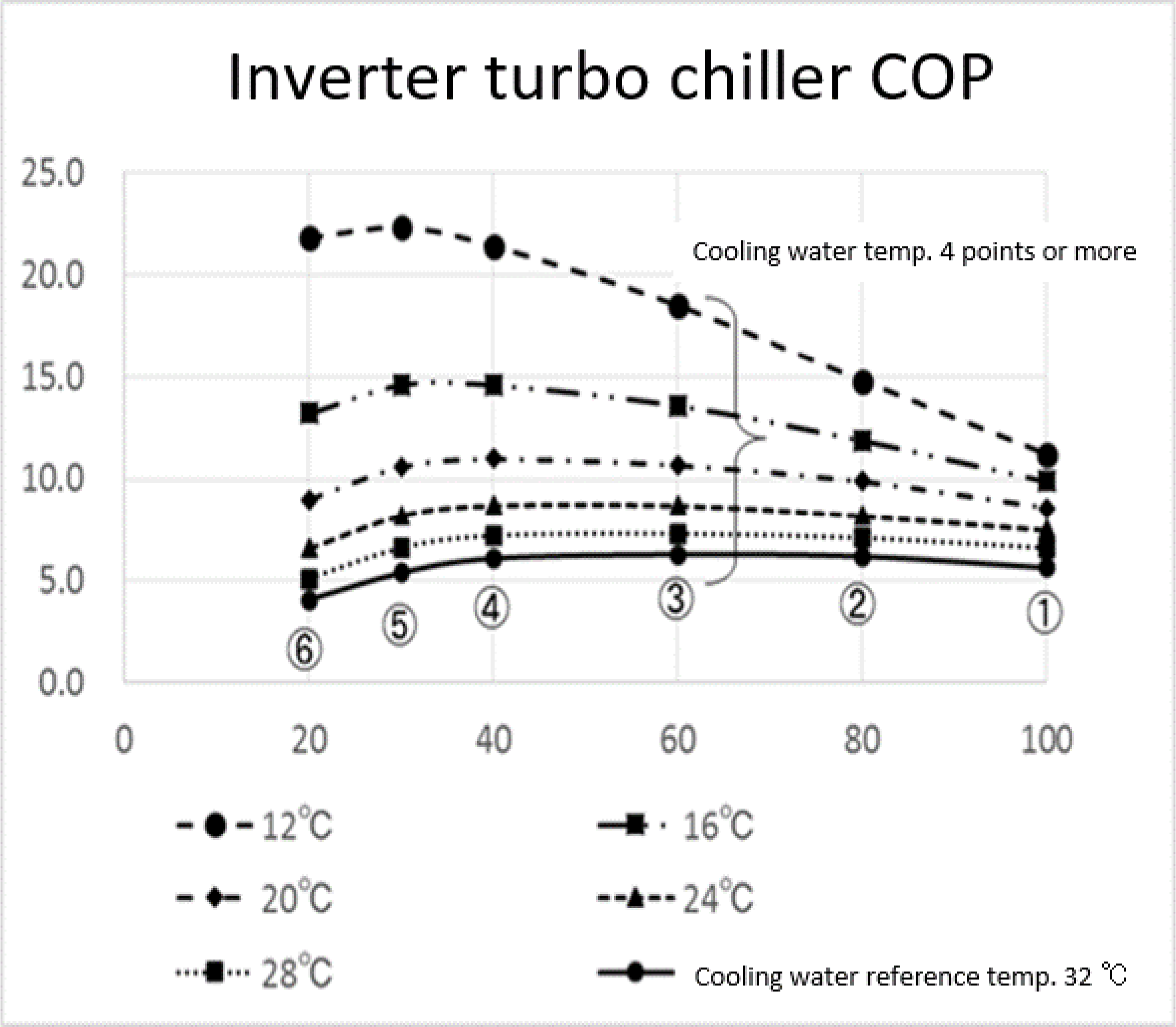
- Load factor vs. cooling water temp. of 4 points or more
  Set 6 sets of COP data (① ～ ⑥) and set COP characteristics

- Cooling water temperature is constant for each load factor

- As a general rule, the minimum load factor ⑥ is the lower limit load factor for operation. Normally 20%

- The minimum cooling water temp. is the lower limit temp. for cooling water operation.

- In the case of an inverter turbo, the shape of the COP changes greatly depending on the temperature of the cooling water.
  Each load factor vs. COP is regressed with a fourth-order polynomial for each of the six load factors.



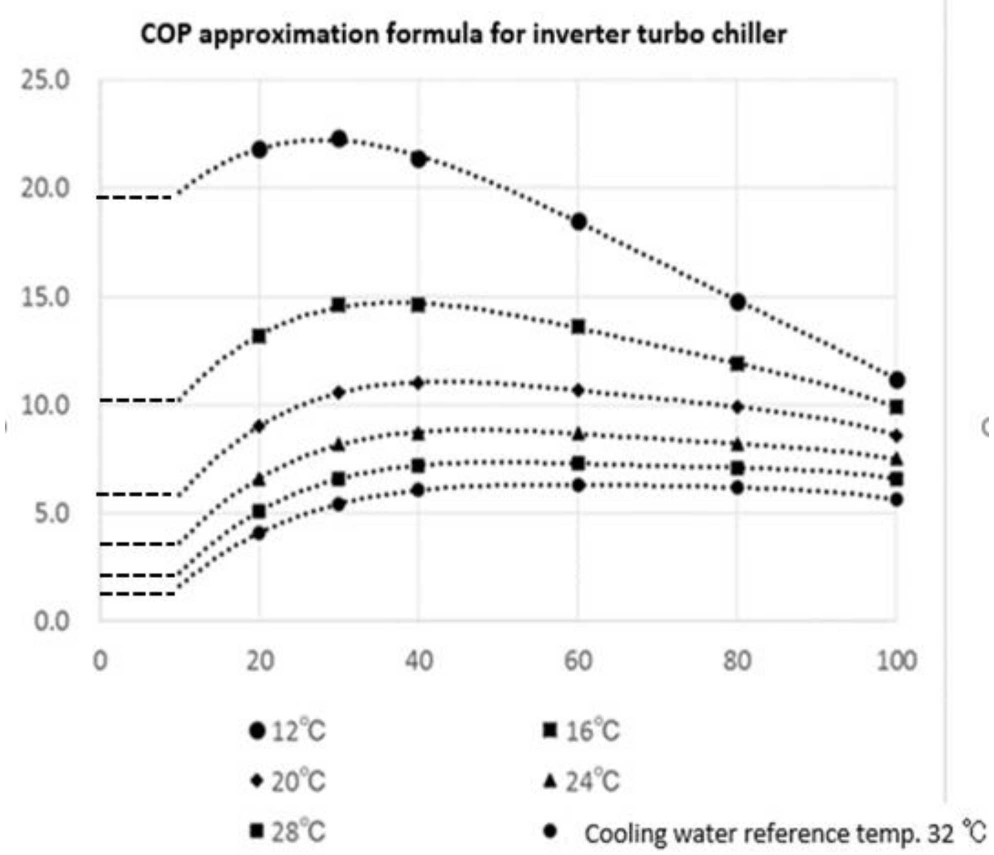
【Creating a COP graph for an inverter turbo chiller】

The minimum operating load factor of a chiller is usually 20%. When the load factor is 20% or less, it enters the ON-OFF operation range in actual operation.

On the other hand, in power consumption calculation, it is necessary to calculate even with a load factor of 20% or less, so the ON-OFF operation state is simulated by continuous operation.

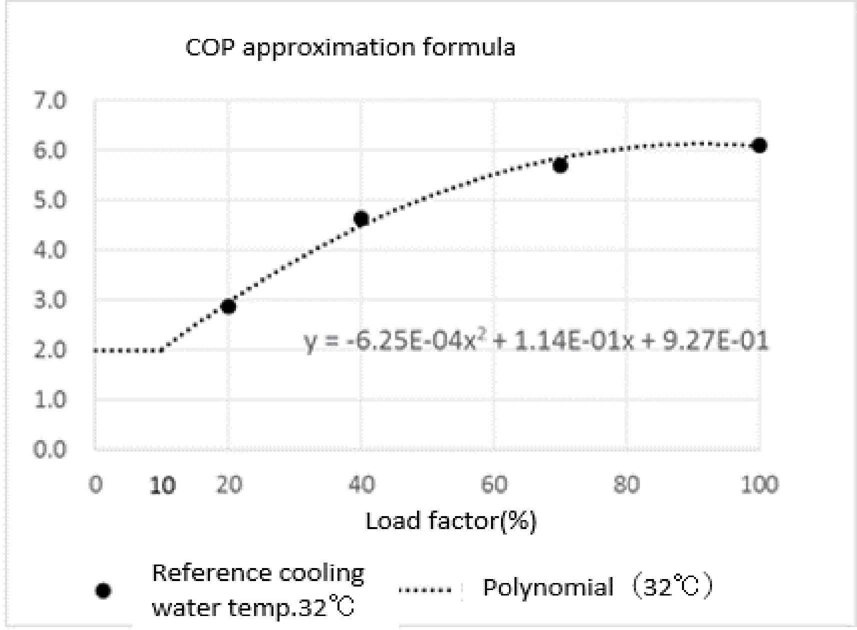
If the COP is extrapolated to a load factor of 10% or less, the COP becomes very small and the power consumption calculation may include a large error. Therefore, the COP is assumed to be constant when the load factor is 10% or less.

In the power consumption calculation, select two regression equations that sandwich the temperature of the refrigerator cooling water at the time of calculation. The COP of the cooling water temperature is calculated by interpolation from the two COP values at the load factor during that period.

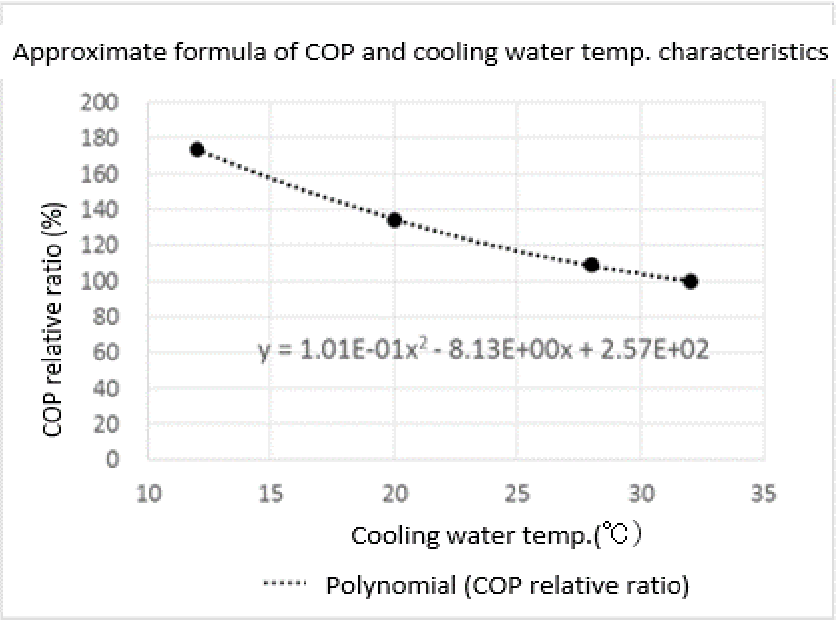


【Inverter turbo chiller COP graph】

②COP characteristics of turbo chillers, absorption chillers, etc.



COP at reference temperature

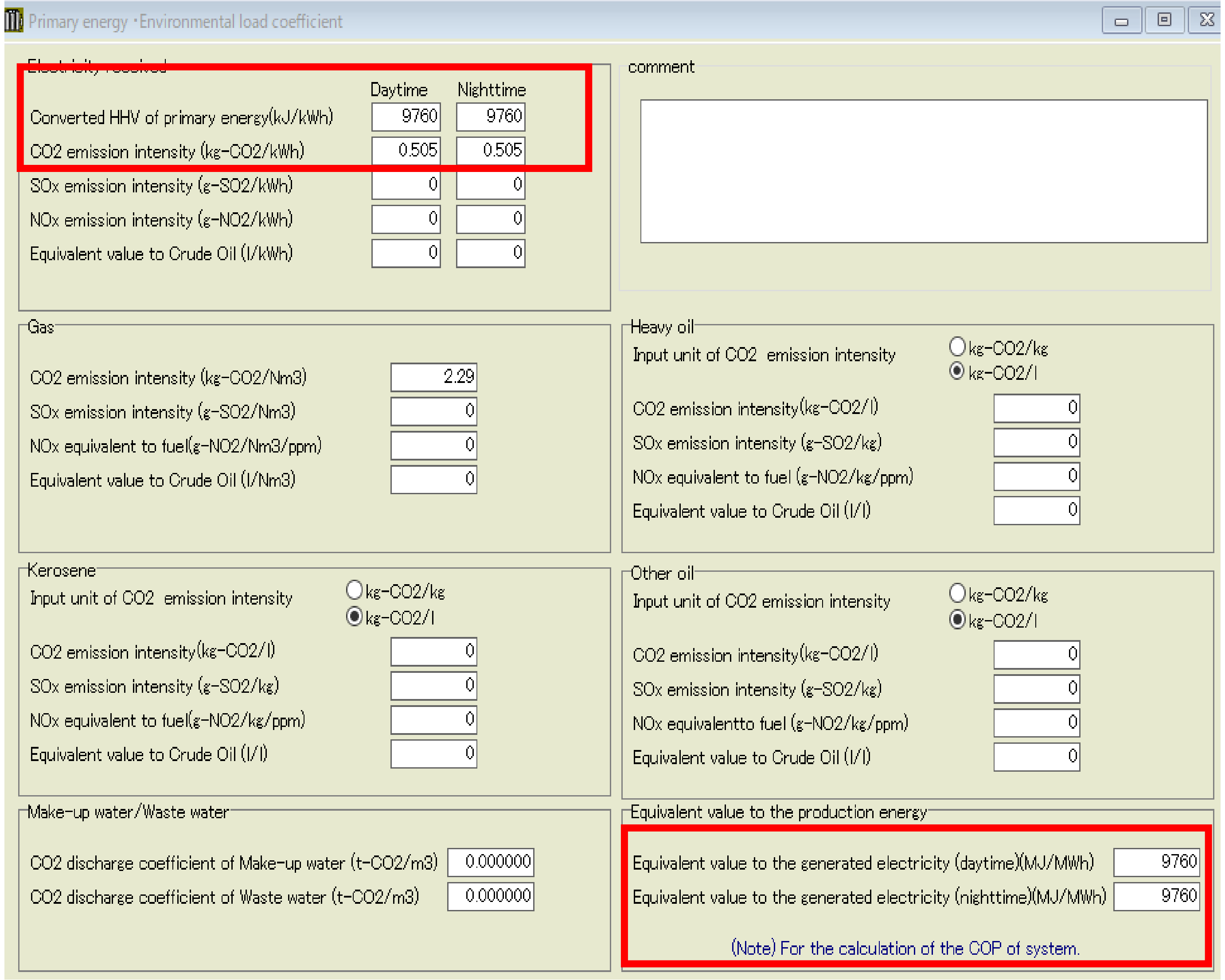


COP and cooling water

- Since the minimum operating load factor of a chiller is usually 20%, an ON-OFF operation is entered in actual operation at a load factor of 20% or less.　On the other hand, when calculating power and gas consumption, it is necessary to calculate even with a load factor of 20% or less. The ON-OFF operation state is simulated by continuous operation, and the COP at that time is extrapolated to 20% or less of the regression equation.
- However, extrapolating the COP to a load factor of 10% or less results in a very small COP and a large error in calculating power and gas consumption.　A COP is considered constant if the load factor is 10% or less, as it may contain errors.

- The COP-cooling water temperature characteristic approximation method is created based on four points using a regression equation of a quadratic polynomial.
- From these two formulas, the operating COP of the unit is determined from the cooling water temp. and the load factor of the unit.

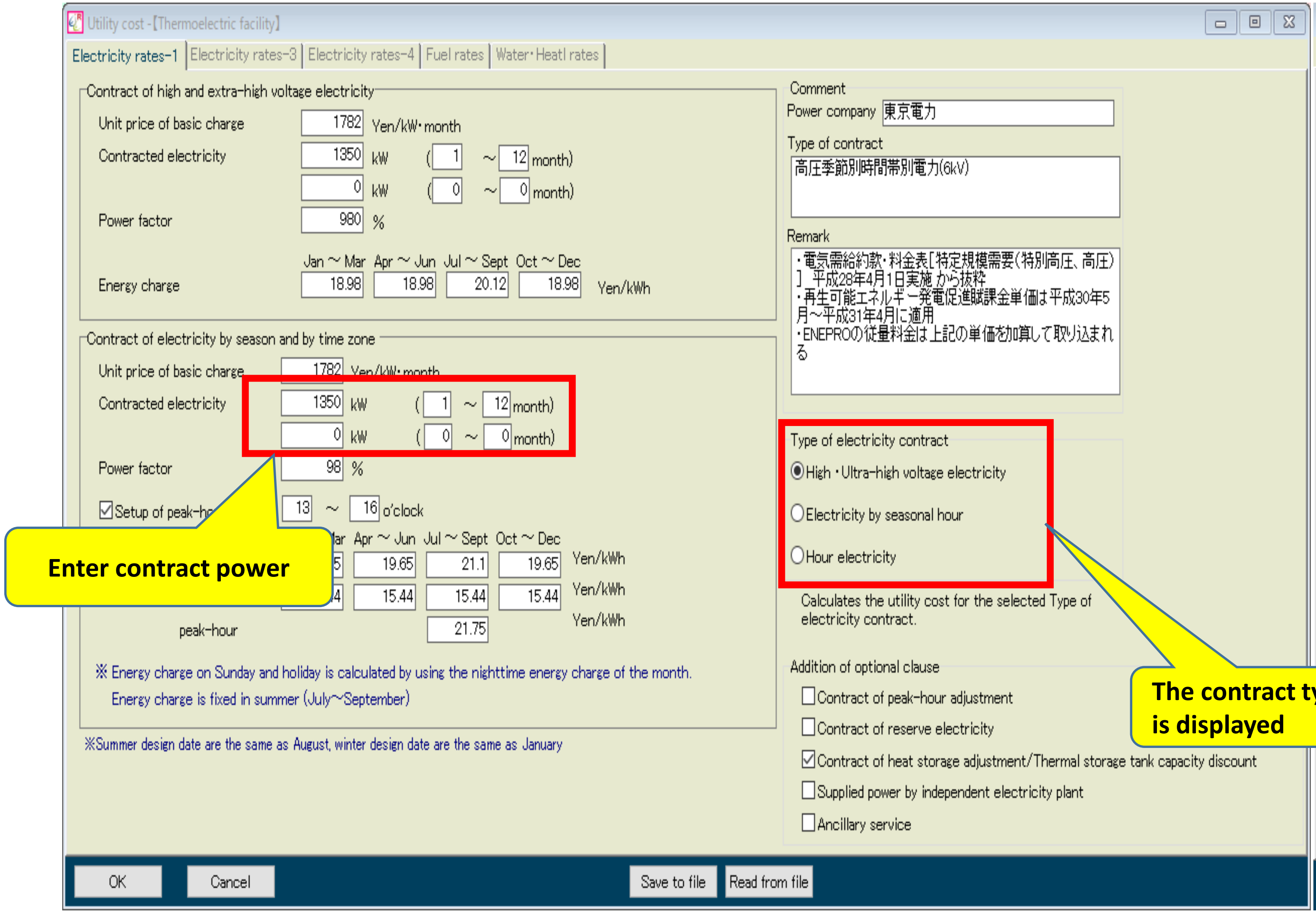
【Environmental load data loaded into Enepro21】

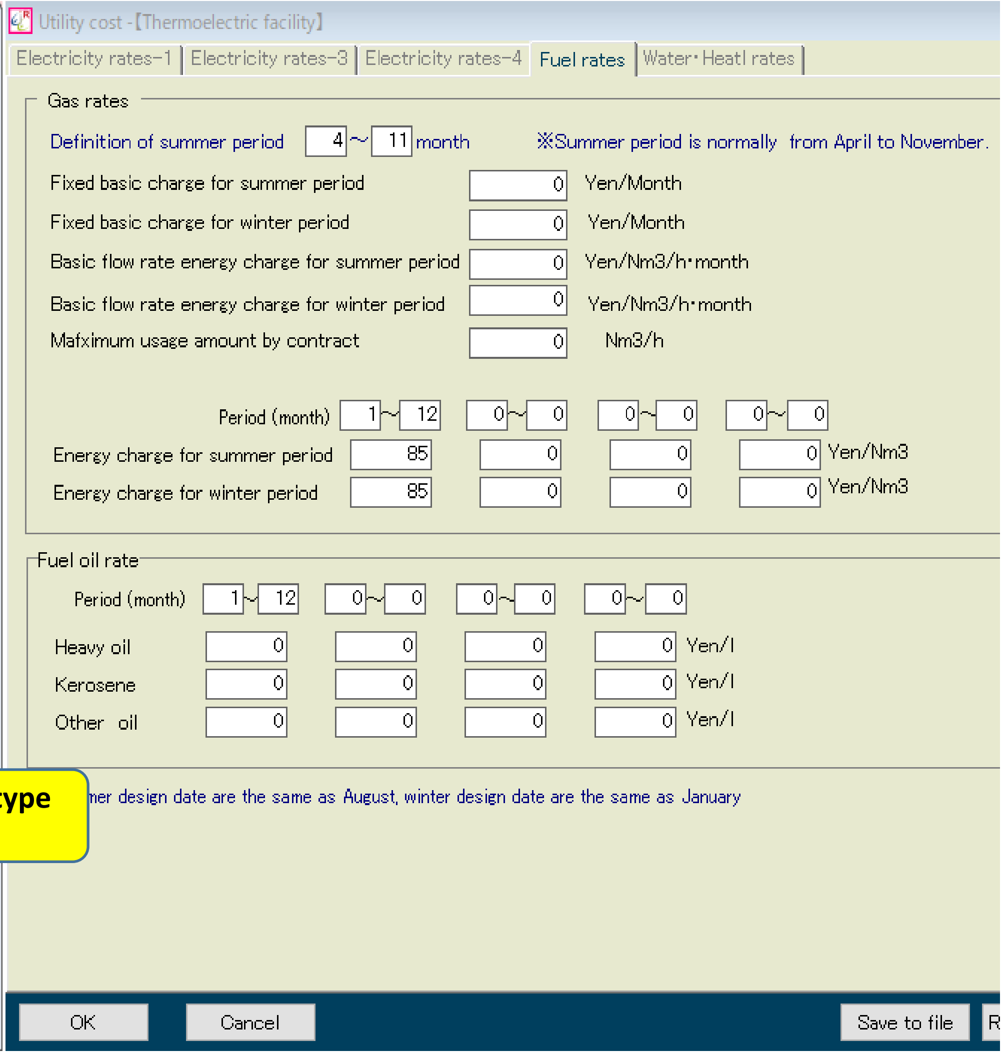


③Electricity charge data　④Gus charge data

【Electricity / gas charge form on Enepro21WE】

Note) Japanese rate form





【Outside air temperature / outside air wet-bulb temperature data read into Enepro21WE】

Temperature data

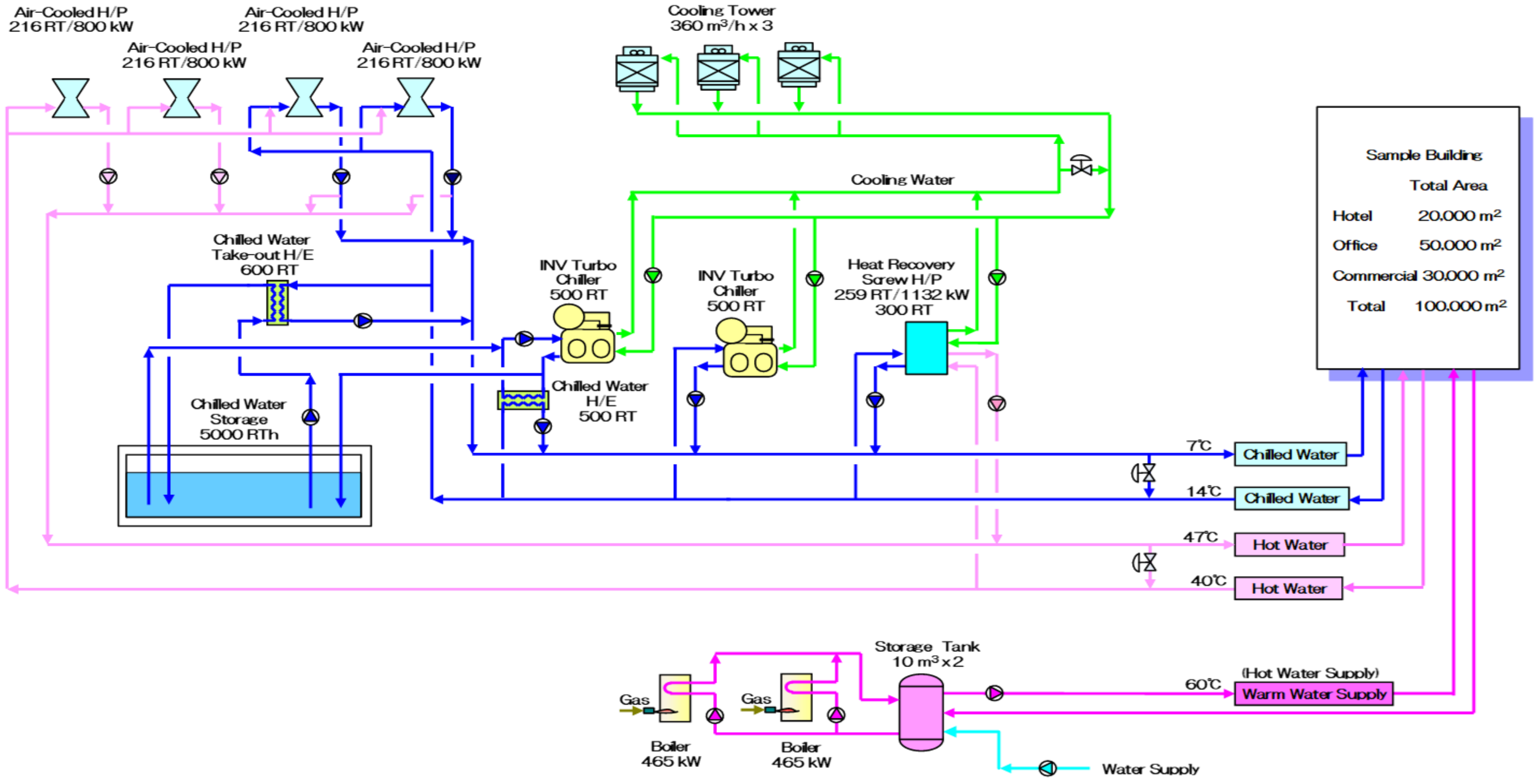
Hour	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	SMR DD	WTR DD
Average	5.8	6.1	9.7	14.3	19.4	22.8	27.1	28.6	25.0	19.4	13.8	7.9	29.5	2.9
0-1	4.1	4.8	7.9	12.1	17.2	20.8	25.2	26.7	23.3	18.0	12.3	6.3	27.1	1.3
1-2	3.7	4.3	7.3	11.6	16.9	20.5	25.0	26.5	23.0	17.6	11.9	6.0	27.0	1.5
2-3	3.3	3.7	6.8	11.2	16.6	20.3	24.8	26.2	22.7	17.3	11.5	5.6	26.8	1.2
3-4	3.0	3.4	6.4	10.9	16.3	20.2	24.6	26.1	22.5	17.1	11.2	5.4	26.5	1.4
4-5	2.8	3.1	6.2	10.7	16.1	20.1	24.4	25.9	22.3	16.8	11.0	5.2	26.3	1.5
5-6	2.6	2.9	6.0	10.6	16.5	20.4	24.7	26.1	22.2	16.6	10.9	5.0	26.5	1.3
6-7	2.8	2.9	6.5	11.5	17.5	21.1	25.5	26.8	22.9	17.0	11.0	4.9	27.3	1.6
7-8	3.2	3.5	7.5	12.7	18.7	22.0	26.5	27.8	23.9	17.8	11.7	5.6	28.2	1.9
8-9	4.2	4.6	8.8	14.1	19.9	23.0	27.5	28.9	25.1	18.8	12.7	6.9	29.3	2.5
9-10	5.4	5.5	10.1	15.4	21.0	23.9	28.7	30.0	26.0	20.0	13.8	8.2	30.1	2.9
10-11	7.0	7.0	11.4	16.5	21.9	24.7	29.4	30.8	26.8	21.0	15.3	9.6	31.5	4.5
11-12	8.3	8.0	12.3	17.4	22.5	25.3	30.0	31.4	27.7	21.8	16.3	10.8	32.5	5.1
12-13	9.1	9.0	13.2	18.0	23.0	25.7	30.3	31.8	28.2	22.3	16.9	11.4	32.8	5.9
13-14	9.5	9.5	13.2	18.1	23.0	25.8	30.3	31.8	28.0	22.3	17.1	11.6	33.0	6.3
14-15	9.3	9.4	13.2	17.8	22.5	25.6	29.9	31.4	27.8	22.1	16.9	11.2	33.1	5.8
15-16	9.0	9.4	13.0	17.5	22.0	25.2	29.5	30.9	27.5	21.9	16.5	10.7	32.6	5.1
16-17	8.4	8.9	12.4	16.9	21.5	24.8	28.9	30.4	26.8	21.3	15.8	9.9	32.1	4.2
17-18	7.8	8.2	11.7	16.1	20.7	24.2	28.2	29.7	26.0	20.6	15.3	9.3	31.1	3.4
18-19	7.1	7.5	11.1	15.3	19.9	23.4	27.4	28.9	25.4	20.0	14.8	8.9	29.9	2.7
19-20	6.6	7.0	10.6	14.7	19.4	22.8	26.8	28.4	24.9	19.5	14.4	8.5	29.1	2.2
20-21	5.9	6.5	10.0	14.2	18.9	22.3	26.4	28.0	24.5	19.1	13.9	7.9	28.8	2.0
21-22	5.4	6.1	9.5	13.7	18.5	22.0	26.1	27.7	24.2	18.8	13.4	7.5	28.7	1.5
22-23	5.0	5.7	9.0	13.3	18.1	21.6	25.9	27.3	23.8	18.5	12.9	7.0	28.5	1.5
23-24	4.5	5.3	8.5	12.9	17.7	21.3	25.6	27.0	23.5	18.2	12.6	6.5	28.4	1.4

Outside air temperature | Outside air wet-bulb temperature | 河川水 temperature | 海水 temperature

OK | Calcel | Calc WBT from relative humidity | Save to file | Read from file

4 Calculation execution and output

【Sample model system configuration　(Complex building with a total floor area of 100,000 square meters)】

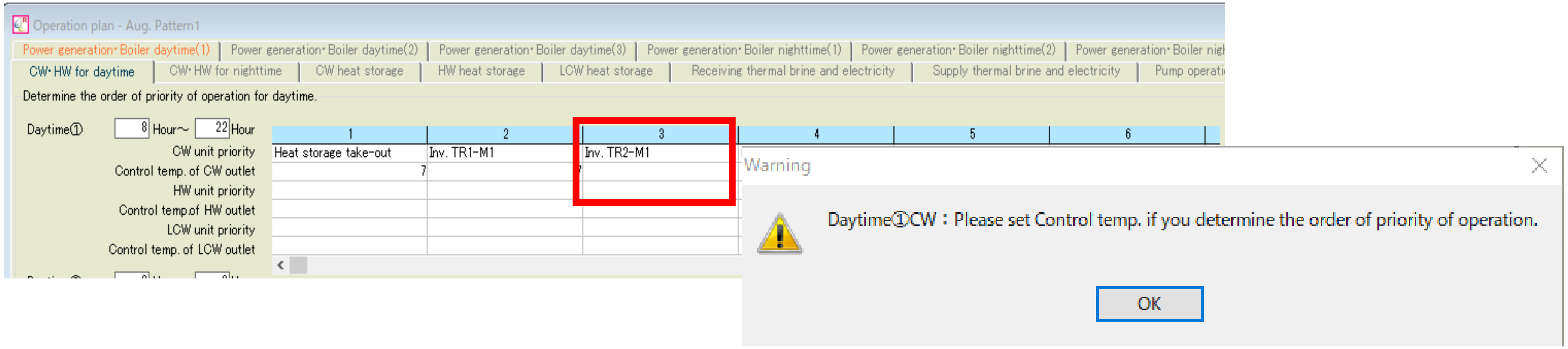


5. Countermeasures for improper settings

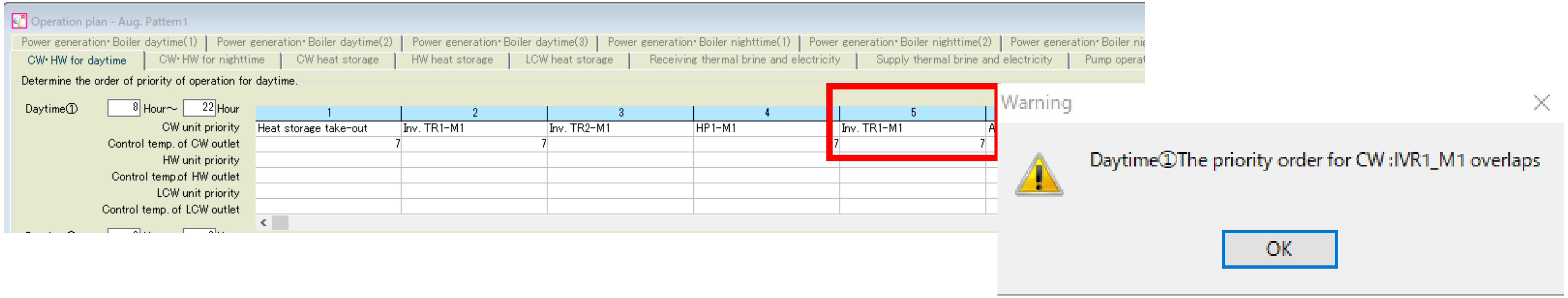
【View warning messages】

If the settings are incorrect or missing, a warning message will be displayed.
The warn function prevents you from doing the wrong simulation.

Case Study 1. Entered equipment priority and forgot to set outlet temperature

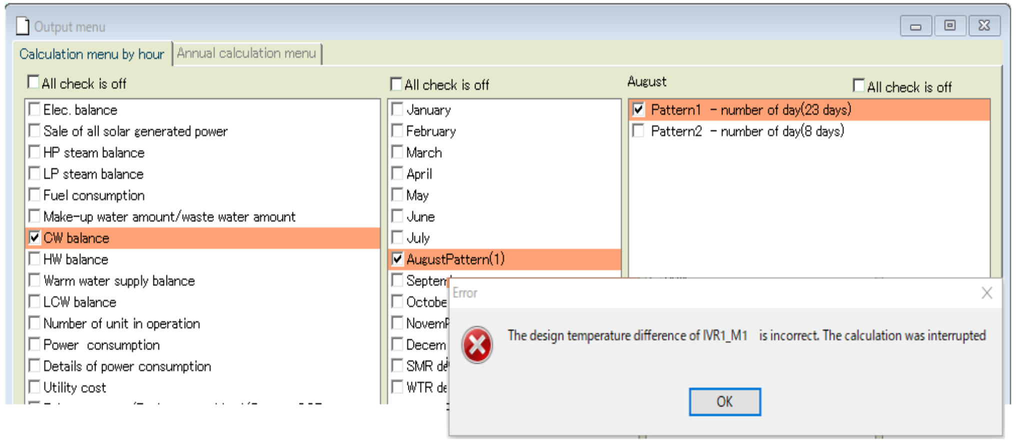


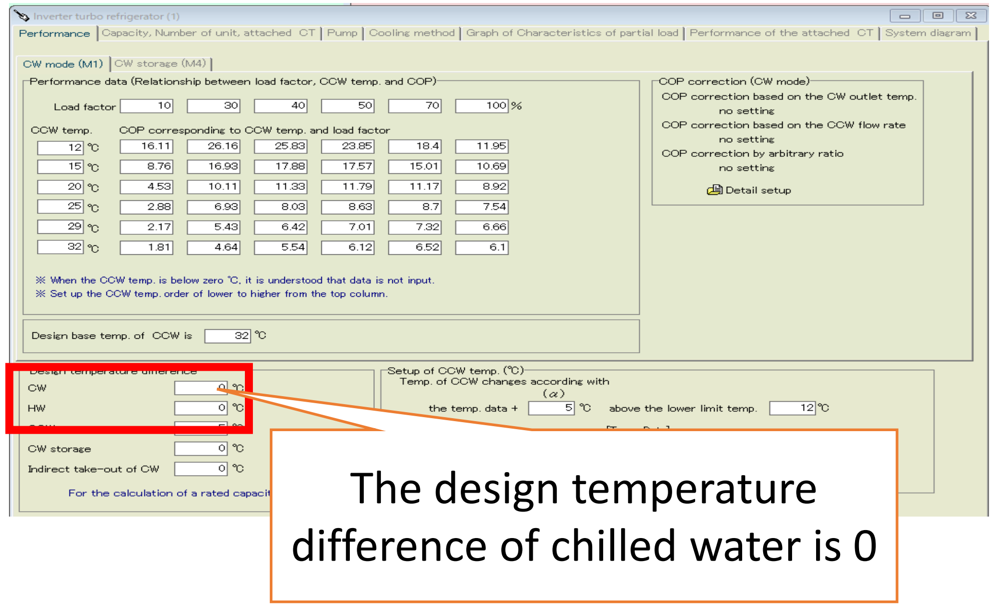
Case Study 2.　If the same equipment is set to equipment priority



Case 3.　When there is an abnormality in the set temp. difference of the unit

Show warn for anomaly settings at the start of output calculation

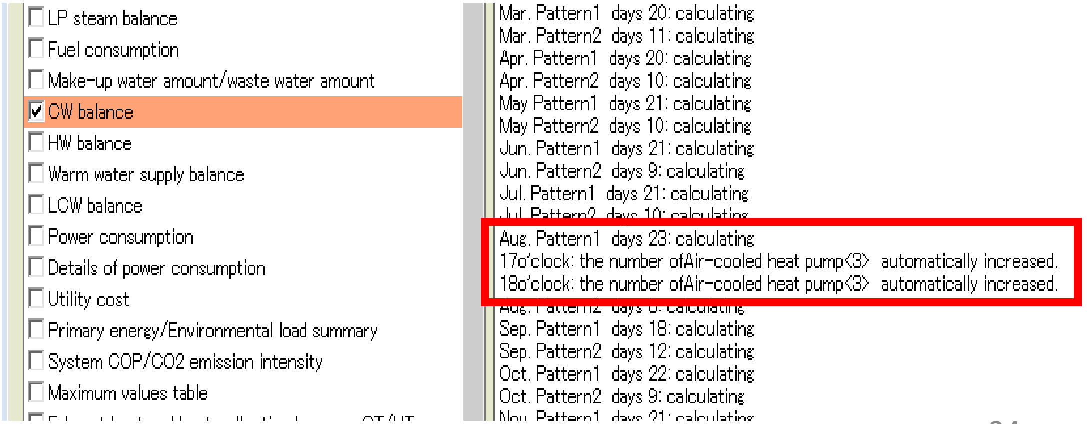




Case 4.　When the capacity and number of units are insufficient for the load

Without stopping the annual calculation, the unit set at the end of the priority is automatically started and balance calculation continues.

The time zone when it starts automatically is described as a warn on the right side.
After completing the annual calculation, it is possible to modify such as adding unit according to this warn or changing the capability of the unit.



6. How to use Enepro21WE

Familiarize yourself with Enepro21WE and think about various ways to prevent global warming.

① Analysis of existing thermoelectric facility

Create an annual load pattern based on one-year operation data

↓

Analyze the performance of the equipment, enter the current performance, and enter the information of the actual equipment operation pattern in the created annual load.

↓

Simulate annual energy consumption

・The difference between the simulation result and the actual energy consumption can be reproduced within an error range of 1 to 2%.。

・Equipment performance and operation patterns accurately reflect the actual operation of thermoelectric facility

・This case file that reproduces the current situation will be the base case for energy conservation measures and system improvement studies.

② Re examination of equipment operation method

① By comparing the result of the base case reproduced in (1) with the simulation result with various settings changed, the following examination can be performed.

- Is the equipment properly allocated to the load?
- Are equipment with different capacities operated in the proper sequence of operations?
- Is the operation considering the relationship between the cooling water temp. and the unit efficiency and the relationship between the outlet temp. of the unit and the load factor?

③ Consideration of facility renewal

Current status reproduction results of existing thermoelectric facility

Comparison

Simulation results by exchanging with equipment scheduled to be renewed

Optimal equipment selection is possible

The performance comparison of the equipment alone cannot accurately reflect the operating conditions of the entire thermoelectric facility, and the partial load characteristics, cooling water temperature dependence of performance, internal power, etc. cannot be evaluated correctly. Therefore, there is a big difference between the energy consumption calculated by the equipment alone and the actual consumption.

④ Verification after equipment renewal

Simulation of operation for one year after equipment renewal

Replace only the renewed equipment with the old one
Simulate operating for one year

You can quantitatively calculate the difference in energy consumption

⑤ Examination of optimum operating and utilization for training of operators

You can consider the optimum operation of thermoelectric facility by following the steps below. It can also be used to improve the skills of operators and to train them in operation.

1） Create the actual thermoelectric load for the week.
Since the thermoelectric load program can set 8 patterns of load per month, input the load for 1 week in order from pattern 1 to pattern 7 on the set date.

2） Connect the thermoelectric load program created in 1) to the case file created in advance in the base case.

3） Set the actual equipment operation pattern and operation parameters for each pattern (setting date).

4） Perform a simulation for each pattern (set date) and compare the energy consumption on the set date with the simulation results to confirm that they almost match.
If there is a large difference, check that there is no difference in the operation pattern and parameter settings of the equipment, and correct it if necessary.

5） It is possible to find improvement measures for operation by changing the operation pattern and parameters of the equipment for each pattern (setting date), performing a simulation, and comparing and examining the actual operation results.

7. Enepro 21 License Achievements and Patents

① Approved by the Ministry of Land, Infrastructure, Transport and Tourism

Enepro21″ is recognized as accurate simulation software by ″Guidelines for calculating primary energy″ when planning new construction and large-scale renewal of thermoelectric facility.

② License record

Enepro21 has been used by major Japanese companies such as major design companies, energy companies, heat supply companies, equipment manufacturers, universities since 2008, and these companies will greatly benefit from the design and analysis results by Enepro21.

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- Shibaura Institute of Technology • Yokohama National University • Kogakuin University

③ Patent

Obtained domestic patent and US patent

Name ″Simulation system for thermoelectric facility″ U.S. patent ：US 8,396,605 B2

④ Award history

- 22nd SME Excellent New Technology / New Product Award
  Software department Received ″Excellence Award″ and ″Environmental Contribution Special Award″
- 7th Air Conditioning and Sanitary Engineering Society Promotion Award ″Technology Promotion Award″

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